2016

An Analysis of the Demand for Rail Transportation of Corn, Soybeans, and Wheat in South Dakota

Melinda Sommer
South Dakota State University

AN ANALYSIS OF THE DEMAND FOR RAIL TRANSPORTATION OF CORN, SOYBEANS, AND WHEAT IN SOUTH DAKOTA

BY

MELINDA SOMMER

A thesis submitted in partial fulfillment of the requirements for the

Master of Science

Major in Economics

South Dakota State University

2016

AN ANALYSIS OF THE DEMAND FOR RAIL TRANSPORTATION OF CORN, SOYBEANS, AND WHEAT IN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Matthew Diersen, Ph.D. Date
Major Advisor

Eluned Jones, Ph.D. Date
Head, Department of Economics

Dean, Graduate School Date

ACKNOWLEDGEMENTS

First, I wish to thank the Wheat Growers Scholar in Agribusiness Management for the graduate research funding I received. My graduate education would not have been possible without this contribution.

I wish to express my genuine appreciation to everyone who has helped me throughout my graduate program. A special thanks goes to my thesis and major advisor, Dr. Matthew Diersen, for his patience and guidance as I wrote this thesis. This work would not have been possible without his encouragement. I would also like to thank the other members of my thesis committee, Dr. Nicole Klein and Dr. Zhiguang (Gerald) Wang, for their advice and support, and my graduate school representative, Dr. Gary Van Guilder, for his willingness to serve on my committee. Thank you to Dr. David Davis for helping me understand some of the econometric concepts with respect to my thesis even though he was not on my committee.

My sincere appreciation also goes to my fellow graduate students for their friendship and support, other faculty members in the Economics Department for their care and willingness to help, and to the secretaries in the department for always pointing me in the right direction. My time at SDSU was a memorable experience, and I am going to miss all of the people who made that happen.

Finally, I would like to thank my parents and my family for supporting and encouraging my decision to attend graduate school. Thank you for being there for me in every situation I encountered in my journey. I thank God for you every day.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

AN ANALYSIS OF THE DEMAND FOR RAIL TRANSPORTATION OF CORN, SOYBEANS, AND WHEAT IN SOUTH DAKOTA

MELINDA SOMMER

2016

The cropping patterns, grain marketing flows, and transportation needs have changed in South Dakota as increased ethanol production has led to a significant increase in corn production and the production of distiller's dried grains with solubles (DDGS) as a co-product. Previous studies have not focused specifically on the grain and oilseed transportation needs in South Dakota over an extended period of time that covers the influence of ethanol production. Quarterly rail data from the Surface Transportation Board Public Use Waybill Sample for 1991 to 2013 were used in a regression analysis of the demand for rail transportation of corn, soybeans, and wheat in South Dakota. Crop production levels, crop prices, rail prices, lagged rail volumes, and ethanol production were considered as determinants of the rail volumes of corn, soybeans, and wheat. Instrumental variables were used to test for endogeneity bias present in the ordinary least squares estimation. Truck prices and rail shipment sizes were used to instrument for rail price in a generalized method of moments estimation of the corn model. The soybean and wheat models were corrected for autocorrelation.

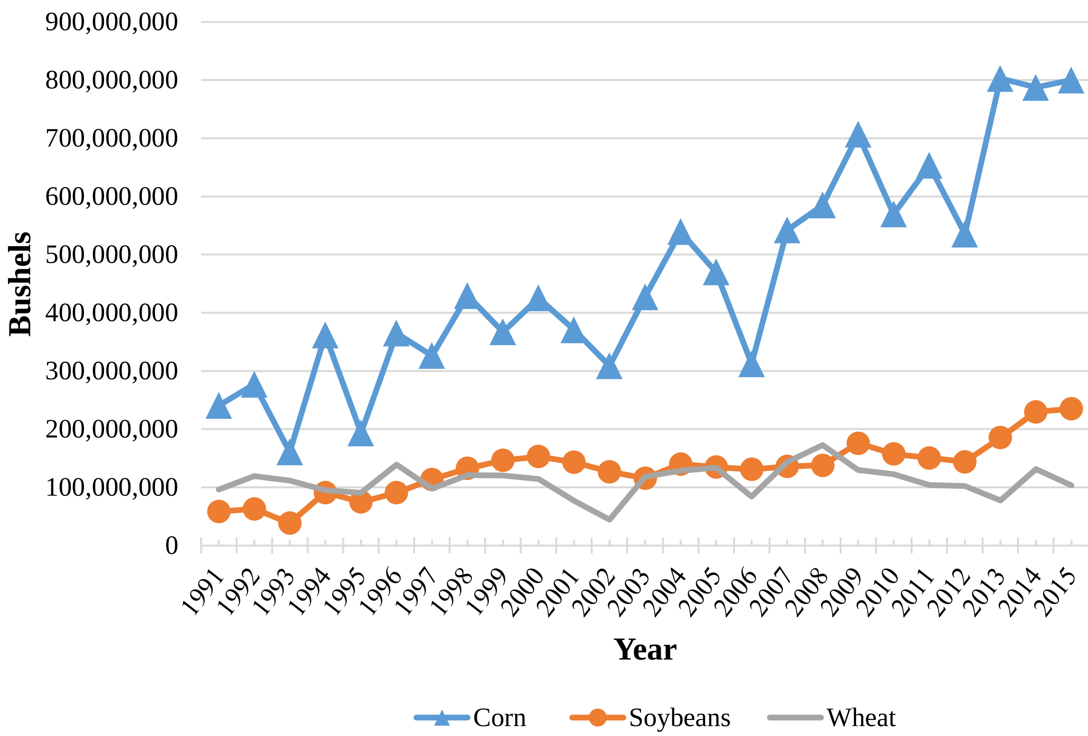
The results for the corn model matched with theoretical expectations, and ethanol production was found to be positively associated with rail volumes of corn and DDGS. This result indicates that the increase in bushels of corn produced in South Dakota was enough to compensate the railroads for the volume of corn lost to ethanol plants. Not all results of the soybean and wheat models were consistent with theoretical expectations, but stocks were found to have a strong positive influence on rail volumes of soybeans, consistent with the concept that soybeans are not stored long and are exported shortly after they are harvested. Additionally, rail volumes of wheat in the previous quarter were found to have a strong positive influence on rail volumes of wheat in the current quarter, indicating momentum swings in the marketing of wheat. Differences were also found in the relationships between rail prices for each of the crops and truck prices and shipment sizes, indicating the importance of rail and truck competition and the influence of shuttle trains in South Dakota.

Chapter I. Introduction

Agriculture, consisting of both livestock and crop production, is an important industry in the United States. According to the United States Department of Agriculture (USDA) Economic Research Service (ERS), agriculture and its related industries added $789 billion to the U.S. gross domestic product (GDP) in 2013, which is a 4.7 percent share. Field crop production, especially the bushels of corn and soybeans produced, has continued to increase. Each of these two crops makes up about 20 to 30 percent of the crop production in the U.S. according to *Crop Production* reports by the National Agricultural Statistics Service (NASS).

Some states, such as South Dakota, have seen a shift in planted acres from more traditional crop rotations, pasture, and grassland to corn and soybean rotations (Luri, 2015). South Dakota in particular has seen a significant increase in corn production, not only because of increased acres but also because of improvements in yield. The large shift to corn production coincided with the growth in production of ethanol and was further supported when corn prices increased from 2010-2012. Before this time, South Dakota’s corn production hovered around 400 million bushels per year for several years until about 2008 when it began to increase to 600 – 800 million bushels per year. Nearly 803 million bushels of corn were produced in 2013, a record level of corn production for the state. Corn production remained at a high level with 787 and 800 million bushels produced in 2014 and 2015, respectively. Soybean production has also been increasing while wheat production has remained relatively constant. Figure 1.1 shows the bushels of corn, soybeans, and wheat produced in South Dakota from 1991 to 2015.

Figure 1.1. Corn, Soybeans, and Wheat Produced in South Dakota from 1991-2015

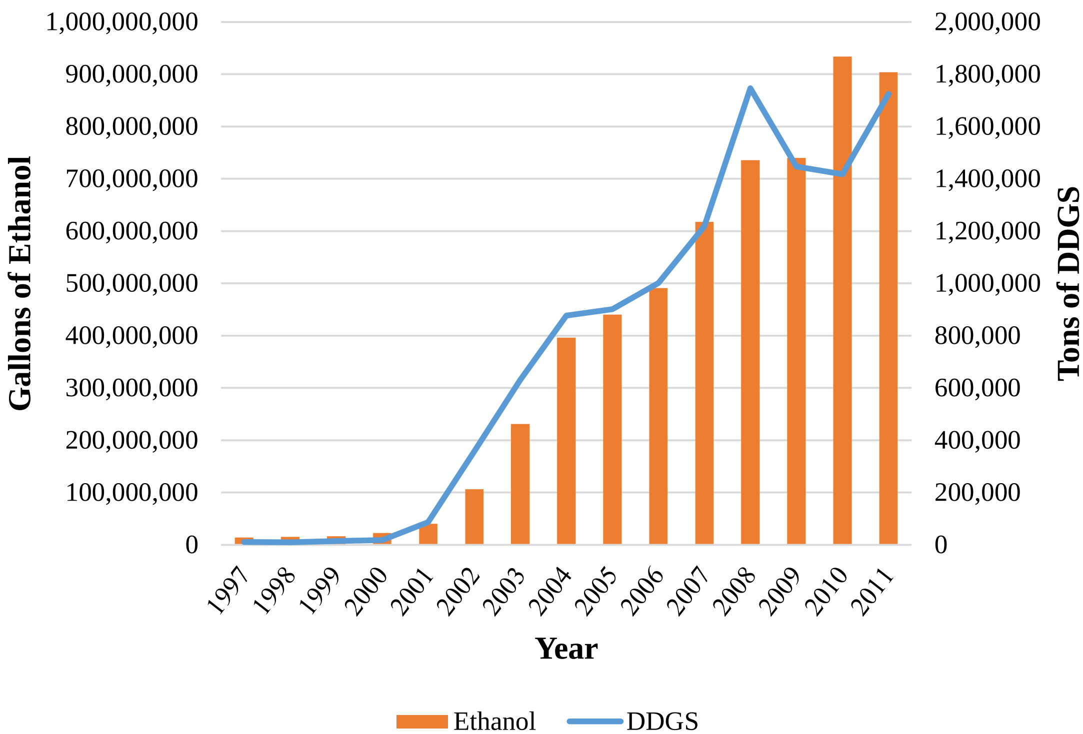


Source: USDA NASS

The increased corn production was mainly driven by the ethanol industry. Ethanol production increased sharply in the 2000s, also leading to increased sales of a major ethanol co-product, distiller's dried grains with solubles (DDGS). DDGS are used as a feed ingredient for livestock, mainly beef and dairy cattle. Figure 1.2 shows the increase in gallons of ethanol produced simultaneously with the increase in tons of DDGS sold in South Dakota.

Increased crop and ethanol production has important consequences for farmers, elevators, other businesses, and the transportation system. The excess supply generally must go somewhere before the next harvest. This has led farmers and elevators to increase their storage capacity by building more bins, although this has not been enough to facilitate excess carryover in some states like South Dakota.

Figure 1.2. Ethanol Production and DDGS Sales in South Dakota from 1997-2011

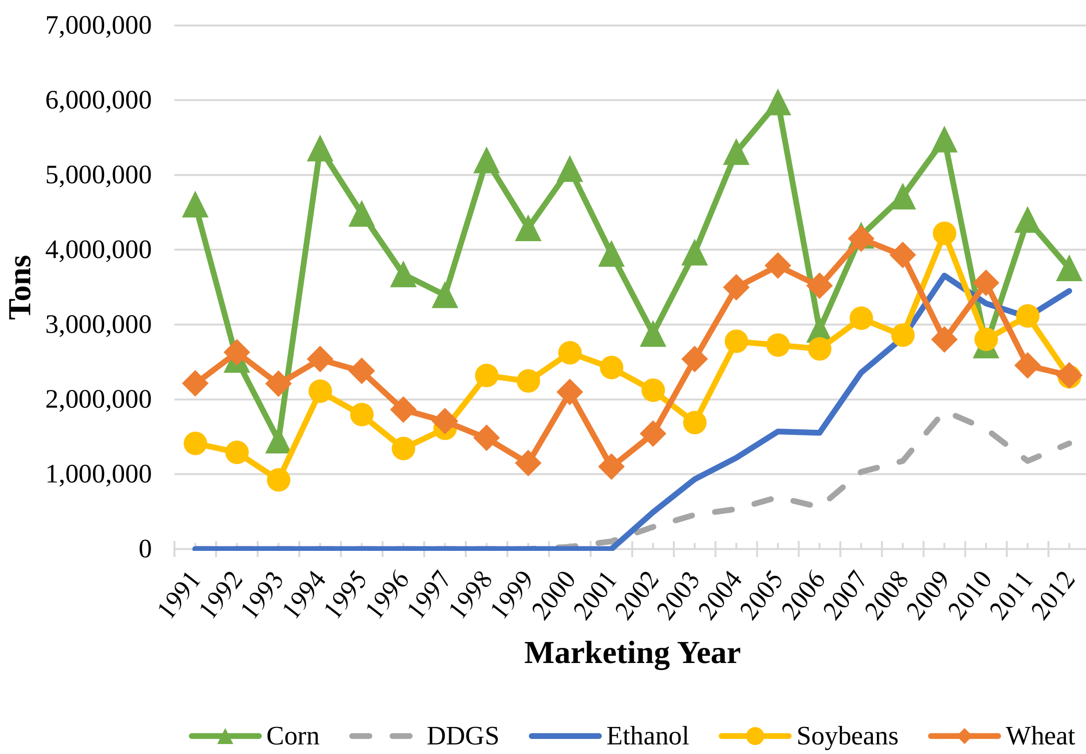


Sources: South Dakota Department of Revenue and South Dakota Department of Agriculture

In September of 2014, a USDA Grain Transportation Report predicted that South Dakota could be short of grain storage capacity by 197 million bushels or about 20 percent of storage capacity, one of only seven states predicted to be short on storage capacity. In addition, more facilities such as ethanol plants and soybean crushing plants have been built or opened to utilize more of the excess supply of grain. Elevators have also been adding shuttle facilities, which allow for trains of 100 cars or more to load grain all at once. These facilities are expensive to build and require large amounts of grain to be available, but they improve efficiency where they are feasible.

Transportation of agricultural products is important because of the seasonality and timeliness involved in the process. With the increase in the number of shuttle loading facilities, rail has increased in importance. South Dakota is primarily an outbound and through state, and most of the products transported out of the state by rail are agricultural products. Only about 2.8 percent of freight movements by rail in the state were inbound in 2011, and cereal grains and other agricultural products made up the highest share of movements at 37 percent (excluding coal which mainly moves through a small portion of the southwest corner of the state) (Cambridge Systematics, Inc. and Civil Design Inc., 2014). Corn, soybeans, and wheat are frequently transported by rail, but greater volumes of ethanol and DDGS have been transported by rail in recent years. Figure 1.3 shows the tons of corn, soybeans, wheat, DDGS, and ethanol originated in South Dakota by rail for the 1991 through 2012 marketing years.

Figure 1.3. Rail Volumes of Corn, Soybeans, Wheat, DDGS, and Ethanol in South Dakota from 1991-2012



Source: STB Public Use Waybill Sample

South Dakota is one of the few states that transports over half of its agricultural commodities by rail (USDA and DOT, 2010). While most of the crop production and rail services are concentrated in the eastern half of the state, some production has moved farther west in recent years. The increased crop production places higher demand on a rail system that has been reduced since the Staggers Act was passed in 1980. Additionally, some of the state's smaller rail lines operated by short line railroads cannot handle the heavier cars typically used on most Class I rail lines and are in need of capital and ongoing maintenance (Cambridge Systematics, Inc. and Civil Design Inc., 2014). Maintaining the rail system in South Dakota is important because diversion of grain traffic from railroads to trucks causes increased wear on the road system in South Dakota.

The purpose of this study is to examine the relationship between the level of crop production in South Dakota and the volume of grain and oilseeds transported by rail over time so that the demand for rail transportation may be determined. Other important factors that will be included in explaining the demand for rail are crop prices, rail prices, the effects of previous rail shipments, and ethanol production. The results can aid in understanding current rail relationships within the state and determining whether the state has enough capacity to handle future levels of crop production. Furthermore, trends in size of shipments and truck competition will be examined in relation to the price of rail to analyze the effects of increased crop production and the use of shuttle trains. Finally, the dynamics of increased corn production in South Dakota will be investigated through the consideration of ethanol production numbers and rail originations of DDGS, an ethanol co-product.

Problem Identification

With increased production of crops in South Dakota, particularly corn, the question of where grain is used becomes increasingly important. If the grain cannot be immediately stored or used, it must be transported somewhere else. Some of the soybeans produced in South Dakota are transported to crushing facilities in the state, but the rest leave the state. In addition, most of the wheat leaves the state. The corn goes to ethanol plants or is fed to livestock in the state. The corn that goes to ethanol plants ultimately leaves the state in the form of ethanol or DDGS. Any corn not used by the ethanol plants or as livestock feed is generally transported out of the state.

In South Dakota, the two most common modes of transportation are truck and rail. Rail is commonly used to transport agricultural products like grains, oilseeds, DDGS, and ethanol that are leaving the state. Rail is more efficient in transporting these commodities because they are bulky and are shipped long distances to end users, typically in large quantities.

During the harvest of 2013, large production levels, adverse weather conditions, and increased rail shipments of other non-agricultural commodities caused major delays for elevators getting rail cars. Rail car prices on the secondary market increased sharply. For example, the monthly average bid for shuttle grain cars on the Burlington Northern Santa Fe (BNSF – a large Class I railroad) secondary market went from being sold at a discount in July 2012 to close to $5,000 per car between July of 2014 and January of 2015 (Davies, 2015). Meanwhile, the prices farmers were receiving dropped as elevators filled up because of the shortage of railcars. Studies such as that by Norton (1995) have examined the effect of railcar availability on grain prices because transportation costs have a large impact on the price farmers receive. The farmers who could store their grain and wait for higher prices did, while those who could not had limited alternatives. There were also concerns about necessary fertilizer shipments arriving on time in spring. Because of the seasonality of agriculture, efficient, on-time transportation is important. Transportation costs also make up a large portion of the basis which affects the price a farmer receives in a given area.

These capacity issues led to questions about investing in more storage, contracting rail cars ahead of time, and investment in new shuttle loading facilities since railroads were more likely to send a large shipment of railcars on time rather than just a few cars. The railroads and the state of South Dakota also had to consider new investments into the rail system.

Railroads spent years with excess capacity prior to the Staggers Act of 1980 because it was very difficult for them to abandon lines. Once the Staggers Act was passed, it was much easier for railroads to abandon lines that were being underutilized. According to a study of rural transportation issues by the USDA, the state of South Dakota was one of the top three states that lost the most rail service between 1965 and 1997 (USDA and DOT, 2010). South Dakota lost 46 percent of its rail lines, but the loss was not realized until capacity issues started to occur as rail traffic picked up in the 2000s. Although conditions have improved because the railroads have had some time to react, the right combination of factors could cause more capacity issues in the future. It remains unclear how production levels effect the rail volumes in South Dakota and how the rail volumes affect the crop flows out of the state. This is partially because of limited rail data that are available only to certain groups including Federal agencies, state transportation departments, railroads, transportation practitioners, consultants, and law firms involved in transportation-related proceedings (Surface Transportation Board, 2015).

A few studies have been conducted on rail flows in South Dakota over short time periods. Informa Economics (2010) is a study on corn rail rates prepared for the National Corn Growers Association (NCGA). This study used the Public Waybill Sample to provide statistics on corn flows out of South Dakota and six other states in the Midwest along with a summary of the U.S. as a whole. However, this study only covered the 2000/2001 through 2007/2008 marketing years and was more focused on rail rates charged for corn shipments. The study period was not relatively long and did not include the recent record production years. The main focus of the study was not on South Dakota.

South Dakota's State Rail Plan also used Waybill data to analyze commodity flows into and out of the state. While the study used better data because it had access to the Confidential Waybill Sample, it only provided an analysis of one year, 2011. It would be more helpful to have a longer analysis covering the years before ethanol production expanded and the recent record production years specific to South Dakota to determine a relationship between production levels and rail volumes. This would provide a better picture of the relationship and allow for analysis on future capacity issues that could arise if the correct investments are not made in the rail system.

Research Objectives

The general objective of this study is to use empirical data to analyze grain and oilseed demand for rail transportation in South Dakota. This will be done by examining how rail volumes of corn, wheat, and soybeans in South Dakota are related to crop production levels, crop prices, rail prices, former rail volumes, and ethanol production over time. Production and rail volumes of corn, soybeans, and wheat will be examined along with the effects of ethanol and DDGS as products derived from corn production. Changes in average shipment sizes and changes in truck prices will be related to rail prices to further explain the model. Regression analysis will be used to determine these relationships.

The estimated relationships will provide insights on crop flows out of the state over time and how future production levels may affect capacity issues and the need for increased investments in the rail system in South Dakota. They will also provide insights into the competition between rail and truck modes and how it may differ among the three commodities studied.

The specific objectives are to:

1. Estimate rail demand equations for corn, soybeans, and wheat in South Dakota using data from 1991 to 2013,
2. Utilize the Surface Transportation Board's (STB) Public Waybill Sample to generate rail data for an analysis specific to South Dakota,
3. Examine the effect of a shift to increased corn production in South Dakota in relation to increased ethanol production and DDGS originations, and
4. Investigate trends in average shipment sizes and truck prices as they relate to rail prices and how the relationships differ for each commodity studied.

Justification

Demand for agricultural transportation is a relevant issue to grain producers, producer groups, federal and state governments, elevators, ethanol plants, soybean processing facilities, and other users of railroads as well as the railroads themselves in South Dakota. With recent capacity issues, producers have seen reduced prices and fear of not getting fertilizers on time in the spring. Elevators have paid high prices for rail cars that were not delivered on time and have looked into building more storage or shuttle loading facilities. Increased corn production has led to more ethanol capacity and increased shipments of ethanol and co-products by rail. The railroads are looking into added investment to increase their capacity. These issues are serious enough that Senators Thune and Klobuchar, of South Dakota and Minnesota respectively, requested that the USDA examine the rail service challenges in the Upper Midwest (Office of the Chief Economist and AMS-USDA, 2015). While this problem was isolated to a short period, it may occur again. This research examines longer run production changes and what would be expected in a stable environment for railroad volumes. The analysis conducted in this study estimates a relationship between rail volumes and crop production levels along with other factors to help determine normal rail flows of corn, soybeans, and wheat. Studying these relationships is a starting point for determining if there could be capacity issues again and whether or not additional investment is needed.

Policy makers are concerned about transportation because the U.S. needs a cost-effective, reliable transportation system to remain competitive in the global export market. The current transportation infrastructure in the U.S. is aging and congested in many areas. A five year, $305 billion highway bill was passed in early December 2015 to provide money for roads, rail projects, and other transportation-related needs. The bill is the longest (in terms of the number of years it covers) transportation measure that has been passed in seventeen years (Hughes, 2015).

Producer groups such as the Soybean Transportation Coalition (STC) push for legislation for transportation research to improve transportation infrastructure and service for stakeholders such as producers and shippers. Producers generally pay for transportation costs in the form of lower bids from elevators, so improvements in efficiency and lower costs to the transportation system affect the price producers receive for their crops.

This research is also important because there are not a lot of studies over time on rail flows of agricultural commodities in South Dakota. Rail data sources are not readily available. Previous studies have either not focused on South Dakota or have not covered sufficient periods of time with respect to major changes in grain marketing patterns occurring in South Dakota. This research should be able to provide rail users with more information about rail flows and volumes and how they have changed over time in South Dakota.

There are four chapters following this one. Chapter Two is a review of literature on grain marketing, shuttle trains, ethanol production, railroad pricing and competition, and the demand for grain and oilseed rail transportation. Previous studies using the Waybill rail data will also be included to provide more support for the data that are used in this research. Chapter Three explains the data used in this study and the methods of analysis. Chapter Four is a discussion of the empirical results. Finally, Chapter Five provides a summary of the thesis as well as limitations of the study and recommendations for future research.

Chapter II. Literature Review

Although South Dakota transports a large share of its agricultural commodities by rail, there have not been many studies conducted specifically on South Dakota and its rail transportation of grains over time. However, the state does have its own rail plan, and there have been a few studies on the grain marketing system in South Dakota, as well as several larger studies that have included South Dakota with other states.

One reason for the limited number of studies is because of the limited rail data that are available. Most of the previous literature uses data from the Surface Transportation Board (STB) Confidential Carload Waybill Sample, which is only available to certain users such as government organizations because of the sensitive revenue information, specific geographical information, and railroad identification that are included in the data. In contrast, the Public Use Waybill Sample omits this confidential information and is available to the public on the Surface Transportation Board website. Some of the literature that will be discussed here makes use of this publically available data.

While studies specific to South Dakota may be limited, studies on railroads and transportation demand in a more general sense are not. Previous research findings in these areas will be discussed in this chapter. Some studies related to ethanol, shuttle trains, and grain marketing will also be reviewed because of their direct and indirect effects on the demand for grain transportation in South Dakota.

Background Studies Using Waybill Data

The following studies are important because they show the type of analysis that has been done using the Waybill Sample and provide further justification for this research because they are not specific to South Dakota, or they do not cover as long of a study period as the analysis provided in this research. They do, however, provide a good basis for future research and justify the use of the Waybill data for analysis.

The South Dakota State Rail Plan provides an in-depth analysis of the rail system in South Dakota, including its role and goals, history and programs, railroads and current infrastructure, demand and impacts, needs and opportunities, as well as project evaluations and recommendations (Cambridge Systematics, Inc. and Civil Design Inc., 2014). It addresses the current and potential demand of the railroad system in the state through the analysis of Confidential Waybill data and the Federal Highway Administration (FHWA) Freight Analysis Framework (FAF). “The Freight Analysis Framework (FAF) integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation” (FHWA-USDOT, 2015). The data can then be used to forecast future commodity flows by transportation mode. Rail volumes for 2011 according to the Confidential Carload Waybill Sample are provided for through, outbound, inbound, and intrastate flows of commodities. Overall in South Dakota rail handled about 25 percent of freight movements, most of which were through or outbound movements. Excluding coal, because it mainly moves through a small portion of the southwest corner of the state, the top four commodities transported by rail were all agricultural commodities: “cereal grains (incl. seed)” (26 percent), “other ag products exc. for animal feed” (11 percent), “alcohol (ethanol)” (10 percent), and “animal feed and products of animal orig., n.e.c.” (nine percent). Most of the inbound and outbound rail flows were in the eastern part of the state, and the top three trading partner regions were the Pacific, East North

Central, and West South Central regions at 36 percent, 16 percent, and 15 percent of total state trade, respectively. While the rail plan provides a snapshot of one year's rail flows, it does not say anything about the changes in rail flows over time nor does it break down the specific commodities for further analysis. One year may not provide an accurate representation of typical rail volumes.

In a study on corn rail rates for the National Corn Growers Association (NCGA), Informa Economics (2010) used the Public Use Waybill Sample to analyze corn flow patterns and other rail summary statistics and rail rates for the marketing years 2000/2001 to 2007/2008 for the U.S. and for seven states: Illinois, Indiana, Iowa, Minnesota, Nebraska, North Dakota, and South Dakota. Some statistics on carloads, tons, freight revenue, dollars per ton, and average miles were also provided for corn syrup, ethanol, and DDGS on a calendar year basis for 2000-2008. Corn production in key areas and shuttle loading facilities in those areas were briefly addressed for each of the states studied. Corn destinations from each state were broken down into business economic areas (BEAs). The study found that Western Corn Belt states primarily send their corn to the Pacific Northwest (PNW) for export and to California and the Texas Panhandle feed markets. Eastern Corn Belt states send a large share of their corn to the Southeast feed market. Additionally, increased exports and more efficient use of shuttle trains has increased the geographic reach of the Corn Belt states as average miles per carload have increased for the U.S. as a whole over the time period studied. However, both shuttle train rates and single car rates have increased over time, and nearly half of the corn tons moved by rail in 2008 were equal to or greater than the 180 percent revenue-to-variable cost (RVC) threshold. This threshold is used to evaluate rail rates and is "the STB's jurisdictional threshold for reviewing the reasonableness of railroad rates" (Informa Economics, 2010). While this study covers a longer time period than the State Rail Plan, it is still relatively short compared with the data that are available now. It is also limited in that it only covers one commodity, corn.

A large study by Prater, O'Neil, and Sparger (2013) provides a summary of grain rail statistics for each state, including South Dakota. According to this study from 2013, South Dakota ranked seventh in average annual grain and oilseed production from 2006-2010 and sixth in total grain and oilseed rail shipments. This study also used the Confidential Carload Waybill Sample data from 2006 to 2010 and included breakdowns of rail shipments by termination BEA, rail receipts, grain and oilseed production, animal and poultry production, grain and oilseed exports, rail rates per ton mile for grains and oilseeds, and shipment sizes. The study found that corn made up the largest share of South Dakota grain crops in millions of bushels at 65 percent, then soybeans at 18 percent, and wheat at 16 percent for the time period studied. Railroad grain and oilseed originations increased their market share from 2007-2010 relative to the period from 2001-2004. The top destination by BEA for both South Dakota corn and soybeans from 2006-2010 was Seattle-Tacoma-Bremerton, WA. However, the top destination by BEA for wheat was Chicago-Gary-Kenosha, IL-IN-WI. The primary shipment size for this time period was 75 plus cars (shuttle trains), and the average tariff rail rates increased from 2.13 cents per ton mile in 2004 to 3.2 cents in 2010. The study is useful because of the information and analysis it contains on South Dakota. However, it is once again limited to a brief time period, and it does not cover commodities such as ethanol or DDGS. Additionally, rail flows of corn, soybeans, and wheat were not analyzed in relation to crop production. It is interesting because it shows the breakdown of shipment sizes over the time period analyzed, although the data are aggregated over time for the state.

Prater and Sparger (2013) also used the Confidential Carload Waybill Sample in another study at the national level. Their analysis focused on changes in shipment size and length of haul for corn, soybeans, wheat, sorghum, and barley from 1994-2009. They sought to compare those changes in relation to exports, production, and usage of each of these crops. Over time the shipment size and distance for corn and soybeans have increased because of additional cost savings and efficiency for the railroads and increased exports. This has led to an increase in shuttle-loading facilities. Shuttle trains are defined formally as "entire trains, usually between 75 and 120 cars, that haul a single commodity between a single origin and destination and are operated on a continuous cycle for a specified length of time under contract" (Prater and Sparger, 2013). Corn and soybean production have increased, while production of wheat, sorghum, and barley have declined. Ethanol's share of corn use has increased while corn exports have decreased. At the same time, soybean exports increased significantly, while wheat usage remained fairly constant over the time period studied. For commodities like barley where the distance hauled has not increased over time, rail market share has declined due to increased competition from trucks at shorter distances. The analysis is interesting because it breaks down the shipment sizes and distances hauled by specific commodity and begins to analyze other factors such as production and usage. However, it is still aggregated to the national level rather than by state.

In a comprehensive study prepared for national soybean interest groups, Informa Economics (2012) conducted an analysis of the crop and livestock outlook and the transportation of soybeans and key transportation and infrastructure issues to determine the impact on U.S. agriculture. This information was also broken down by state for seventeen key states including South Dakota. Production, net shipments, rail volume, and barge volume for soybeans were given for the marketing year 2009/2010 and forecasts were provided for 2020/2021. Both production and rail volumes were forecasted to increase in South Dakota. Informa Economics used some Public Use Waybill data to determine export destinations for soybeans and found that 90 percent of the soybeans from South Dakota went to the Pacific Northwest. They also found that 39 percent of the soybean meal left the state by rail while the rest remained in the state, and all of the soybean oil left the state. The value of soybean production in South Dakota was provided from 2002-2012, and it nearly tripled over that time period. The average length of haul for soybeans transported by rail in South Dakota was 1,432 miles, reflecting the large amount of soybeans exported.

A map of soybean production in South Dakota indicates that soybean production densities are highest in the southeastern corner of the state. South Dakota's main type of livestock are cattle, which do not typically use soybeans. South Dakota had 1,741 miles of rail line, 22 shuttle facilities, one soybean crush facility, 16 ethanol facilities, and 210 grain elevators when this study was conducted. According to the study, in 2009/2010, 3.2 million tons of soybeans were transported out of the state for exports and domestic crush while 533 thousand tons went to the soybean processing facility in the state. The value of soybean production was estimated at $1.6 billion.

Studies in Grain Marketing and Transportation

Transportation is a central part of the grain marketing process. Available transportation modes and transportation costs are some of the main determining factors in patterns of grain flows. Previous work on the transportation of grain in South Dakota is limited, but there are a few studies relating transportation to the grain marketing system. Lamberton and Rudel (1977) analyzed the South Dakota grain marketing system by using data obtained through a 1974 survey of grain elevators in the state and through the estimation of assembly, handling, and distribution costs. They found patterns of increasing truck use along with a shift to larger elevators and indicated deterioration in South Dakota's rail system. Their results also indicated a high degree of substitutability between truck and rail, suggesting that changes in the relationships between the rates for the two modes of transportation would cause significant changes in mode choices and destinations. The estimates found in the study reveal marketing costs of $0.42 per bushel in 1974, or about $53 million for all the grain marketed from farms to terminals in South Dakota. Using an analysis of elevator costs, the study found that nearly 10 percent of this cost could be saved by using only the most efficient elevators to handle grain, thereby significantly reducing the amount of elevators in operation.

Lamberton (1977) provides additional background information on grain transportation in South Dakota including a brief history and future expectations. Grain transportation needs have historically been an important motivation for the development of the transportation system in South Dakota. Although South Dakota initially had few alternatives to rail, most of its transported products were agricultural products, and thus agricultural shippers received lower rates for rail service based on value-of-service transportation rates that regulated railroads were required to provide. After the two World Wars, when trucks began to increase in importance for freight transportation, railroads were not allowed to easily change their rates to compete and suffered from excess capacity they were not allowed to abandon. South Dakota's railroads could not afford to upgrade their lines to handle the new larger covered hopper cars, and the elevators did not yet have the larger loading facilities needed to take advantage of lower unit train rates. Trucks continued to get bigger and utilized the new highway and interstate system. At the time the study was written, rail deregulation changes were just beginning to take place. The Railroad Revitalization and Regulatory Reform Act of 1976 provided financial assistance to railroads and increased the ability of railroads to change their rates. The Staggers Acts would further deregulate the industry in 1980. Lamberton predicted that elevators with larger capacity would continue to be built, and the railroads would improve their infrastructure for these larger elevators to take advantage of improved technologies and efficiency, while trucks would continue to handle grain shipments to the elevators. In this way, he anticipated that "the development of the transportation system in South Dakota [would] occur coincident with the evolution in the state's elevator industry" (Lamberton, 1977). The study also gives some insights into the importance and relevance of storage availability, transportation costs, production, demand for a final product, and the availability of transportation substitutes in determining the elasticity of demand for transportation.

More recently, Qasmi et al. (2010) studied grain marketing patterns for South Dakota for the 2005/2006 marketing year based on the results of grain elevator surveys and compared the results to those from a previous study. The results indicated that corn, soybeans, wheat, and sunflowers were the most important cash crops in the state, "accounting for 93.3% of cash receipts from all crops in the state, during calendar year 2005" (Qasmi et al., 2010). During the eleven years between the two studies, there was a large increase in the production of corn and soybeans in the state with a smaller increase in wheat production and a decrease in sunflower production. Most of this production was in the eastern half of South Dakota. Of these four crops, sunflowers were mainly transported by truck, while the majority of wheat and soybeans were transported by rail, and the share of transportation for corn was about half truck and half rail. For the marketing year 2005/2006, rail transported just over half (55 percent) of the grains and soybeans handled by elevators in South Dakota. Rail increased its share of transportation between the two marketing years studied for soybeans, wheat, and sunflowers, but its share was less for corn in 2005/2006. More wheat and soybeans were shipped by rail because a large percentage of their production left the state. A majority of the wheat was headed to the Minneapolis area or other out-of-state destinations while about half (47 percent) of soybean shipments in 2005/2006 were bound for the Pacific Northwest, an eight percent increase from 1994/1995. However, the share of corn transported to the Pacific Northwest declined from the 1994/1995 marketing year to the 2005/2006 marketing year. At the same time, the amount of corn sold to in-state buyers increased dramatically (from 28 to 63 percent) with a large increase in capacity and number of ethanol plants in the state over that time period. Even though other studies found that elevators' share of corn in states such as Indiana and Iowa had declined due to increased ethanol production, Qasmi et al. (2010) found that elevators' share of corn in South Dakota had actually increased even with increased ethanol production. Another interesting finding from the survey results was the significant increase in storage capacity (90 percent increase) even though the total number of elevators in South Dakota declined (19 percent decrease) during the eleven years between the two studies, indicating a consolidation and restructuring of the industry.

In the region, Vachal et al. (2010) examined the competitive position of wheat in North Dakota in relation to market flows and trends in transportation through descriptive analysis of several data sources including the North Dakota Public Service Commission Elevator Grain Movement Database (GMDB), Surface Transportation Board Public Use Waybill Sample, U.S. Department of Agriculture grain export and marketing price data, and railroad published rate tariffs. BEA origin states and BEA destination territories were used to determine flows of wheat from North Dakota, South Dakota, Minnesota, Nebraska, Kansas, and Montana. A rail utilization index was calculated to provide a measure of the relative importance of rail in marketing wheat in the region. "It is calculated as the ratio of rail to production for an individual state in wheat compared with that for the region" (Vachal et al., 2010). This index was not an exact measure of rail shipments for a state because BEA boundaries do not follow state boundaries. The trend from 2001 to 2008 showed increased rail utilization in North Dakota, Montana, and South Dakota, decreased rail utilization in Minnesota, and relatively steady utilization in Nebraska and Kansas. Rail wheat shipments by BEA freight territory were provided for 2008. The highest percentage of South Dakota's wheat shipments were bound for the Western BEA freight territory, an increase of about 50 percent since 1999. Rail rates were also examined using the Public Use Waybill Sample. From 2001-2008, rates trended down for BEAs in North Dakota although the Public Use Waybill does not account for fuel surcharges or other premiums or discounts from the rail market. This study has very limited data on South Dakota, but it does use the Public Waybill Sample to examine wheat flows.

Vachal (2012) conducted a similar but more extensive study by surveying elevators in the north-central plains region including North and South Dakota, Minnesota, Kansas, and a small sample from Nebraska. Respondents included 208 elevators from throughout the region, including 43 from South Dakota. The results provide insights into transportation of grains in the region and allow comparisons to be made between South Dakota and other states in the region. According to FHWA data, cereal grain shipments constituted 80 percent of all agricultural shipments in South Dakota in 2010 (Vachal, 2012). This was the highest share in the region, which was the same share as in North Dakota and well above the average share of the U.S. which was 45 percent. This shows the importance of transportation to grain production and marketing, particularly in states such as South Dakota with large agricultural sectors and high grain production.

Elevators were asked what they see as the most important transportation issues for the future. The top responses from the elevators in South Dakota included export market demand, local road investments, local processing/feeding demand, and rail industry capacity (Vachal, 2012). Local demand with respect to increased ethanol production has caused increased transportation demand for corn to be moved to ethanol plants and for ethanol and its co-products to be shipped to end users. Rail capacity has been an issue with increased production levels. Export demand has increased, causing a higher demand for rail service, especially an increase in shuttle trains.

Corn dominated the largest share of grains both produced in this region and handled by elevators in the survey, while soybeans and wheat had a similar share. Transportation demand has increased as a result of increased production. The study found that production of the major grains in South Dakota had increased 45 percent when compared to the average annual production level from 1999-2001. Increase in local processing in the states affects the conversion of production volumes into transportation demand (Vachal, 2012). This is why local processing demand was included as one of the top transportation issues for the future.

Trucks held the largest market share of grain handled by elevators across the region at 53 percent, but South Dakota actually transported a slightly higher share of its grain by rail (54 percent). Over half of the corn in the region was transported by truck, while over half of the soybean and wheat volumes were handled by rail. This is consistent with the study by Qasmi et al. (2010). Truck-only elevators made up the largest group of elevators in Kansas, Minnesota, and South Dakota, while North Dakota had more shuttle elevators and 25-69 car elevators. Shuttle elevators (70 cars or more) were the second highest category in the South Dakota sample. Shuttle elevators were unsurprisingly found to be the most efficient type of elevator with the highest turnover ratios and the highest share of the grain market handled for all states. Shuttle facilities have also increased storage capacity in the states and increased draw areas for grain originations for the elevators.

Within the study region and in South Dakota, most of the grain was shipped by truck to in-state end users such as local processing plants and animal production units. However, soybeans were more likely to be shipped to the Pacific Northwest for export, mainly by rail. The Pacific Northwest was the second largest market for corn. A significant share of the wheat was shipped to domestic markets to the east by rail.

The survey also investigated truck ownership. South Dakota was found to have the highest share of elevators leasing trucks as well as the highest share of ownership. Shuttle elevators in the region had the highest share for both leasing and owning trucks.

In addition to the use of trucks, rail service was also investigated. Service types for rail shipments included shuttle, other guaranteed, tariffs, and other. Shuttle rates are for large trainloads (around 100 cars) that haul a single commodity between one origin and destination point on a continuous basis for the length of the contract. Other guaranteed services are car placements offered through auctions. Tariffs are standard rates which are available to all shippers. Before contracts became widely available, rail service for grain shipments was provided through tariffs. Shuttle service was the most commonly utilized service in the region due to pricing incentives and service reliability along with increased exports. In 2011, shuttle service constituted 65 percent of all rail shipments in South Dakota. However, South Dakota still used the highest share of tariffs because of the number of short line railroads servicing elevators in the state. Most elevators in the region were likely to contract through a third party for their freight, but South Dakota elevators were the most likely to contract directly with the railroad. In 2011, the highest average premiums for guaranteed rail service were paid by South Dakota elevators for both shuttle service and other types of guaranteed service programs. This was well above the other states. Some states, such as Kansas, were getting a discount on guaranteed shuttle service on average. Finally, survey respondents were asked to rate their rail carriers on their service. South Dakota only had one major rail carrier included, Burlington Northern Santa Fe (BNSF). BNSF was rated second among the Class I rail carriers in the region.

Studies on Unit/Shuttle Trains

After deregulation, railroads had greater pricing flexibility and ability to take advantage of technology improvements, such as larger cars and shuttle train movements, which enhanced efficiency and productivity of the railroads. "A shuttle train involves shipping 100 (or more) cars from a single origin loaded in fifteen hours, to a single destination and unloaded in fifteen hours, and operating the train as a continuous cycle with a number of successive movements" (Sarmiento and Wilson, 2005). Railroads offer significant rate incentives for these types of shipments, and this had a major effect on the structure of the grain marketing and transportation system. Elevators that could do so took advantage of these competitive rates by making substantial investments in larger loading facilities and adding grain capacity. Hanson et al. (1990a), using data from a survey of elevators in Kansas, Oklahoma, North Dakota, South Dakota, Minnesota, Iowa, and Nebraska, found that railroads were more likely to offer lower contract rates to an elevator if it shipped more tons of corn, soybeans, or wheat. Reduced shuttle rates are important to elevators because of the effect of transportation costs on elevator handling margins (Hanson et al., 1990b). The rate incentives and improved efficiency have also lead to an increase in the amount of shuttle loading facilities in South Dakota. Not much research has been conducted on the impact of this relatively new technology in South Dakota, but the impact of shipment sizes on rail rates is examined in this research so some previous studies are reviewed here.

Sarmiento and Wilson (2005) modeled the strategy to adopt shuttle train elevators. They pointed out the change from single car shipments to smaller unit trains to shuttle trains of 100 or more cars that has taken place because of the increased productivity and efficiency that larger shipments provide. The results from the study indicated that agronomic factors such as production density, variability, and homogeneity are important factors in the adoption decision for building a shuttle loading facility.

Vachal and Button (2003) estimated the impacts of shuttle train rates on grain flows in North Dakota. They defined grain draw areas for current shuttle facilities by using relationships between rail rates, the road network, and truck costs as part of producer delivery costs. A sensitivity analysis was also conducted to determine the influence of different commodities, changes in freight rates, producer truck investment, and commercial truck delivery. Wheat, barley, and corn were compared. A feasible shuttle operation required about twelve million bushels so it could not rely on barley alone. Corn was only produced in the southeastern corner of the state so it was not applicable to all of the shuttle loading facilities in the state. Results found that shuttle rates increased an elevator's draw area by about 50 percent. Increases in truck costs had varied effects depending on the location, but higher costs decreased draw areas at all locations by anywhere from 18 to 62 percent. Commercial truck rates were found to significantly increase draw areas by 60 to 80 percent. Implications of the study were that fewer elevators could be handling a higher percentage of the grain produced in the state, which could significantly impact the transportation infrastructure.

Huang (2003) examined the factors that affect an elevator's decision to adopt shuttle trains. Data from elevators on the rail lines of Burlington Northern Santa Fe

(BNSF), Union Pacific (UP), and Canadian Pacific (CP) in nine states (including South Dakota) from 1996 to 2000 were used in a logit analysis. Characteristics of the elevators, agronomic characteristics, and competitive factors were considered. The variables considered in the analysis are the railroad the elevator is on, the elevator's storage capacity, the storage capacity of the nearest elevator, the nearest elevator's shuttle adoption strategy, the miles to the nearest competitor, the number of elevators in a county, average yields for main crops (wheat, corn, soybean, sorghum, barley, and sunflowers), the standard deviation of crop yields, and the Herfindahl Index of crop diversities. Results indicated that the nearest competitor has a strong influence on an elevator's decision to adopt shuttle trains, an elevator that is larger will be more likely to adopt a shuttle train, and that railroads also have an effect on an adoption strategy. Additionally, a lower diversity of crops with higher yields and less variation supports a shuttle train adoption strategy. The results of the study indicated that smaller elevators may find it hard to compete in a new marketing system that involves shuttle trains.

Kenkel et al. (2004) investigated the investment costs and profitability of a 100-car unit train load out project in Oklahoma. The savings in transportation costs were found to be five to fifteen cents per bushel, and the elevator could increase bids to farmers by four cents. Grain volumes were a very important consideration. With a load out facility cost of $2 million dollars, the break-even grain volume needed to go through the load out facility was about 7.5 million bushels.

Ethanol Studies

The increase in ethanol production has also had an impact on the grain marketing system through changes in corn production and the demand for transportation. In South

Dakota, corn production has doubled, with implications for changes in land use, crop production regions, and patterns of transportation. Because of its importance to transportation demand in South Dakota, some previous studies on ethanol will be reviewed in this section. However, there are not many studies that focus on the relationship between ethanol and its transportation demand specifically.

Denicoff (2007) provided an overview of ethanol supply and demand, current and projected ethanol transportation needs, infrastructure issues, and government biofuels activities at the national level. At the time of the study, rail was the primary mode for transporting ethanol with a 60 percent share, followed by trucks with a 30 percent share, and barges with a 10 percent share. Trucks were the main mode used for transporting corn to ethanol plants. An increase in corn production was predicted to have a mixed impact on transportation demand. Rail and barge demand could decrease if corn exports decreased, but increased ethanol and DDGS shipments could offset a decline in rail shipments in the short-term.

De La Torre Ugarte et al. (2007) assessed the future economic and agricultural impacts of ethanol and biodiesel expansion under different scenarios. Wilson et al. (2008) developed a spatial optimization model of world trade in grains to project cropping patterns and grain flows from ports as a result of ethanol expansion. Lee and Kennedy (2008) studied the price response of crop acreage to determine the impacts of ethanol expansion on U.S. agriculture. Yu and Hart (2009) conducted a survey of farmers, grain handlers, grain processors, and biofuel facilities regarding grain, biofuel, and co-product flows in Iowa during the 2006/2007 marketing year. Results showed that more corn was going to ethanol plants at the expense of exports, livestock, and food.

Thompson and Meyer (2009) examined the relationship between consumer demand for ethanol and ethanol transportation costs. The results showed that the types of blends purchased and the quantities of ethanol demanded are affected by changing benchmark prices for oil and ethanol in a non-linear way. These changes in the quantity of ethanol demanded also affect transportation expenditures. States, like those in the Midwest, that already have high levels of additive use were found to be less sensitive to changes in relative fuel prices.

Babcock (2010) examined the impact of increased ethanol production on transportation. He points out that most of the ethanol is used by California, Texas, and some eastern states, but most of the ethanol is produced in the Midwest. This shows the importance of transportation to the ethanol industry. At the time of the study, South Dakota had the fourth highest capacity and number of operating plants, comprising about nine and eight percent of the U.S. totals, respectively. Managers of Kansas ethanol production plants, managers of Kansas grain companies, and personnel of the railroads serving Kansas ethanol plants were interviewed and asked to fill out questionnaires. Results indicated that most of the ethanol was transported by rail (60 percent) while most of the DDGS were transported by trucks to feedlots in Kansas and surrounding states. Most of the transportation of corn was still handled by trucks, but more corn was being taken to ethanol plants.

Specific to South Dakota's ethanol production, Qasmi et al. (2009) used their survey of South Dakota grain elevators for the crop marketing year 2005-2006 to examine how the increase in ethanol production affected cropping patterns and grain marketing in South Dakota. South Dakota is one of the top ethanol producing states and used nearly 70 percent of its corn in ethanol production during the marketing year 2006-2007. The rapid expansion in ethanol production has caused several changes in the state regarding crop production and marketing flows. Qasmi et al. (2009) found a negative relationship between the amount of corn an elevator handled and that elevator's distance from an ethanol plant. Elevators located closer to ethanol plants were also found to have greater capacity, more likely to be located on a rail line, and have a larger loading facility on average. These findings suggest that increased ethanol production did not hurt the elevators' market share of corn handled as was found in other studies for different states such as Indiana (Dooley, 2006) or Iowa (Yu and Hart, 2009). However, the impact of increased ethanol production could be clearly seen through changes in major destinations for corn. The survey results indicated that local destinations within 30 miles accounted for 54 percent of the corn handled by elevators in marketing year 2005-2006 while only 24 percent of the corn went to local destinations in 1994-1995 (Qasmi et al., 2009). This meant that less corn was being shipped to the Pacific Northwest for export and more was being kept in state for ethanol production, consistent with the survey study results from Iowa (Yu and Hart, 2009) and Kansas (Babcock, 2010).

Railroad Studies Related to Pricing and Competition

Several studies were conducted on railroads after the Staggers Act of 1980, which deregulated the railroads. Many of these studies focused on the effects of deregulation on railroad rates or the competition between railroads and other modes of transportation. The following studies are just a small sample of the many studies on railroads that are available. These types of studies are important to note because they provide background information on the railroad industry and point out changes in pricing and competition in the industry over time. These changes are important in relation to transportation demand and the grain marketing system because transportation costs and available modes of transportation strongly influence grain marketing patterns. Studies on the competition between rail and truck are also directly relevant to South Dakota where barge is not a significant factor. Additionally, several of the studies used the Public Use Waybill Sample data for analysis, the same data that will be used in this research.

Michaels et al. (1982) examined a significant shift from rail to truck for grain transportation in Minnesota from 1970 to 1979. They reexamined the traditional model of competition between trucks and rail based on distance only and argued that the volume of grain shipped must also be considered along with distance when railroads are setting their prices. They validated this argument through the Minnesota case study. As trucks took some of the volume from rail, rail costs increased, so railroads raised their rates. This allowed trucks to compete at even greater distances, taking more of the rail business and causing rail costs and therefore rates to rise again. Michaels et al. (1982) argued that this cycle could have been partially avoided if railroads had only increased their rates to customers beyond the distance where per-unit costs for trucks and rail were equal.

Fuller et al. (1990) studied the effect of legislation passed in 1986 that required railroads to disclose contract terms on railroad grain rate levels. Their study region focused on the rail transportation market for wheat in the South and Central Plains including states such as Kansas, Oklahoma, and Texas. These states exported a significant amount of wheat by rail. To analyze this relationship, they used a regression model with railroad rates as the dependent variable. The rate measure used was revenue per ton-mile which was obtained from the Interstate Commerce Commission’s (ICC)

Public Use Waybill Files for 1983-1988. Some of the independent variables were also obtained from the Public Use Waybill including: short-line miles of haul, number of cars in the shipment, average number of tons per car in the shipment, region/state where the haul originated, and the day, month, and year of the shipment. Several control variables were also included as independent variables. Monthly hard red winter wheat exports were included as a proxy for hard red winter wheat demand. The data were obtained from the USDA *Grain and Feed Market News.* The supply of hard red winter wheat was also included as a control variable and was represented by the annual hard red winter wheat production and carryover which came from the USDA *Wheat Situation and Outlook* report. The supply of rail transportation service could also have an effect on rates so the annual capacity of the railroad industry's grain fleet obtained from *The Grain Book,* a publication of the Association of American Railroads (AAR), was used as a measure for railroad supply. Additionally, the AAR's monthly index of railroad costs was used to shift supply. A ratio variable was calculated to capture the potential favorable effect on rates and costs from the use of grain carrying capacity because a large portion of railroads' costs are fixed. Rail-transported grain shipments per month was included as the numerator, and the grain carrying capacity of the rail fleet was included as the denominator. Quarterly dummy variables were included to capture any seasonal changes in rates, and an annual trend was included to provide information on the region's rail rate trends. A dummy variable was included for the contract disclosure policy, and interaction terms between the disclosure policy and the annual trend and the disclosure policy and the state dummy variables were also included.

All of the variables were statistically significant at the 1% level except for rail supply and wheat supply. Distance of haul, number of cars per shipment, and mean tons per car in a shipment all had large negative effects on rates, as was expected. Monthly exports of wheat and railroad costs both had smaller, positive effects on rates. Results indicated that rates declined from 1981-1986 in the study region but increased by a significant amount after the contract disclosure legislation came into effect, suggesting that railroads were able to adjust their rates upward together because they did not have competition from other modes in the study region, and they knew what prices they faced from competitors.

Bessler and Fuller (2000) studied regional rail rate interactions between seven central plains wheat production regions that export to the Texas Gulf. In their analysis, the authors made use of Public Waybill data from 1988 to 1994. They used the rate data from the sample to calculate a monthly, volume-weighted average rate for their seven chosen Business Economic Areas (BEAs) which originated nearly all wheat exports to the Texas Gulf. The regions included parts of Kansas, Oklahoma, Colorado, and Texas. The results obtained from the data were useful in showing how the rail transportation markets were linked. Some regions were found to be highly independent with respect to rate-setting. Other regions were more interactive with rates established in other regions due to a variety of reasons including: rail market shares of different carriers in a region, railroads' aggressiveness in providing incentives for larger shipments, and the amount of storage and transshipment facilities in a region.

Wilson and Wilson (2001) used data from the Public Use Waybill file to develop an econometric model of rail rates for grains from 1972-1995. Explanatory variables used in the model to explain rail rates included: systemwide ton-miles, commodity ton-miles, the end-use value of the commodity, demand shifters, cost controls, a time index, and the regulatory regime. The effect of the Staggers Act on rates was found to be negative for all commodities studied (barley, corn, sorghum, wheat, and soybeans). Results also suggested that there were no productivity changes prior to deregulation, but because of the Staggers Act, there was a large improvement in productivity with increases that continued into the following years, causing rate reductions. However, these effects gradually disappeared, with most of the benefits realized after about ten years after the Staggers Act.

Harbor (2009) assessed the effect of competition on rail rates for shipments of corn, soybeans, and wheat. The study used Waybill data in a weighted least squares regression to estimate the effect of shipment distance, shipment tons, volumes between specific origin-destination points, a dummy variable for ports, an index for competition between railroads, number of miles to barge or port, and seasonal dummy variables on revenue per ton-mile for shipments of corn, soybeans, and wheat. Results showed that for corn, competition from railroads was more important closer to water, while for soybeans it was the opposite. Competition among railroads was not found to have any influence on rail rates for wheat.

Prater et al. (2010) measured changes in railroad market concentration since the Staggers Act using an inverse Herfindahl-Hirschman Index (HHI) for tons originated by crop reporting district (CRD) for four commodity groups which included grain and oilseeds, grain products including DDGS, food products, and fertilizers. South Dakota has only one railroad serving significant parts of the state and does not have close access to barge transportation. The study found that by 2007, South Dakota was paying more to ship grain per ton by rail than every other state except for Nebraska.

MacDonald (2013) examined railroad price discrimination during three separate time periods which included the late 1800s before the Interstate Commerce Act was passed, a period of thirty years during the mid-1900s when rates were regulated and railroads faced intense competition from other modes, and the twenty years after the passage of the Staggers Act in 1980.

Prater et al. (2013) developed a state-level statistical model to test what factors have been contributing to the decline in rail market share of grain and oilseed transportation. Most states have seen a decline in rail market share, but South Dakota was actually one of the states that saw a slight increase in rail market share of grain and oilseed transportation from the 2001 to 2004 average to the 2007 to 2010 average. To investigate the cause for these changes in market share, the authors developed a linear regression model. Twenty-one of the top grain and oilseed producing states were included in the model for the marketing years 2001-2010. The dependent variable was rail market share as a percent of grain and oilseed production by state and marketing year. Independent variables included in the model were conventional ethanol operating production capacity (million gallons/year) by state and calendar year, millions of gallons of biodiesel production by state and calendar year, average barge rate ($/ton) divided by average rail rate for grains and oilseeds (cents/ton-mile) by originating state and marketing year, average yearly on-highway diesel fuel price for a state's Petroleum Administration for Defense District divided by average rail rate for grains and oilseeds (cents/ton-mile) by originating state and marketing year, and average distance (miles) to ports on major inland waterways (Mississippi, Illinois, Ohio, Columbia/Snake rivers) or to export ocean ports by state. Other variables also included were the ratio of route miles of railroad track compared to route miles in 1974 by originating state and year, each state's contribution to total national grain exports (million tons) adjusted for surpluses and deficits related to animal feed requirements, estimated grain consuming animal units (millions) for milk cows, beef cows, sheep, poultry broilers, turkeys, and hogs by state and year, an index of crop prices weighted by the amount of each crop produced (bushels) in each state and marketing year, with the marketing year ending in 2001=100, the proportion of grain and oilseed moved by rail in more than 50-railcar shipments to total tons of grain and oilseed shipments by state and marketing year, and percent of total grain and oilseed production belonging to commodity *i* by state and marketing year. Commodities included soybeans, wheat, rice, cottonseeds, peanuts, flaxseeds, barley, oats, rye, and sorghum. Data came from a variety of sources, but the Confidential Waybill Sample was used for the tonnage of grain and oilseeds hauled by rail for each state by marketing year, shipment sizes, and rail rates. On-highway diesel prices were used as a proxy for truck rates because fuel makes up a large part of the cost and truck data are not readily available. The data came from the U.S. Energy Information Administration. Other sources of data included the USDA, the Renewable Fuels Association (RFA), the National Biodiesel Board, the Association of American Railroads (AAR), and the U.S. Census Bureau, Foreign Trade Statistics. Corn was not included in the model so that the issue of multicollinearity could be eliminated. The results indicated that ten of the variables had a significant influence on rail market share. Ethanol and biodiesel production and animal feeding were found to decrease rail market share while truck competition, exports, and shipment sizes were found to increase rail market share.

Studies on Transportation Demand

Several studies have estimated the demand for transportation, including railroads, trucks, and barges. Interest in the supply and demand of transportation is not a new research topic (see, for example, Benishay et al., 1966 and Miklius, 1967). Although there are different methods for estimating demand and demand elasticities, some of the same factors were considered in previous models. The studies were for different regions and commodities, but many of them considered cost functions, spatial price competition, service quality and performance characteristics, mode and destination choices, and shipment sizes among other important aspects.

Miklius et al. (1976) used a logit model to estimate the elasticities and cross elasticities for rail and truck transportation of 1972 cherry and apple shipments from the Northwest region of the U.S. Oum (1979a) utilized a derived demand model for rail and truck transportation with cost functions specified in a translog form for eight different commodity groups in Canada in 1970. Oum (1979b) also employed a derived demand model of Canada's freight transportation with a translog cost function from 1945 to 1974 to estimate the price elasticities and the cross elasticities between rail, truck, and water carriers. Friedlaender and Spady (1980) specified a similar derived demand model with a general translog cost function to estimate the demand for rail and less-than-truckload (LTL) shipments using a cross-section of 96 manufacturing industries in five different rail regions as given by the Interstate Commerce Commission (ICC) in 1972. Wilson (1984) also favored the derived demand model in the estimation of modal demand elasticities for rail and truck transportation of wheat and barley from North Dakota to Minnesota from 1973 to 1982. Inaba and Wallace (1989) implemented a mixed continuous/discrete choice model of rail, truck, and barge transportation demand for wheat in the Pacific Northwest in 1984. Wilson et al. (1988) specified a block-recursive equation system to first estimate a rail pricing equation and then estimate truck supply, truck demand, and rail demand for wheat transportation from North Dakota to Minneapolis and Duluth from 1973 to 1983. These are not all of the studies on transportation demand, but they represent some of the common articles cited in more recent studies.

Fitzsimmons (1981) used an approach that is more related to this research to estimate the demand for rail transportation of grain and soybeans. The purpose of the study was to determine price elasticities, cross elasticities (using barge transportation), and income elasticities of the demand for rail transportation. Ordinary least squares (OLS) was used to estimate the effect of the quantity of grain used for domestic consumption and exports, the rail freight rate, and the barge freight rate on the rail volume of grains. Because some of the data were expected to be collinear and cause high standard errors, the rail freight rate and the barge freight rate were replaced by the average rate level between the two types of rates and the ratio of the barge rate to the rail rate. Both annual and quarterly data were used in a model for different time periods from 1968 to 1979. The income elasticity for corn was greater than one, indicating that a one percent increase in corn use would cause rail volumes to increase by more than one percent. This was because more corn was used for feed and delivered by truck which was in contrast to wheat that was mainly transported by rail to distant end users. Price elasticities were found to be less than one, indicating inelastic demand for rail transportation of grains and soybeans. Cross elasticities found barge transportation to be a substitute for rail transportation, but barge rates were not found to have a major effect on rail volumes of grains and soybeans. However, corn movements by rail were found to be more sensitive to barge rates, which was consistent with the close proximity of the Mississippi River to the Corn Belt.

More recent transportation demand-related studies are available. Babcock et al. (1999) used a time series model to forecast quarterly railroad grain carloadings. They pointed out that carloadings are difficult to forecast because they are unstable and depend on the demand and supply of railroad transportation of grain. It was difficult to find data published quarterly for variables related to the demand and supply of grain rail transportation. Some of the data they did find were not highly correlated with grain carloadings, or they did not have the theoretically expected relationship. For this reason, they used a time series forecasting model with data from the fourth quarter of 1987 to the fourth quarter of 1997. The results obtained from the model show that some of the forecasts differ significantly from the actual grain carloadings quarterly, but that annually the model does a better job of forecasting short-term rail grain carloadings.

Miljkovic et al. (2000) used three-stage least squares to estimate a system of four equations which include the supply and demand for rail transportation of grain as well as the supply and demand for barge transportation of grain from the Midwest to the Gulf ports. Data included were monthly from January 1986 to November 1995. Rail data on rail rates, tonnage, and origin and destination points were obtained from the annual Carload Waybill Sample. The origin considered was Illinois while the destinations used were the Gulf States. Explanatory variables included in the model were barge rates (as a percent of tariff), barge shipments (tons), rail rates from Illinois to the Gulf (dollars per ton-mile), rail shipments from Illinois to the Gulf (tons), the corn price spread between the PNW and the Gulf (cents per bushel), total grain exports from the Gulf (tons), and seasonal dummy variables. Lagged dependent variables were also included in both supply and demand equations. Miljkovic et al. (2000) asserted that the current quantity of grain transported is related to past quantities because of delays caused by weather-related issues, the unavailability of rail cars or barges, and the time it takes price to adjust to differing expectations on rates and quantities.

The model was run with and without seasonal dummy variables. Not all of the seasonal dummy variables were significant, but they tested jointly significant. Excluding the seasonal dummy variables did not significantly change the results for the other variables. The relationship between price and quantity was found to be negative in both demand equations; however, it was only statistically significant for barge demand. Conversely, the relationship between price and quantity was found to be positive in both supply equations, but only statistically significant for rail supply. Exports were not found to be significant in the estimated supply or demand equations. Rail and barge modes were found to be strong substitutes. Lagged dependent variables were found to be positively associated with the dependent variables and statistically significant in all four supply and demand equations.

Dybing (2002) studied the demand for grain transportation in North Dakota by estimating demand elasticities for rail and truck transportation of hard red spring wheat, durum wheat, and barley from North Dakota elevators to Minneapolis and Duluth in

Minnesota. The study utilized a derived demand function which treated transportation demand as an input demand or derived demand that results from the production of and demand for grain. In this way, demand can be estimated by using the elevator's transportation cost function and including other factors such as elevator track capacity which indicates the quality of service, the length of haul which represents the distance to the destination, and a time variable to account for changes over time. The demand for rail transportation was found to be inelastic, which indicates that rail is the dominant mode of transportation in North Dakota. Based on the elasticities found, the elevators shipping greater quantities of grain were more likely to use rail. Additionally, elevators were more likely to use rail as the distance to the destination increased. This makes sense because trucks have higher variable costs per unit shipped. Therefore, the advantage of trucks is in shorter hauls because trucks have lower initial fixed costs.

Yu and Fuller (2005) measured the demand for grain barge transportation on the Mississippi River. While barge and rail are different forms of transportation, they are similar in some aspects, and some of the same types of factors influence the demand for each of them. The explanatory variables considered in the estimation of demand for barge transportation included barge grain rates, grain exports, regional supply of grain (measured by the amount of grain stocks in Minnesota and Iowa), domestic corn consumption, the rail rate for grain to the Pacific Northwest (PNW), the spread in ocean freight rates between the Mississippi Gulf and the PNW to Japan, the rail rate for Minnesota-originated grain shipped to upper Mississippi River elevators, a dummy variable for the winter quarter, and a dummy variable for river closures caused by floods. The data used were monthly from 1992 to 1999. Because previous grain shipments by barge can influence current barge demand, an autoregressive distributed lag model (ADL) was used with a partial adjustment. This means that lags of the dependent variable were included as regressors. Quantity of grain shipped by barge lagged one month and lagged twelve months were the lags included in the study because of the strong seasonal patterns displayed by grain barge movements.

Because barge rates, rail rates, and ocean freight rate spreads were expected to be endogenous, both OLS and 2SLS were used to estimate the parameters of the model. Lagged barge rate and the number of barges available on the river each month were included as instruments for the barge rate. Diesel price, the wage index for transportation and warehouse industries, and the lagged term of each variable were included as instruments for rail rates to the PNW, rail rates to the Mississippi River, and the spread between ocean freight rates. The Hausman test found that OLS was consistent in this case so it was preferred over 2SLS. The lags for quantity of grain transported by barge, grain barge rates, grain exports, rail rates to the Mississippi River, the dummy for winter, and the dummy for floods were all found to be statistically significant in explaining the demand for grain barge transportation. Grain barge rates were found to have a negative relationship with the quantity of grain transported by barge as expected. The own-price elasticity for grain barge demand was found to be inelastic in the short-run but elastic in the long-run. Grain exports were found to be positively and strongly associated with grain barge demand. Grain barge demand was found to be elastic with respect to grain exports. Rail rates to the Mississippi River have a negative relationship with grain barge demand. The winter season and floods reduce grain barge demand as expected.

Yu et al. (2006) conducted a very similar study, but they estimated the demand for grain barge transportation on both the Mississippi and Illinois Rivers using the Seemingly Unrelated Regression (SUR) estimation technique because barge demands on both rivers should be related. They also made use of some rail rate data from the Carload Waybill Sample and extended the study by two years. Rail prices, the corn price in Iowa, grain stocks in Iowa and Minnesota, ocean freight rate spreads, and water level were not found to be significant in explaining the demand for grain barge transportation on the Mississippi River, while previous shipments of grain by barges, grain exports, barge rates, winter, and floods were found to be significant. Results were similar for the model of the demand for grain barge transportation on the Illinois River except that even more of the explanatory variables were significant including the corn price in Illinois, ocean freight rate spreads, and the water level.

Train and Wilson (2006) derived spatially generated transportation demands by taking into account the effects of access costs on mode choice. The data used included information on grain shipments and grain shippers in eastern Washington obtained from a survey conducted in 2004. Results indicated that profits for rail were higher relative to barge, profits decreased with an increase in rates, increases in access costs to either rail or barge decreased the likelihood of using that alternative, and profits from rail were higher relative to barge for shippers that have a higher car loading capacity.

Henrickson (2011) utilized a model of spatial competition between grain elevators along the Upper Mississippi and Illinois Rivers to estimate transportation demand using interview data gathered by the Tennessee Valley Authority in 1994 and 1997. The model was specified several times using OLS, a pool-level fixed effects (FE) model, and a spatial autoregressive or spatial-lag model using maximum likelihood techniques. Annual ton-miles were explained by barge rates, transportation rates from farmer to elevator, alternative rates, distance to the nearest competitor, capacity, number of firms in the area, capacity of firms in the area, area production, proportion of shipments that are corn, and a dummy variable for large conglomerate firms. The estimated elasticity of barge demand was found to be negative and in the elastic region. Results also indicated that as farmers' transportation costs increase to an elevator, the quantity shipped by that elevator decreases. Increases in production area increased the amount of grain shipped by river elevators. Elevators which shipped a higher proportion of corn shipped more annual ton-miles. Elevators with higher capacity or elevators that were part of a large national conglomerate shipped more grain.

The study also aimed to uncover geographic patterns in elasticities along the rivers by using a model that included interaction terms between barge rate and river mile and an endogenous switch point model. This makes sense because farmers in different areas along the river may have different options (e.g., railroads). Using these methods, barge demand was found to be more elastic on the southern and northern ends of the Upper Mississippi River relative to the center while elasticity varied little on the Illinois River.

Most recently, Babcock and Gayle (2014) estimated a model of railroad grain transportation demand to obtain price elasticities and differences in rail demand between the east and west regions of the U.S. Corn, soybeans, wheat, and sorghum were the major grain crops studied. The authors used a two-region spatial equilibrium model. The general model included grain tonnage transported by rail of each of the four commodities for each of the two regions for each year as a function of rail rates, grain production, barge rates, a commodity fixed effect, a region fixed effect, and a time trend. An inverse relationship should exist between rail demand and rail rates. Grain production captures the derived demand for rail transportation. Barges are a substitute for rail and so their rates affect rail demand. The other three variables control for determinants of rail demand that are commodity-specific, region-specific, and time-specific and unobserved to the researchers. Data for rail tonnage of the commodities and rail prices came from the *Freight Commodity Statistics* published by the AAR. Data for grain production and barge rates came from the USDA. Data were collected for the period from 1965-2011.

Three variables were used as instruments for rail price when estimating demand: railroad labor cost, railroad diesel fuel price, and number of covered hopper railcars. This was because rail price was found to be endogenous, and ordinary least squares (OLS) estimates of the parameters were biased. The demand equation parameters were then re-estimated using the instruments for rail price with the generalized method of moments (GMM) estimation. In the results of the study, all variables had the theoretically expected signs and were statistically significant (except for sorghum). Barge transport was confirmed as a substitute of rail transport for grain with a barge rate elasticity of 0.48. Soybeans were found to have a lower rail demand compared with corn, while wheat was found to have a higher rail demand compared with corn. Region also had an effect in the model with railroad grain demand higher in the west region compared with the east.

Summary

Although South Dakota is a major agricultural state that has undergone significant changes in its grain marketing patterns, there have not been many studies specific to South Dakota and its demand for grain transportation. Lamberton (1977) and Lamberton and Rudel (1977) were some early studies on the grain marketing system and grain transportation in South Dakota. More recently, Qasmi et al. (2009) studied the impact of increased ethanol production on grain marketing flows in South Dakota. The State Rail Plan provided a snapshot of agricultural shipments for 2011 only (Cambridge Systematics, Inc. & Civil Design Inc., 2014). None of these studies have examined the impact of grain marketing factors on the demand for rail transportation in South Dakota over time.

One potential reason that there are limited studies is that sources of rail data are difficult to find. One source used in several of the studies was the Public Use Waybill Sample. A study by Informa Economics (2010) used this data to analyze rail rates for corn shipments over a time period of nine years. The study and others like it justify the use of the Public Waybill data in analysis. However, the study is only specific to corn and not specific to South Dakota over a longer time frame.

Understanding the grain marketing system, effects of increased shipment sizes, and the effects of ethanol production allows for the determination of factors that affect the demand for grain rail transportation in South Dakota. Qasmi et al. (2010) found the relative importance of rail in transporting just over half the grains and soybeans in South Dakota. Additionally, changes in destinations have occurred over time, with more corn going to processors in the state rather than to export markets and more soybeans being exported to the Pacific Northwest. An increase in total storage capacity of elevators combined with a decrease in the overall number of elevators pointed to a consolidation of the industry, which Lamberton and Rudel (1977) predicted would occur. Vachal (2012) found cereal grains to constitute a majority of the agricultural shipments in South Dakota and shuttle service to constitute over half of all rail shipments in South Dakota. Elevators stated rail capacity to be one of the important transportation issues to affect them in the future.

Vachal and Button (2003) found that shuttle rates could increase an elevator's draw area by 50 percent. Huang (2003) found that the decision to adopt a shuttle train depended on the elevator's own characteristics, competitive conditions, and agronomic characteristics including production density and variability. Denicoff (2007) showed that rail had an important share in transporting ethanol (60 percent). Yu and Hart (2009), Qasmi et al. (2009), and Babcock (2010) found increases in ethanol production in Iowa, South Dakota, and Kansas had the effect of diverting corn production in the states from livestock use and exports to ethanol production.

Fuller et al. (1990), Bessler and Fuller (2000), Wilson and Wilson (2001), and Harbor (2009) used Public Waybill data in varying studies on rail competition and rail rates. A number of factors were studied in their relationship to rail rates. Shipment sizes and competition were both found to be negatively associated with rail rates.

Finally, many studies estimated the demand for transportation. These studies varied by region, commodity, time period, mode of transportation, competitive effects, factors considered, and model used. Results vary by study depending on the region and modes of transportation available. Many of the recent studies have focused on the demand for barge in grain transportation. None of these studies are specific to rail transportation of major crops in South Dakota. This research aims to fill this gap by defining variables based on previous literature and using a demand model similar to that utilized by Babcock and Gayle (2014) to determine the demand for grain rail transportation in South Dakota with consideration of factors related to the grain marketing system, shuttle trains, ethanol production, and the competitive position of the railroads.

Chapter III. Research Design

In this chapter, the determinants that are most likely to affect rail volumes of different grains produced in South Dakota are selected based on findings from previous literature and the availability of data. The model is then specified based on these variables. Rail volumes of corn, soybeans, and wheat will be modeled because these three crops account for a majority of the cropland acres planted in South Dakota, and all three crops are commonly shipped by rail.

This chapter is divided into three major sections. The first section is a conceptual framework that provides an analysis of the research problem using economic theory. The next section specifies important variables and the model that will be used to determine the relationships between these chosen variables. The third and final section contains information on the data used and sources.

Conceptual Framework

Agricultural transportation is an important factor in the marketing process because many agricultural products are produced some distance from their end markets. Transportation costs constitute a major portion of the price producers receive for their grain (Casavant et al., 2011; Prater et al., 2010). Producers generally incur transportation costs to truck their crops from their fields to the nearest elevator or processing facility (such as an ethanol plant or soybean crushing facility). These facilities will also adjust the prices paid to producers according to their demand for grain and their own transportation costs to distribute the grain to end users. Therefore, higher transportation costs reduce the price received by producers because agricultural commodities are typically lower value, bulky goods.

The mode of transportation used depends on a number of factors including the distance shipped, the amount of crop production in an area, the type of crop, and relative costs and prices between competing modes for a particular shipment. In South Dakota, the two major modes of transportation are truck and rail. Rail competes with trucks to a certain extent, but the two can also be considered complementary. For example, corn may be trucked a short distance from a producer's field to an elevator, and then rail may be utilized to ship the corn a long distance from the elevator to an export market. Rail is generally utilized for larger shipments over longer distances because it becomes more fuel efficient than trucks after a certain distance depending on the relation between fixed and variable costs (Dybing, 2002; Michaels et al., 1982).

Although South Dakota has lost a significant portion of its rail network, rail still remains an important mode of transportation for agricultural commodities for the state. A majority of the soybeans and wheat produced in South Dakota goes to end users outside the state. Thus, significant portions of these crops are transported by rail to end destinations (Qasmi et al., 2010). Therefore, when production of these crops increases, rail volumes of these crops can be expected to increase. Production of soybeans and wheat can be captured as can quarterly beginning stocks. Other major factors that can be expected to influence rail volumes of soybeans and wheat in South Dakota include the price of rail and price offered for soybeans and wheat in South Dakota versus the prices offered in other places in the U.S.

Corn in South Dakota is a slightly different story. A high percentage of the state's corn production is utilized by ethanol plants in the state, which produce ethanol and co-products, such as distiller's dried grains (DDGS), which are used as feed for livestock.

While increased corn production may lead to higher rail volumes of corn being shipped, it depends on the amount of ethanol being produced in the state. Greater ethanol production would be expected to decrease the amount of corn being shipped out of the state by rail and increase the amount of ethanol and DDGS transported by rail instead.

These interesting dynamics have become increasingly important in South Dakota in recent years as the production of ethanol has increased substantially in a relatively short period of time, causing changes to grain marketing patterns in the state (Qasmi et al., 2009). Additionally, improved yields and more acres planted to corn, soybeans, and wheat have led to greater volumes of commodities produced and therefore increased demand for transportation. Corn, in particular, has seen a high increase in production at the expense of pasture, grasslands, and other crops (Luri, 2015; Qasmi et al., 2009; Wilson et al., 2008). Ethanol is a major driver of this change and must be considered in relation to transportation demand.

Model Specification

In order to estimate rail demand of commodities in South Dakota, three equations are specified, one each for wheat, soybeans, and corn. The soybean and wheat equations are similar as both commodities are regularly transported out of South Dakota to reach their markets.

Following the example of Babcock and Gayle (2014), the soybean and wheat regression models are each specified separately by the following equation:

Rail Volumes = *f*(*Rail Price, Stocks, Grain Price Ratio, Lagged Rail Volumes*)

where *Rail Volumes* are the total bushels of wheat or soybeans transported by rail during a quarter, *Rail Price* is the amount of money in dollars per bushel the railroads received for their service transporting wheat or soybeans during a quarter, *Stocks* are beginning stocks of either wheat or soybeans for each quarter in bushels, *Grain Price Ratio* is the crop price (wheat or soybean price in dollars per bushel) in South Dakota divided by the average crop price (wheat or soybean price in dollars per bushel) received in the U.S., and *Lagged Rail Volumes* are the bushels of wheat or soybeans that were transported by rail the previous quarter.

The equation for corn requires a slightly different treatment to account for the increase in ethanol production and DDGS and the effects on the demand for rail transportation. The corn regression model is specified by the following equation:

Rail Volumes = *f*(*Rail Price*, *Stocks-Feed Use*, *Ethanol Production*, *Grain Price Ratio, Lagged Rail Volumes*)

where *Rail Volumes* are the total bushels of corn and DDGS transported by rail during a quarter, *Rail Price* is the amount of money in dollars per bushel the railroads received transporting corn and DDGS during a quarter, *Stocks-Feed Use* is quarterly stocks of corn minus corn used for feed in bushels, *Ethanol Production* is the gallons of ethanol produced in a quarter, *Grain Price Ratio* is the South Dakota/U.S. price ratio for corn (the same measure as for wheat and soybeans), and *Lagged Rail Volumes* is the lagged dependent variable (same as for wheat and soybeans).

The main objective of this study is to explain rail volumes and to find a relationship between rail volumes and grain production. Therefore, rail volumes in bushels of each of the three major crops in South Dakota was determined to be the desired dependent variable. However, the corn model varied in that the tons of DDGS shipped by rail in each quarter were also added to the bushels of corn transported. To do this, tons of DDGS were converted into equivalent bushels of corn by taking tons of DDGS in a quarter, multiplying by 2000 pounds, and then dividing by 56 pounds (56 pounds in a bushel of corn). In the data set that was used, DDGS were not shipped by rail until about halfway through the sample period, so including them picks up on the effect of increased ethanol production.

Following Babcock and Gayle (2014), rail prices (rates) should be included as an explanatory variable because of the law of demand, which indicates an inverse relationship exists between price and demand. If the price for rail services increases, the demand for rail can be expected to decrease as shippers look to other modes of transportation (mainly trucks), which is reflected as a decrease in the amount of bushels transported by rail in a given quarter.

Based on the objectives of the study, as well as the model provided by Babcock and Gayle (2014), an explanatory variable needs to be included for grain production. The demand for rail transportation is a derived demand based on the supply and demand in the grain market, so grain production is a variable that can be used to capture these changes in the supply and demand of grain that may affect rail volumes. While Babcock and Gayle (2014) used annual grain production in their study, this research will utilize quarterly beginning stocks so that more observations can be added to capture usage in the state which is not typically transported by rail. However, annual grain production will be added to beginning quarterly stocks for the harvest quarter of each crop to account for a harvest effect. During the harvest quarter there is more grain available to transport. For all three models (corn, soybeans, and wheat), increased stocks are expected to increase rail volumes because of limited storage space and more grain available that needs to be marketed. For the corn model, corn used directly as feed for cattle and hogs in South Dakota is subtracted because it will not be transported by rail.

The corn model includes one additional explanatory variable, the gallons of ethanol produced in South Dakota in a quarter. Since DDGS are included as part of the dependent variable, ethanol production must be included to pick up the effect of increased DDGS shipments. Ethanol production itself is expected to have a negative effect on rail shipments of corn because more corn is trucked to ethanol plants rather than transported out of the state. However, an increase in shipments of DDGS caused by increased ethanol production could partially offset the decline in corn shipments because both corn and DDGS shipments are included in the dependent variable. Additionally, corn production was increasing at the same time that ethanol production increased. If the increased corn production more than compensated for the increased ethanol production, then there would be a greater amount of corn not utilized by the ethanol industry that would require rail transportation to out-of-state markets.

The price of the product being shipped by rail could also impact the demand for rail transportation. *Grain Price Ratio* is defined as the South Dakota price in dollars per bushel divided by the average U.S. price in dollars per bushel for corn, wheat, and soybeans in their respective models. This variable is used as a proxy for basis effects which determine whether the grain will be shipped out of the state or remain in the state. For example, if the price for soybeans at the South Dakota Soybean Processors plant in Volga, South Dakota is higher than surrounding states or export markets, more soybeans will be shipped to the plant, most likely by truck because it is a relatively short distance. If prices are higher elsewhere, more grain will leave the state. Therefore, the ratio of crop prices in South Dakota relative to the U.S. can be expected to have an inverse relationship with rail volumes. If *Grain Price Ratio* as a percentage increases, that means the price in South Dakota is rising relative to the U.S., so more grain would be expected to stay in the state and rail volumes would decline.

Finally, following the example of Yu and Fuller (2005), lagged rail volumes are included in the model. These are the bushels of corn and DDGS, wheat, or soybeans that were transported by rail during the previous quarter. The coefficient on this variable could have either sign depending on the quarterly rail pattern that may vary for each commodity. This variable was included to account for adjustments that take place over time and as a control to help correct for autocorrelation issues that are more fully discussed in the results section. Additionally, rail contracts may require that a certain amount be shipped each month, so lagged rail volumes capture some of this effect.

Data Collection

In this section, data used to estimate the empirical model are described. To estimate rail demand in South Dakota, rail volumes of wheat, soybeans, corn, and DDGS are used in this research. South Dakota has relatively high production levels of these particular commodities, and rail transportation is important as significant volumes leave the state and are therefore transported longer distances, causing a need for greater utilization of rail.

The empirical data for rail volumes were obtained from the Surface Transportation Board's (STB) Public Use Carload Waybill Sample. The Carload Waybill Sample "is a stratified sample of carload waybills for all U.S. rail traffic submitted by those rail carriers terminating 4,500 or more revenue carloads annually" (Surface

Transportation Board, 2015). This includes all Class I railroads, which are railroads with operating revenue of $467 million or more during 2013 (Association of American Railroads, 2015). This figure is adjusted for inflation each year. Some short line railroads (operating revenue less than $467 million) are also included in the Waybill Sample. This sample covers a majority of the rail lines in South Dakota because it includes all Burlington Northern Santa Fe (BNSF) lines and the old Dakota, Minnesota and Eastern (DM&E) line. BNSF owns almost 900 miles of the 1,851 miles of track in South Dakota, primarily in the eastern part of the state where most of the grain production occurs. It "is South Dakota's largest railroad by a number of measures, including miles of active track owned, South Dakota counties served, number of rail yards, most trains per day, and total volume of freight carried" (Cambridge Systematics, Inc. and Civil Design Inc., 2014). BNSF serves more than 60 grain facilities in the state. Also included in the Waybill Sample is the old DM&E line which runs from east to west through the center of the state and covers about 600 miles. In 2008, this line was bought by Canadian Pacific (CP), a Class I railroad, and in 2014, the line was sold to Genesee & Wyoming, a short line railroad holding company. The line is now called the Rapid City, Pierre, and Eastern (RCP&E). These two railroads cover most of the miles of rail line and most of the grain facilities located in South Dakota.

A waybill is a shipping document prepared by the originating railroad which contains specific information about a shipment such as the date of the shipment, number of carloads, weight, shipping charges, distance, origination, destination, and other relevant information. The Interstate Commerce Commission (ICC) started the first annual all commodity Waybill Sample in 1939, and the continuous sample started in

1946 (Wolfe and Linde, 1997). In 1981, the sampling methods were changed to improve the quality of Waybill data. Prior to 1981, the sample was only about one percent of shipments, and the waybills were sampled depending on their serial number. Beginning in 1981, the Machine-Readable-Input (MRI) format was used, so serial number had no effect on which waybills were chosen for the sample. "Under this method, a series of four random sub-samples from five strata are chosen based on the number of carloads listed on the waybill" (Wolfe and Linde, 1997). Sampling rates are higher for waybills with higher numbers of carloads. This new method allowed the sample size to increase to around three percent today, and expansion factors are utilized to obtain population estimates for carloads, tons, and revenue.

In 1996, the Surface Transportation Board (STB) took over the Waybill Sample. Less transportation data were collected after deregulation of the railroad industry because it was not needed for regulation purposes anymore (Wolfe and Linde, 1997). The Waybill Sample is therefore one of few transportation data sources left. Shippers, railroads, consultants, and federal and state agencies have used the Waybill Sample for several different purposes, including regulation and market research. "The Waybill is also used in the annual calculation of the statutorily-mandated Cost Recovery Percentage and as the basis for the Productivity Adjustment Factor for the Rail Cost Adjustment Factor" (Wolfe and Linde, 1997).

There are two separate files of Waybill data: the Confidential file and the Public Use file. The Confidential file contains more fields of information and is usually only accessible to government organizations. The Public Use file is "a truncated version of the Master Waybill Sample that excludes fields showing railroad, detailed equipment ownership, and detailed geographic information" (Wolfe and Linde, 1997). This file is available for certain years on the STB's website for anyone to use.

The Confidential file includes more detail on the origins and destinations by including state and county, while the Public Use file only lists origination and termination points by economic area. An economic area is defined by the Bureau of Economic Analysis as a metropolitan area and surrounding counties that are economically related based on commuting patterns (Johnson, 1995). In this thesis, these areas are referred to as economic areas, but due to inconsistencies between different sources they may also be called business economic areas (BEAs). "A BEA is only reported if there is activity for at least three FSACs [Freight State Accounting Codes] on one railroad for a given commodity within that BEA, or if there are at least two more FSACs with activity than there are railroads in that BEA for a given commodity" (Surface Transportation Board, 2015). Records that do not pass this rule are still included but without geographic information to protect competitive interests. Only about half of the waybill records have full geographic information.

In South Dakota there are three major economic areas currently defined as: 114, which is Aberdeen and includes the northeast and north central parts of the state; 115, which is Rapid City and includes all of western South Dakota as well as one county each in Montana and North Dakota and three counties in Nebraska; and 116, which is Sioux Falls and includes the southeast part and some of the north east part of the state as well as a few counties in Iowa, Minnesota, and Nebraska. Economic area 112, which is centered around Bismarck, North Dakota, also includes one county in South Dakota, and economic area 117, which is Sioux City, Iowa, also includes a few counties in South

Dakota. However, for this analysis, only economic areas 114, 115, and 116 will be included since they cover the majority of South Dakota. Including 117 could also potentially overstate rail traffic in South Dakota since Sioux City is a large rail hub and Iowa has high grain production.

These current economic areas were first used beginning in 1996. Prior to 1996, the economic areas were slightly different because they had been defined in 1977. Since there was a span of nearly 20 years between redefinitions of the economic areas, they are slightly different in the first part of the data set from 1991-1995. During this earlier time frame, the three main economic areas were 146 (Rapid City), 147 (Sioux Falls), and 148 (Aberdeen). While these three areas were not exactly the same, including a dummy in the models did not significantly affect the results and did not improve the fit of the model so it was dropped.

The Confidential file also includes the names of the railroads involved and an estimate of the variable cost incurred by the railroad for each leg of the move, while the Public Use file does not disclose that information. The Public Use file uses the five-digit Standard Transportation Commodity Code (STCC) to identify the commodity for each shipment while the Confidential file more specifically uses the seven-digit STCC. However, even at the five-digit STCC, shipments of corn, soybeans, wheat, ethanol, and DDGS can easily by identified. While the Public Use file contains most of the same records as the Confidential file, some waybill records are excluded if a commodity was not handled by at least three Freight State Accounting Codes (FSACs) in the U.S.

A few issues have been identified in using and interpreting the Waybill Sample. After deregulation of the railroad industry, contracts became more common. Because of railroad industry concerns about releasing sensitive contract rate data which could affect competition, "railroads were allowed to disguise their contract revenues through factoring them by a scalar value at the three digit STCC level" (Wolfe and Linde, 1997). This change began in 1986, so data on revenues before this time are not directly comparable to more recent years. Revenues could be overstated or understated depending on which factor the carrier uses to mask its contract revenues. Additionally, not all carriers use a contract factor because they are not required to, although it has been estimated that two-thirds of all waybills do utilize this method (Wolfe and Linde, 1997).

Other issues include multiple car reporting, which has increased significantly since 1981, freight rate statistics based on billed rather than actual lading weights, rebilling of deregulated traffic, which can cause an overstatement of tonnage and an understatement of the length of haul, and high occurrence of one box to one car billing of intermodal traffic even when the car contained more than one platform (See Wolfe and Linde, 1997 for further detail regarding these issues.) However, for the purposes of this study the Waybill data should be sufficient.

The primary rail data used in this thesis come from the Public Waybill Sample for the years 1991-2013, so all of the years should be comparable as they occurred after the years when major changes were made in the sampling procedures. Additionally, this study is not looking to analyze rail rates, so the fact that the revenue data are masked is not a major issue. Complete Waybill data for the entire U.S. for each calendar year were sorted first by origination and then termination economic area to obtain all records of shipments originating or terminating in the state of South Dakota (economic areas 114, 115, and 116, or 146, 147, and 148 as previously mentioned). The South Dakota data were then sorted by commodity and date. Approximately 6,000 corn observations, 5,000 wheat observations, 3,000 soybean observations, and 1,500 DDGS observations were aggregated into quarters. Quarterly data capture seasonal changes in the relationships and allow the relationships to change over short periods of time. Quarterly data were used rather than annual data to add observations and improve the model.

Quarters are defined as March-May(1), June-August(2), September-November(3), and December-February(4). The data start in Quarter 1 (March – May) of 1991 and go through Quarter 3 (September – November) of 2013. However, the first quarter of 1991 is dropped because lagged rail volumes are used as an independent variable. Rail volumes were given in tons in the Waybill data, but tons were converted to bushels for this study because most of the explanatory variables were also in bushels.

Beginning stocks by quarter of corn, wheat, and soybeans for all storage positions were considered to explain rail volumes. Total production for the year was added to beginning stocks for the harvest quarter (September-November for corn and soybeans and June-August for wheat) to capture increased flows of grain at harvest time. These data are available from USDA-NASS in their quarterly *Grain Stocks* reports and annual *Crop Production* summaries as well as through NASS *Quick Stats*. Additionally, corn used for feeding cattle and hogs in the state was subtracted from the stocks for each quarter in the corn model. Since cattle and hogs are the main users of corn in South Dakota, the pounds of cattle and hogs produced each year were found by using data from USDA's *Meat Animals Production, Disposition, and Income* report which comes out in April. The data were then cross-referenced with an article on corn use in South Dakota (Brown and Diersen, 2015) to estimate how much corn would be needed for the pounds of animals produced each year. The data were then divided by 12 and allocated into the respective quarters. Feed use was subtracted from stocks because if it was corn that was used for feeding the animals produced in the state, it would not be shipped out of the state by rail. *Stocks-Feed Use* is the stocks variable plus production in the harvest quarter minus feed use from every quarter.

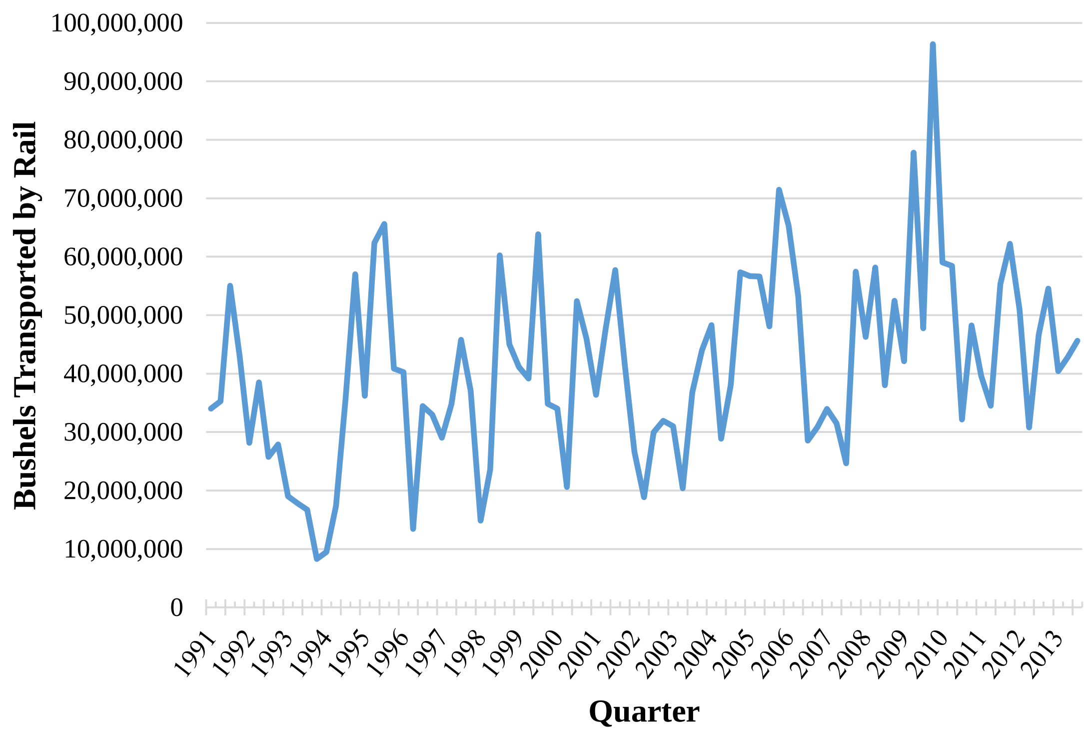
The amount of ethanol produced in gallons was then included as a separate variable in the corn model. Ethanol production data came from the South Dakota Department of Revenue. The data were monthly but only went back to June 1995. Prior to 1995, not much ethanol production occurred in the state, and it was relatively constant each quarter, so a constant amount of 3,000,000 gallons was assumed. This was approximately the same amount of ethanol produced at the beginning of the data series, and ethanol production capacity did not change substantially prior to that time. When the data series began in June 1995, the gallons for each month in a quarter were added together to come up with a quarterly amount of ethanol produced in the state.

When considering demand for rail, the price of rail must also be considered. The Public Waybill data included a field for total revenue earned by the railroad on each shipment. This was used as a proxy for the price of rail service. For wheat and soybeans, the total revenue each quarter was divided by the bushels shipped that quarter to determine a price per bushel. For the corn model, total revenues for corn and DDGS were added for each quarter and then divided by the total bushels of corn and corn equivalent bushels of DDGS shipped that quarter to determine a price per bushel.

Monthly prices received for corn, soybeans, and wheat were obtained from USDA-NASS *Quick Stats* for both South Dakota and the U.S. as a whole. An average was taken for the monthly data for each quarter to obtain quarterly data from 1991-2013. South Dakota prices for each quarter were divided by U.S. prices for each quarter to obtain a ratio of the South Dakota price relative to the U.S. price.

Figures 3.1 to 3.3 show the bushels of corn along with corn-equivalent bushels of DDGS, soybeans, and wheat transported by rail each quarter from 1991-2013 in South Dakota. These figures display the variation in the dependent variable for each model for the duration of the data series. Over this time frame, typically more bushels of corn were shipped by rail compared with soybeans and wheat. The addition of corn-equivalent bushels of DDGS slightly increased the corn bushels shipped by rail beginning in the first quarter of 2001. Prior to that quarter, the sample did not record any rail shipments of DDGS for South Dakota.

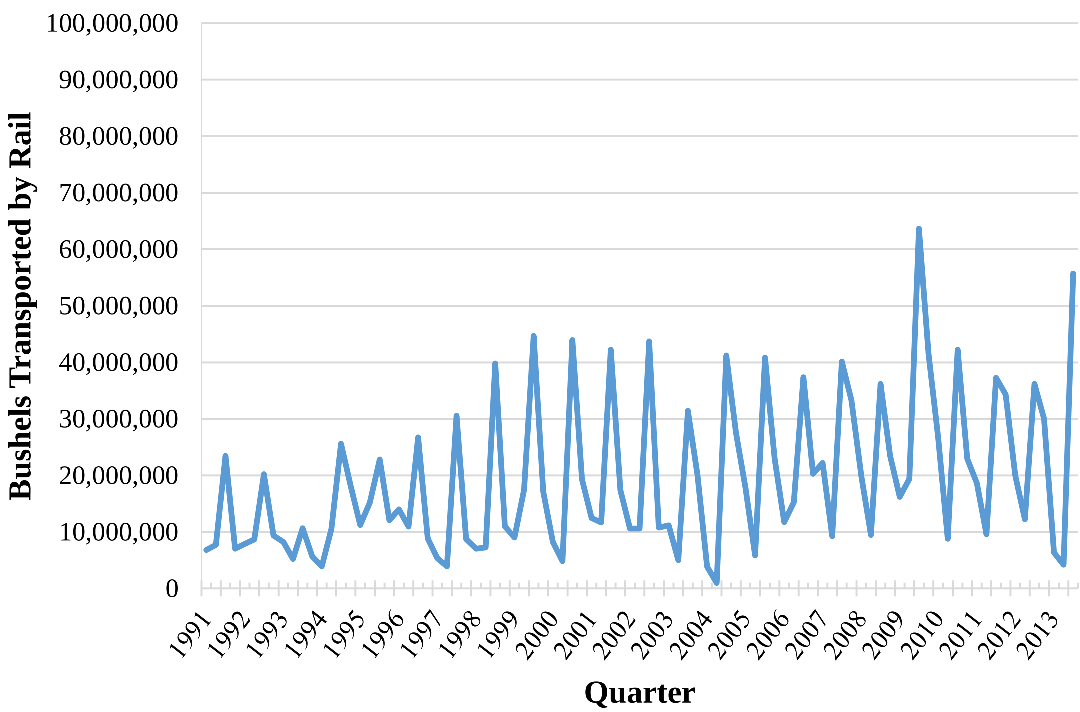
Figure 3.1. Bushels of Corn and DDGS Transported by Rail in South Dakota from 1991-2013



Source: STB Public Use Waybill Sample

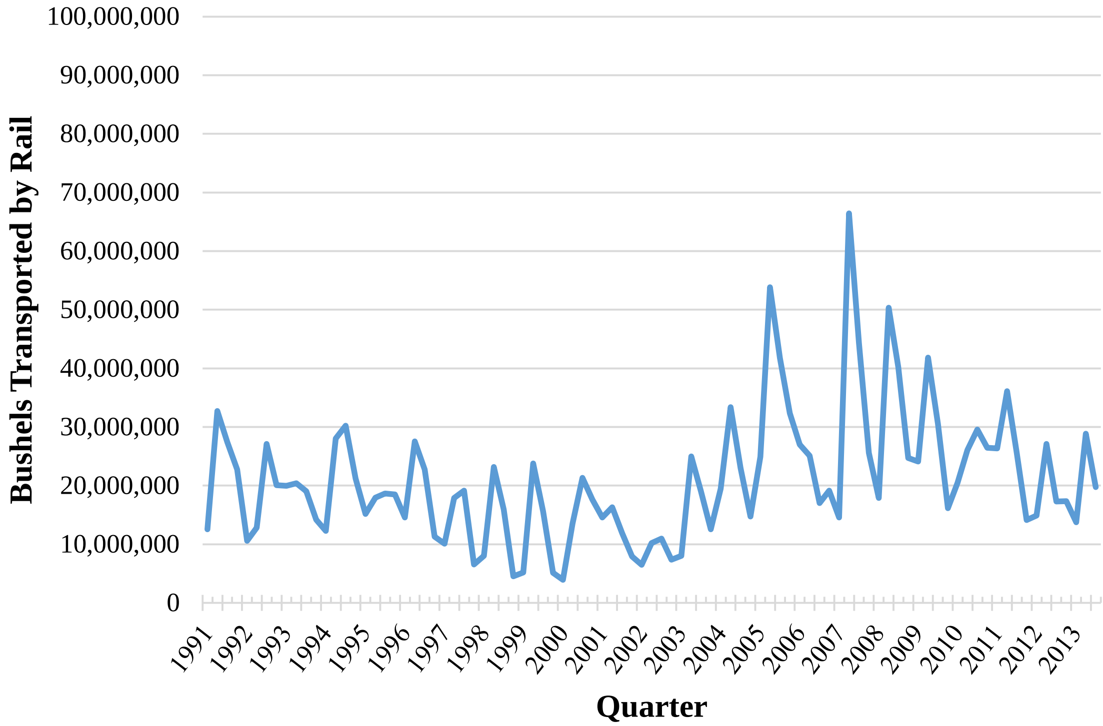
All three commodities appear to display some seasonal or quarterly patterns. Volumes of soybeans shipped by rail remained relatively constant with normal oscillations over the time period based on this data set. The third and fourth quarters usually have the most bushels transported by rail, which is consistent with moving more grain and soybeans during and immediately after harvest when there is a larger volume of the crops available. Wheat volumes decreased slightly, then increased sharply before decreasing again. Variability increased with time. Wheat was often shipped in high volumes during the second quarter which is consistent with an earlier harvest quarter for wheat compared to corn and soybeans. Overall, the volumes shipped by rail do not appear to display strong trends over this sample period, although all three commodities ended the data period at a higher value than what they started.

Figure 3.2. Bushels of Soybeans Transported by Rail in South Dakota from 1991-2013



Source: STB Public Use Waybill Sample

Figure 3.3. Bushels of Wheat Transported by Rail in South Dakota from 1991-2013



Source: STB Public Use Waybill Sample

Summary statistics for each of the variables in the corn, soybean, and wheat models are provided in Table 3.1. The table includes the mean, standard deviation, number of observations, minimum value, and maximum value for each variable. Over the time period studied, corn and DDGS have the largest mean of bushels transported by rail followed by wheat and then soybeans. Corn also shows slightly more variation based on a relatively higher standard deviation.

Rail revenue per bushel is used as a proxy for rail price. The mean is similar for corn, soybeans, and wheat at about $0.80 per bushel. Soybeans show the most variability in price when comparing standard deviations of the three commodities. Corn may not be directly comparable however because some DDGS revenue data are included as well as corn equivalent bushels of DDGS which may be priced differently than corn itself. It is also important to remember that within the Public Waybill sample, railroads are allowed to mask their contract rates. Because real rail pricing data are very difficult to find and rarely available to the public, this measure of revenue per bushel was the easiest and most available way to proxy the real rail price even though it may not be the best nor most accurate measure. However, because this study is more concerned with the effects of other explanatory variables rather than rail price on rail volumes, this should be sufficient.

As previously mentioned, the demand for rail transportation comes from the volumes of grain or oilseeds that are available to be transported. It is not surprising, therefore, that the mean for corn stocks is the highest since the mean corn bushels transported by rail were also the highest. This is consistent with the large increase in corn production in South Dakota since ethanol production started to increase. The variation in corn stocks is also significantly higher relative to wheat and soybeans. Some of this variation can likely be attributed to changing marketing patterns and ethanol contributions.

The grain price ratio is highest for wheat; in fact, on average, the price for wheat in South Dakota in dollars per bushel is higher than the average U.S. price for wheat in dollars per bushel. Wheat and corn show more variability than soybeans because of their ability to be stored longer and greater changes in their demand. Corn and soybean prices in South Dakota are generally below the average U.S. price, which is consistent with a large supply in the area and some distance to final markets.

Table 3.1. Summary Statistics for Variables Used in the Rail Demand Models

	Corn	Soybeans	Wheat
Variables	Mean (Std. Dev.; N) [Min] {Max}	Mean (Std. Dev.; N) [Min] {Max}	Mean (Std. Dev.; N) [Min] {Max}
Rail Volumes (measured in millions of bushels)	41.10 (15.80; 90) [8.30] {96.40}	19.40 (13.50; 90) [0.98] {63.60}	21.10 (11.10; 90) [3.92] {66.40}
Rail Price (measured by rail revenue per bushel in dollars)	0.79 (0.21; 90) [0.39] {1.35}	0.81 (0.32; 90) [0.26] {1.55}	0.80 (0.23; 90) [0.48] {1.35}
Stocks (measured in millions of bushels)	279.00 (175.00; 90) [13.20] {820.00}	73.40 (47.80; 90) [11.10] {192.00}	91.90 (37.00; 90) [31.80] {180.00}
Ethanol Production (measured in millions of gallons)	83.70 (91.10; 90) [2.50] {263.00}	N/A	N/A
Grain Price (measured as a ratio of SD price in dollars per bushel to U.S. price in dollars per bushel)	0.92 (0.04; 90) [0.80] {1.05}	0.96 (0.02; 90) [0.91] {1.00}	1.02 (0.05; 90) [0.89] {1.15}
Lagged Rail Volumes (measured in millions of bushels)	40.90 (15.80; 90) [8.30] {96.40}	18.80 (13.00; 90) [0.98] {63.60}	21.00 (11.10; 90) [3.92] {66.40}
Average Number of Cars per Shipment	54.03 (23.38; 90) [15.62] {96.80}	54.74 (28.37; 90) [12.00] {103.91}	25.30 (8.99; 90) [8.50] {52.90}
Truck Rates (measured by a producer price index with a base of June 1992)	116.12 (14.67; 90) [98.10] {144.30}		
Quarters (total of 90)	Quarter 2 of 1991 to Quarter 3 of 2013		

Notes: Rail Volumes and Rail Price for Corn include DDGS data.

As previously discussed, lagged rail volumes are included as a control to help with autocorrelation issues which are often present in time series data. This is rail volumes from the previous quarter, so the sample statistics are very similar to the unlagged rail volumes.

Average number of cars per shipment and truck rates are included as instruments for rail price when estimating demand. The necessity for instruments will be discussed further in the results section, but a brief explanation of the variables and how the data were obtained is provided here. The average number of cars per shipment comes from the Public Waybill Sample just like the rail volumes and rail revenues. Each waybill entered gives a number of cars that were in the shipment. These waybills were separated by date into their respective quarters. Then all of the cars on the waybills in a quarter were added and averaged based on the number of shipments there were that quarter. As Table 3.1 shows, corn and soybeans shipments tend to contain more carloads than what a wheat shipment would contain. This is consistent with the anecdotal evidence that most soybeans and corn transported by rail out of South Dakota travel long distances to export ports while wheat will generally be shipped east to flour mills by Minneapolis, MN or Chicago, IL. This variable picks up on the evolution of shuttle trains which are more efficient and provide a lower price for a longer distance hauled.

Trucks are the biggest competition railroads face in South Dakota for transporting agricultural products. The data for the Truck PPI variable used in this study come from the U.S. Bureau of Labor Statistics (BLS). “The Producer Price Index (PPI) program measures the average change over time in the selling prices received by domestic producers for their output” (U.S. Bureau of Labor Statistics, 2015). The base year for this particular PPI is 1992, specifically June. The data series displays an upward trend over the time period studied, with the only decrease coming after the 2008 recession with a steady climb resuming as the economy began to recover. The summary statistics do not provide much information except for the fact that prices for truck service were nearly 50 percent higher near the end of the sample period than they were at the beginning, which can mainly be attributed to a rise in diesel prices that constitute a majority of truck costs.

Chapter IV. Empirical Results

In this chapter, separate results are provided for the corn, soybean, and wheat rail demand models. First, ordinary least squares (OLS) results are reported. Endogeneity issues are addressed, and instruments are defined and further explained. Finally, the generalized method of moments (GMM) results are provided as appropriate. All results were found using the data analysis and statistical software program Stata.

OLS Estimation

Results from ordinary least squares (OLS) estimation are reported in Tables 4.1, 4.2, and 4.3 for corn, soybeans, and wheat rail demand in South Dakota from the second quarter of 1991 to the third quarter of 2013. The results of the OLS estimation for the corn equation listed in Table 4.1 were not entirely as expected. The coefficients on *Ethanol Production* and *Rail Price* are not statistically significant, and the coefficient on *Rail Price* was expected to be negative, but it is positive in these results. The coefficients on *Stocks* and *Grain Price Ratio* are statistically significant at the 10% level while the coefficient on *Lagged Rail Volumes* is significant at the 1% level.

Table 4.1. OLS Estimated Parameters (Corn)

Variable	Coefficient	Standard Error	T-statistic
Rail Price	8,588,466	1.50E+07	0.57
Stocks-Feed Use	0.017291*	0.010363	1.67
Ethanol Production	0.030233	0.034514	0.88
Grain Price Ratio	-77,900,000*	4.09E+07	-1.91
Lagged Rail Volumes	0.311595***	0.098543	3.16
Constant	85,800,000**	3.91E+07	2.20

Notes: This estimation had 90 observations. R^2 for this model was 0.35. *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

The positive sign on the *Stocks* coefficient is consistent with expectations that increased stocks mean more corn is available to transport by rail. The negative sign on the coefficient for *Grain Price Ratio* is also as expected. As the ratio rises, the price of corn in South Dakota is increasing relative to the U.S. average, so more corn is marketed in the state rather than being transported out of state by rail to export markets or other end users.

It is not surprising that rail volumes from the previous quarter are significant in explaining the current quarter's shipments. However, it was not clear what sign the coefficient should be expected to have. In these results, the positive sign on the coefficient for *Lagged Rail Volumes* suggests that increased rail volumes of corn and DDGS shipped the previous quarter means an increase in rail volumes in the current quarter. This indicates momentum effects in the marketing of corn and DDGS. Corn can be stored for longer periods of time to be marketed and transported when corn prices are higher, which indicates a stronger demand for corn. These marketing patterns vary throughout the year based on export needs, ethanol production, and livestock numbers. The transportation needs may also be transferred to trucks depending on the destination market and the relative prices between the two modes.

Table 4.2 presents the OLS estimation results of the soybean model for rail demand in South Dakota. Like the results from the OLS estimation of the corn model, these results do not show all the expected relationships. However, this OLS estimation for soybeans does have a much higher R-squared and Adjusted R-squared relative to the results for the corn equation.

Table 4.2. OLS Estimated Parameters (Soybeans)

Variable	Coefficient	Standard Error	T-statistic
Rail Price	5,316,859**	2.52E+06	2.11
Stocks	0.245942***	0.014790	16.63
Grain Price Ratio	29,400,000	3.68E+07	0.80
Lagged Rail Volumes	-0.102817**	0.048378	-2.13
Constant	-29,100,000	3.49E+07	-0.83

Notes: This estimation had 90 observations. R^2 for this model was 0.85. *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Most of the explanatory variables are statistically significant. The coefficient on *Stocks* is significant at the 1% level and with the expected positive sign. *Stocks* possess much of the explanatory power in this equation, suggesting that the soybean rail demand strongly depends on the amount of soybeans available in stocks.

The coefficient on *Rail Price* is significant at the 5% level, but the sign is unexpectedly positive. This does not agree with the theory of a demand relationship. There are several reasons why this sign could be positive rather than negative as expected. First, it could be suggesting that the soybean shippers' demand for rail is inelastic, or unaffected by price changes. If price increases, the demand could stay the same or increase depending on the amount of soybeans that need to be shipped. This is because the majority of soybean rail shipments that leave South Dakota are transported to the Pacific Northwest (PNW) for export. Most soybeans from South Dakota that are not processed by South Dakota Soybean Processors in Volga go to the PNW because of the strong demand for soybeans from other countries. The window for exports is narrow because of the timing of South America's soybean harvest, which provides strong competition for U.S. soybean exports. Rail is the most efficient transportation option for transporting South Dakota's soybeans to the PNW. Trucks are not fuel or cost efficient over such a great distance, and they cannot haul as much as a unit train. Therefore, soybean shippers have few other options for transportation to export markets.

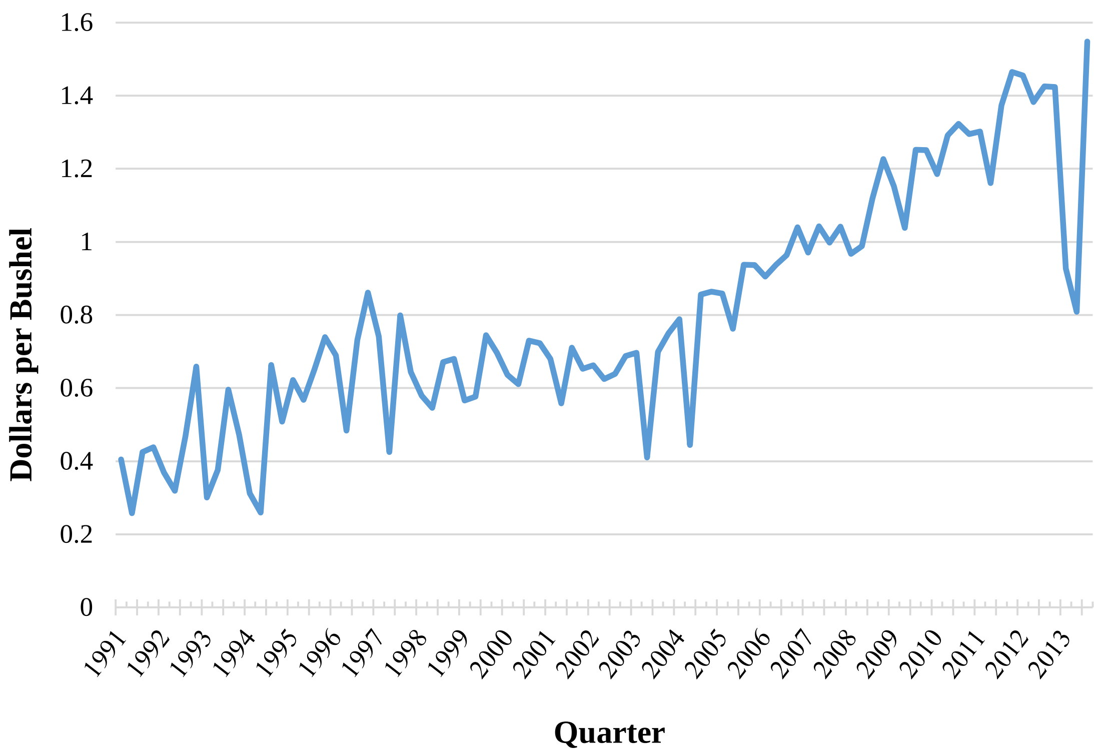
Additionally, rail prices could be increasing over time because it costs more to transport commodities longer distances. The trends in distances shipped are not considered in this model, but the distance has been increasing as more soybeans are transported to the PNW for export, increasing costs for the railroads and therefore prices for rail service. At the same time, soybean production and exports have increased, so rail volumes are also increasing.

Another reason that the sign on *Rail Price* is not as expected may be because of the data that were used. As previously discussed, rail revenue data included in the Public Waybill Sample were used as a proxy for rail prices. Rail revenues may not be a good measure for the rail price, especially considering that railroads are allowed to mask their contract rates.

The data for rail volumes show that there is a quarterly pattern that is based on the production cycle of soybeans in South Dakota. Most of the peaks in the data are high volumes of soybeans being transported by rail in the third quarter, which is also the harvest quarter. This coincides with stronger demand for soybean exports from the U.S. when South American soybeans are in the planting and growing season. Rail demand appears to have increased slightly from the beginning of the data set to the end, but most of the time it stayed relatively consistent with quarterly oscillations.

In Figure 4.1, rail revenue per bushel, the proxy for *Rail Price,* is plotted over the sample time period. According to this data set, there is a clear increasing trend in the amount of revenue railroads receive from soybean shipments. Diesel prices, which are a large factor in railroad costs, were also trending up over this time period as were labor costs, so this is not entirely unexpected even if the revenues are masked. It is interesting to note that most of the quarterly dips in the trend occurred in the second quarter suggesting the effects of lower demand as most soybeans would have already been marketed to prepare for the new crop that would be harvested in the third quarter.

Figure 4.1. Rail Revenue per Bushel for Soybeans from 1991-2013



Source: STB Public Use Waybill Sample

The coefficient on *Lagged Rail Volumes* is also significant at the 5% level. A negative sign suggests that an increase in bushels of soybeans shipped the previous quarter will cause a decrease in the bushels shipped during the current quarter. This smoothing effect is different from the result found in the estimation of the corn equation. Again, this is consistent with the export story, as soybeans are transported by rail relatively quickly after the harvest to fill export needs, which depletes the supply of soybeans to be transported until the next harvest.

Finally, the estimated coefficient on *Grain Price Ratio* was not statistically significant and did not have the expected sign. This ratio was fairly constant over the sample time period, and therefore was not able to explain much of the variation in bushels of soybeans transported by rail.

Table 4.3 presents the results for the OLS estimation of the wheat model for rail demand in South Dakota. This model has a higher R-squared than the corn model, although it is not as high as that of the soybean model. The wheat model has the same significant variables as soybeans and some of the same model concerns.

Table 4.3. OLS Estimated Parameters (Wheat)

Variable	Coefficient	Standard Error	T-statistic
Rail Price	7,189,542*	3.94E+06	1.83
Stocks	0.175061***	0.022819	7.67
Grain Price Ratio	8,126,848	1.92E+07	0.42
Lagged Rail Volumes	0.455578***	0.076075	5.99
Constant	-18,600,000	1.85E+07	-1.01

Notes: This estimation had 90 observations. R^2 for this model was 0.56. *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Similar to the results for the soybean equation, stocks are also highly significant in explaining rail volumes of wheat. The coefficient on *Stocks* is significant at the 1% level and has the expected positive sign.

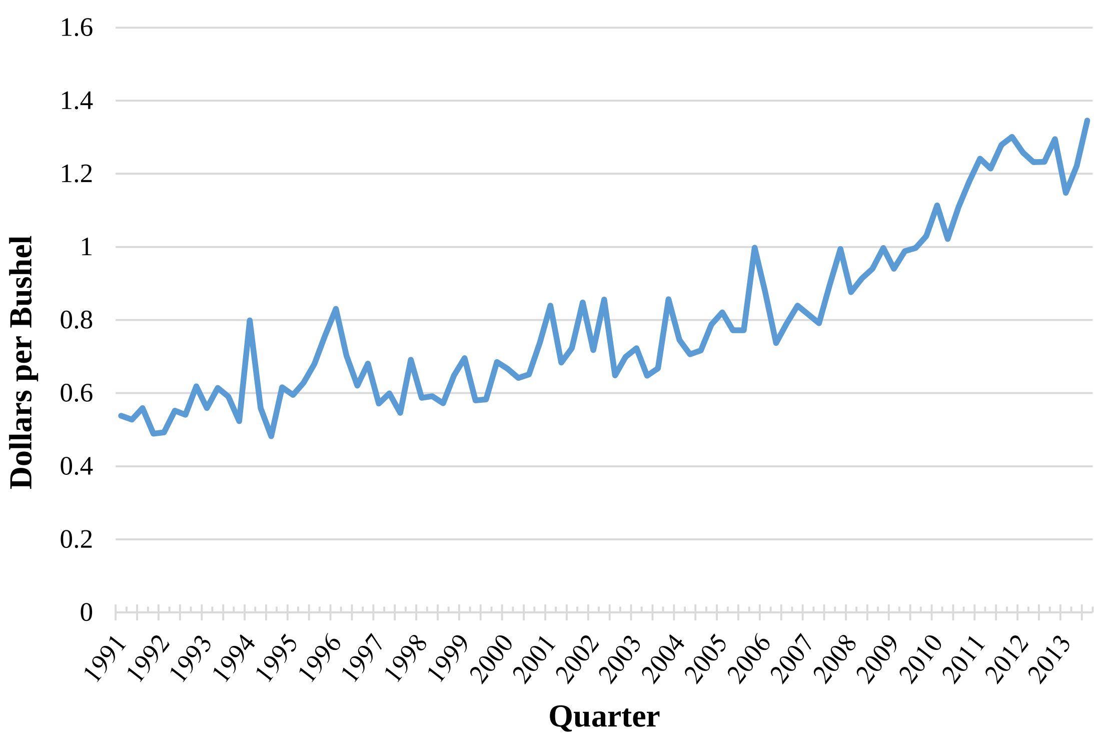
The coefficient on *Rail Price* is significant at the 10% level, but it does not have the expected negative sign as demand theory would suggest. This is the same issue observed in the soybean results, but it is not as easily explained since wheat is marketed differently than soybeans. It may be the data used because the rail revenues are masked. It could also be that the distances to final destinations for wheat shipments have increased or that wheat shippers' demand for rail is fairly inelastic as with the soybean shippers.

From the data on rail volumes transported in South Dakota, the quarterly pattern for bushels of wheat transported by rail is not as strong as that seen in soybeans. Typically the highest volumes of wheat shipped by rail occur in the second quarter (the harvest quarter) and sometimes during the third quarter. Wheat shows less variation than soybeans in the bushels transported from quarter to quarter, but over time the variation in the bushels of wheat transported from quarter to quarter increases. The total bushels of wheat transported by rail decreases slightly during the first part of the data set, then increases sharply before decreasing again. Some of this variability can be attributed to the variability of wheat production in South Dakota which has not increased as corn and soybeans have over the sample time period. This is reflected in the close relationship of rail volumes of wheat with stocks.

Figure 4.2 plots the amount of revenue railroads received per bushel of wheat transported according to the Public Waybill Sample over the time frame from 1991-2013. Revenue per bushel is the proxy for *Rail Price* and shows an upward trend over this time period just as it did for soybeans. The relationship between rail revenues and the volumes of wheat transported by rail is not well defined, suggesting either that masked rail revenues are not a good proxy for the actual price of rail service or that the wheat demand for rail transportation is inelastic and dependent on other factors such as distance to final markets or the amount of wheat requiring transportation.

The coefficient on *Lagged Rail Volumes* is highly significant at the 1% level and positive as it was for corn. This suggests that increased bushels of wheat transported by rail during the previous quarter correspond to an increase in the bushels of wheat transported by rail in the current quarter. Similar to corn, this result indicates a momentum effect in the marketing of wheat, which can be stored longer than soybeans and transported by truck to final markets.

Figure 4.2. Rail Revenue per Bushel for Wheat from 1991-2013



Source: STB Public Use Waybill Sample

Finally, the coefficient on *Grain Price Ratio* is insignificant and has an unexpected positive sign, which is the same result observed in the OLS estimation of the soybean equation. The ratio of the wheat price in South Dakota compared to the average wheat price in the U.S. does not appear to be a good measure of basis as it does not contain enough variation to measure any relationship with wheat rail volumes.

Testing for Endogeneity and Using Instruments

As stated earlier, it is necessary to include rail price in the model because of the law of demand which states that, all else being equal, as the price of a product increases, quantity demanded falls, and vice versa. According to economic theory, prices that producers set affect consumer demand, but consumer demand may also influence the prices that producers set. For example, in the grain rail demand model, if the railroad (the producer in this case) sets a high price for transporting grain, grain shippers (consumers) may try to store the grain longer or find a cheaper alternative for transportation (e.g., trucks). On the other hand, if the railroad is seeing high demand from grain shippers (e.g., at harvest time), they may need to raise their prices because they cannot handle all the grain at once. If demand for grain shipments is low because the grain supply is low right before the next harvest, railroads may lower their prices to incentivize grain shippers to get rid of their remaining supply.

Because both demand for rail and rail price have an impact on each other, rail price would be considered an endogenous variable in these equations. An endogenous variable is an explanatory variable that is correlated with the error term. This can occur for several different reasons including measurement error in the explanatory variables, an omitted explanatory variable, sample selection, autoregression with autocorrelated errors and simultaneity (or reverse causality) (Kennedy, 2008). Simultaneity is the problem in this case with grain rail demand. "If the error term in this equation bumps up it shifts the demand curve and so through its simultaneity/intersection with the supply curve changes the price" (Kennedy, 2008). This means that price may be correlated with the demand curve errors through the supply and demand system of equations. This is a problem because when price is endogenous, “applying ordinary least squares to the estimation of the [demand] equation will generate biased and inconsistent estimators” (Pindyck and Rubinfeld, 1991).

Because of this issue, all three equations were tested for endogeneity bias. In order to test for endogeneity using the Hausman test, two different instruments were identified. The requirements for an instrument are that it is a new variable that is correlated with the endogenous variable but uncorrelated with the error term. As mentioned in the previous chapter, the two instruments used are *Truck PPI*, a producer price index used as a proxy for the price for truck transportation, and *Cars*, the average number of cars per shipment in a quarter. Truck prices and rail prices can be expected to have a positive relationship because they have some of the same cost components, such as labor and diesel fuel, which affect their cost structures. Additionally, since they are competing with one another, each of them will make price changes based on what the other is doing. For example, if trucks reduce their prices, rail will lower its prices to compete. The data used for this study confirm a positive relationship with both *Truck PPI* and *Rail Price* generally increasing over the sample time period.

The average number of cars per shipment is a slightly different story. Railroads charge different rates for different shipment sizes. When the shipment is large enough, the improvement in efficiency will lower costs per unit for the rail, and they will lower their rates. That is what has happened with the advancement of shuttle trains, especially for corn and soybeans in South Dakota. Unlike the measure used for *Truck PPI*, this measure is specific to the commodity. For example, the *Cars* instrument used in the corn model includes the average number of cars for corn shipments. The average shipment size generally increases over the sample time period for corn and soybeans, but it drops off slightly after 2008 for corn and after 2011 for soybeans. Wheat shipment sizes are different. They decline slightly until 1999 where they increase sharply through 2000 and then more steadily increase until after 2007 when they begin to decline. Based on the data used in this study, the relationship between rail revenues and number of cars per shipment over the sample time period is positive for all three commodities. However, as stated earlier, the revenue data are masked, and the positive relationship may not be picking up on the effects of shuttle contracts. Additionally, the average number of cars per shipment in a quarter is never large enough to be considered a shuttle, suggesting that many shipments are still smaller and more costly. Changes in shipment distances over time also affect rail revenues.

Following Babcock and Gayle (2014), an interaction between the two instruments and the squares of both instruments were included in addition to the original instruments to capture any potential nonlinear effects. In the Hausman test, *Rail Price* (the endogenous variable) is regressed on the other explanatory variables (exogenous variables) and the instruments to obtain predicted values, which are then added as an extra explanatory variable in the original regression. Then an F-test is performed to see if the slopes of these predicted values are zero. The null hypothesis is that *Rail Price* is exogenous. Tables 4.4 through 4.9 show these regressions and results.

Table 4.4 shows that *PPI Truck* and *Cars* are correlated with *Rail Price*, the endogenous variable, in the corn model. This is a reassuring result as an instrument needs to be correlated with the endogenous variable. According to the results of this regression, *Truck PPI* is positively correlated with *Rail Price* as expected and as found previously. It is interesting to note that *Cars* now has a negative relationship with *Rail Price* when the other variables are included. This is consistent with the theory that larger shipments (such as shuttle trains) mean lower rates because of improved efficiency. Squared instruments and interactions were included to capture any nonlinear effects present in the relationships. Only *Truck PPI* ^2 was found to have a significant relationship with corn rail rates.

Table 4.4. Corn Rail Price Regressed on Exogenous Variables and Instruments

Variable	Coefficient	Standard Error	T-statistic
Stocks-Feed Use	1.93E-10***	7.20E-11	2.68
Ethanol Production	1.40E-09***	3.92E-10	3.59
Grain Price Ratio	0.014669	2.90E-01	0.05
Lagged Rail Volumes	1.54E-09**	6.67E-10	2.31
PPI Truck	0.053292**	0.023403	2.28
Cars	-0.018330***	0.006981	-2.63
PPI Truck^2	-0.000218**	0.000102	-2.14
Cars^2	0.000058	0.000039	1.47
PPI Truck * Cars	0.000078	0.000080	0.97
Constant	-2.375824*	1.41E+00	-1.69

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Table 4.5 shows the results of including the residuals from the regression in Table 4.4 and the results of the test for endogeneity. The coefficient on the residuals is statistically significant at the 10% level, and the F-statistic is 2.88. Thus, the null hypothesis that *Rail Price* is exogenous is rejected at the 10% level of statistical significance. There is enough evidence for some endogeneity bias which needs to be corrected in the corn model. This will be addressed in the next section of this chapter.

Table 4.5. Corn Regression Including Predicted Values

Variable	Coefficient	Standard Error	T-statistic
Rail Price	-47,500,000	3.63E+07	-1.31
Stocks-Feed Use	0.027895**	1.20E-02	2.32
Ethanol Production	0.124725*	6.53E-02	1.91
Grain Price Ratio	-72,900,000*	4.05E+07	-1.80
Lagged Rail Volumes	0.390923***	1.08E-01	3.62
Residuals	67,500,000*	3.98E+07	1.70
Constant	112,000,000***	4.15E+07	2.69

Test of Endogeneity *Ho:* Rail Price is exogenous	F(1, 83) = 2.88 Prob>F = 0.0936

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Tables 4.6 and 4.7 show the results for the soybean model. Table 4.6 shows that *Rail Price* is more correlated with *Cars* than with *PPI Truck.* This makes sense, as most soybeans are transported out of the state in large shipments for export. Soybeans rely much more heavily on rail transportation because the ports are a long distance from South Dakota. Rail is more efficient than trucks for transporting larger quantities over longer distances. Similar to the results from the corn model, *Cars* is now negatively related to *Rail Price*. This reflects the improved efficiency of larger shipments. Although *Truck PPI* is not significant in explaining *Rail Price*, it does have the expected positive sign. It is interesting to note that the interaction between *Cars* and *Truck PPI* is also significant in explaining *Rail Price.*

Table 4.6. Soybean Rail Price Regressed on Exogenous Variables and Instruments

Variable	Coefficient	Standard Error	T-statistic
Stocks	9.75E-10***	3.52E-10	2.77
Grain Price Ratio	-0.684899	8.87E-01	-0.77
Lagged Rail Volumes	3.07E-09***	1.09E-09	2.81
PPI Truck	0.016416	0.025126	0.65
Cars	-0.026175***	0.006174	-4.24
PPI Truck^2	-0.000070	0.000109	-0.64
Cars^2	-0.000041	0.000031	-1.33
PPI Truck * Cars	0.000277***	0.000064	4.34
Constant	0.123882	1.72E+00	0.07

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Table 4.7 shows the results of including the residuals from the regression in Table 4.6 and the results of the test for endogeneity. The coefficient of the residuals is not statistically significant, and the F-statistic of 0.04 means a failure to reject the null hypothesis that *Rail Price* is exogenous. Although economic theory suggests that *Rail Price* may be endogenous because of the law of demand, the results of the statistical test indicate that there is not significant endogeneity bias. Therefore, there is no need to correct for this issue.

Table 4.7. Soybean Regression Including Predicted Values

Variable	Coefficient	Standard Error	T-statistic
Rail Price	5,597,976*	2.92E+06	1.92
Stocks	0.244991***	1.57E-02	15.64
Grain Price Ratio	27,500,000	3.83E+07	0.72
Lagged Rail Volumes	-0.105085**	5.00E-02	-2.10
Residuals	-1,138,856	5.87E+06	-0.19
Constant	-27,400,000	3.62E+07	-0.76

Test of Endogeneity *Ho:* Rail Price is exogenous	F(1, 84) = 0.04 Prob>F = 0.8466

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Tables 4.8 and 4.9 display the results for the wheat model. Table 4.8 shows that the instruments are generally not significant in explaining wheat *Rail Price*. The fact that average shipment sizes are not significant in explaining *Rail Price* is not entirely unexpected when looking at the data. The plot of the data for the sample time period shows that shipment sizes of wheat did not follow any consistent pattern, while the revenue per bushel (*Rail Price*) increased steadily. The coefficient on *Cars* is positive, which is a change from the negative sign in both the corn and soybean models. This is likely because wheat rail shipments out of South Dakota are much smaller and do not obtain the efficiency and lower prices of shuttle shipments. It is surprising that *Truck PPI* is negatively correlated with *Rail Price* when this specification is used. It is likely that the interactions of all the instruments in this regression are affecting the true relationships because the specification may be incorrect.

Table 4.8. Wheat Rail Price Regressed on Exogenous Variables and Instruments

Variable	Coefficient	Standard Error	T-statistic
Stocks	-4.18E-10	3.13E-10	-1.34
Grain Price Ratio	0.172827	2.58E-01	0.67
Lagged Rail Volumes	-1.13E-11	1.07E-09	-0.01
PPI Truck	-0.011904	0.017202	-0.69
Cars	0.018748	0.014337	1.31
PPI Truck^2	0.000127*	0.000075	1.70
Cars^2	-0.000054	0.000135	-0.40
PPI Truck * Cars	-0.000158	0.000152	-1.04
Constant	0.345136	9.74E-01	0.35

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Table 4.9 shows the results of including the residuals from the regression in Table 4.8 and the results of the test for endogeneity. The coefficient of the residuals is not statistically significant, and the F-statistic of 1.89 means a failure to reject the null hypothesis that *Rail Price* is exogenous. Although economic theory suggests that *Rail Price* may be endogenous because of the law of demand, the results of the statistical test indicate that there is not significant endogeneity bias. Thus, similar to the soybean model, the wheat model does not need to be corrected for this issue.

Table 4.9. Wheat Regression Including Predicted Values

Variable	Coefficient	Standard Error	T-statistic
Rail Price	9,854,700**	4.37E+06	2.25
Stocks	0.178895***	2.29E-02	7.82
Grain Price Ratio	3,369,337	1.94E+07	0.17
Lagged Rail Volumes	0.438236***	7.67E-02	5.71
Residuals	-13,500,000	9.85E+06	-1.37
Constant	-15,900,000	1.85E+07	-0.86

Test of Endogeneity *Ho:* Rail Price is exogenous	F(1, 84) = 1.89 Prob>F = 0.1731

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

Although the soybean and wheat equations did not show significant endogeneity bias, there is still the potential issue of serial correlation (also known as autocorrelation). "Serial correlation occurs in time-series studies when the errors associated with observations in a given time period carry over into future time periods" (Pindyck and Rubinfeld, 1991). Because the data used in this study are time series data, autocorrelation can be affecting the efficiency of the OLS results. OLS standard errors and tests are also invalid in the presence of autocorrelation. To test for this problem, residuals were regressed on lagged residuals for each of the equations (corn, soybeans, and wheat). If the lagged residuals are significant in explaining the residuals, then autocorrelation is present in the model. Autocorrelation was found in both the soybean and wheat models. These models will be corrected for autocorrelation in the next section along with the corrections for endogeneity bias found in the corn model.

GMM Estimation and Corrections for Autocorrelation

In this section, the endogeneity bias found in the corn equation is corrected using generalized method of moments (GMM) to re-estimate the corn rail demand equation parameters using *PPI Truck* and *Cars* as instruments for *Rail Price*. Then the soybean and wheat models are corrected for autocorrelation using Newey-West standard errors.

GMM was chosen to estimate the corn demand for rail because it is more efficient (meaning smaller standard errors) than using two stage least squares (2SLS) and instrumental variables (IV) estimation techniques. It also is a good method to use when several instruments are being used for one endogenous variable, which is the case in this study as *PPI Truck, Cars*, their squares, and their interaction are all being used to instrument for *Rail Price*. Finally, it has the potential to correct for heteroskedasticity and autocorrelation in the standard errors. A bandwidth is used in kernel estimation to determine what range of data points will be more heavily-weighted. The bandwidth chosen for using GMM is five in this case, which means that four lags are included. Because the data are quarterly, this should be sufficient time for any autocorrelation to fade out. Table 4.10 provides the results from the GMM estimation of the parameters of the corn equation.

When more instruments are included than there are endogenous variables, the equation is said to be overidentified. In this case, there exists an overidentification test, reported in Table 4.10, which is used to determine the validity of the instruments used in the GMM estimation. The null hypothesis is that the instruments are not correlated with the residuals of the model. Given the Chi-square statistic of 0.5751, the null hypothesis cannot be rejected. This means the instruments are valid. The Identification/IV relevance test also confirms the adequacy of the instruments in identifying this equation.

Table 4.10. GMM Estimated Parameters (Corn)

Variable	Coefficient	Robust Standard Errors	T-statistic
Rail Price	-49,500,000*	2.75E+07	-1.80
Stocks-Feed Use	0.032149***	0.011142	2.89
Ethanol Production	0.123207***	0.045358	2.72
Grain Price Ratio	-62,200,000*	3.57E+07	-1.74
Lagged Rail Volumes	0.446519***	0.109536	4.08
Constant	100,000,000***	3.26E+07	3.08

Test of Endogeneity *Ho:* Rail Price is exogenous	F(1, 83) = 2.88 Prob>F = 0.0936
Test of Overidentifying Restrictions	Hansen J Statistic = 2.897 Chi-sq(4) P-val = 0.5751
Identification/ IV Relevance Test	Anderson canon. corr. LR statistic = 16.546 Chi-sq(5) P-val = 0.0054

Notes: This estimation had 90 observations. Centered R^2 for this model was 0.23. Uncentered R^2 was .90. *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

The GMM results show that all of the explanatory variables are now statistically significant, which is an improvement over the OLS results where *Ethanol Production* and *Rail Price* were not statistically significant.

The coefficient on *Rail Price* now has the theoretically expected negative sign and is significant at the 10% level. This means that as the price for rail service increases, the amount of corn shipped by rail can be expected to decrease, consistent with the law of demand. The coefficient is larger and in the opposite direction in the GMM results, which suggests an even larger impact of *Rail Price* on *Rail Volumes*.

The coefficient on *Stocks-Feed Use* did not change much and remained positively related to *Rail Volumes* as expected. However, it did become more statistically significant at the 1% level rather than at the 10% significance level.

In the OLS estimation results, *Ethanol Production* was not significant. However, when using GMM, the coefficient on *Ethanol Production* is significant at the 1% level. Both sets of results suggest a positive relationship between *Ethanol Production* and *Rail Volumes* of corn and DDGS although the effect is stronger in the GMM estimation. This likely reflects greater levels of corn production and increased amounts of DDGS transported by rail over the sample time period.

The coefficient on *Grain Price Ratio* remained negative as expected suggesting that increased corn prices in South Dakota will cause more corn to remain in the state and vice versa. *Grain Price Ratio* did lose some significance in the GMM estimation relative to the OLS estimation, but it is still statistically significant at the 10% level. The value of the coefficient was also lower in the GMM estimation meaning its effect on *Rail Volumes* was not as large as originally estimated.

Lagged Rail Volumes were highly significant in the OLS estimation and even improved slightly in the GMM estimation. The coefficient is significant at the 1% level. The sign remained positive in the GMM estimation, and a slightly larger coefficient value in the GMM estimation indicates a stronger effect on *Rail Volumes*. The positive sign suggests that an increase (decrease) in corn and DDGS rail shipments in the previous quarter means that corn and DDGS shipments will increase (decrease) in the current quarter.

Because the soybean and wheat models contain a lagged dependent variable as an explanatory variable and have serially correlated errors, OLS is not consistent. To correct for autocorrelation, Newey-West standard errors are calculated based on a lag of four because the data are quarterly. The lag chosen must be a sufficient amount of time for the serial correlation to fade out and is based on the periodicity of the data. Newey-West standard errors are used because they are robust to higher-order autocorrelation and to heteroskedasticity. This method is also appropriate when strict exogeneity fails, such as in the presence of a lagged dependent variable. Tables 4.11 and 4.12 provide the results of the soybean and wheat models estimated with Newey-West standard errors.

The coefficients reported in Table 4.11 are the same as those reported in the OLS results for the soybean equation (Table 4.2). However, the standard errors have been corrected for autocorrelation according to the Newey-West method.

Table 4.11. Estimated Parameters with Newey-West Standard Errors (Soybeans)

Variable	Coefficient	Standard Error	T-statistic
Rail Price	5,316,859***	2.13E+06	2.50
Stocks	0.245942***	0.011331	21.71
Grain Price Ratio	29,400,000	3.21E+07	0.91
Lagged Rail Volumes	-0.102817	0.068513	-1.50
Constant	-29,100,000	3.01E+07	-0.97

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

The coefficient on *Rail Price* is positive and is now significant at the 1% level, still indicating a theoretically unexpected positive relationship between the amount of soybeans shipped by rail and the price of rail service. As previously discussed in the OLS results, this could be because of the masked contract revenues, some inelasticity in the demand for soybean rail transportation, or because the distances of the shipments are increasing. The coefficient on *Stocks* is positive and significant. *Stocks* holds most of the explanatory power in this equation, indicating that the amount of soybeans that will be shipped by rail depends highly on the amount of soybeans available to ship. The coefficient on *Grain Price Ratio* is positive, which is theoretically unexpected, but it is not statistically significant. The variation in this variable was not enough for it to establish any significant relationship with rail volumes. Finally, the coefficient on *Lagged Rail Volumes* is negative but no longer statistically significant.

Just as with the soybean results, the coefficients provided in Table 4.12 are the same coefficients reported in the OLS results for the wheat equation (Table 4.3). The standard errors and T-statistics changed based on the Newey-West correction for autocorrelation.

Table 4.12. Estimated Parameters with Newey-West Standard Errors (Wheat)

Variable	Coefficient	Standard Error	T-statistic
Rail Price	7,189,542**	3.53E+06	2.04
Stocks	0.175061***	0.032119	5.45
Grain Price Ratio	8,126,848	2.26E+07	0.36
Lagged Rail Volumes	0.455578***	0.058529	7.78
Constant	-18,600,000	2.09E+07	-0.89

Notes: *** indicates statistical significance at the 1% level, ** is the 5% level, and * is the 10% level.

The coefficient on *Rail Price* suggests a theoretically unexpected positive relationship between the amount of wheat transported by rail and the price for rail service. It is now more statistically significant at the 5% level. Just as with the soybean model, this positive relationship suggests potential issues with the data, some inelasticity in the demand for wheat rail transportation, or some effects of longer distances to final destinations. The coefficient on *Stocks* is positive and significant at the 1% level, suggesting that stocks of wheat play a large role in wheat shipments by rail. This effect is the same for soybeans, except it is much stronger for soybeans. The effect of *Grain Price Ratio* on wheat *Rail Volumes* in these results is unexpectedly positive and statistically insignificant. Again, this variable does not exhibit significant variation that would be able to explain rail volumes. The coefficient on *Lagged Rail Volumes* is positive and highly significant as it was in the original OLS results.

Overall, the empirical results are not entirely as expected, but they do show some differences among rail demand for each of the three crops studied. The results for the corn equation follow theoretical expectations more closely than do those for the soybean and wheat equations. The relationship between *Rail Price* and *Rail Volumes* is negative as expected in the corn equation, but the sign on *Rail Price* is positive in both the soybean and wheat equations. *Stocks* are positive and highly significant in all three equations, especially for the soybeans. *Grain Price Ratio* is negative as expected and statistically significant only in the corn equation, while it is positive and statistically insignificant in both the soybean and wheat equations. The estimated relationship between *Rail Volumes* and *Lagged Rail Volumes* is positive and statistically significant for the corn and wheat equations, but it is negative and statistically insignificant for the soybean equation.

The dynamics of increased ethanol production in South Dakota and its effect on rail are explored in this study but not fully covered. The positive coefficient found on *Ethanol Production* indicates that the increased gallons of ethanol being produced in the state are increasing the amount of corn shipped by rail. This result suggests that the increase in bushels of corn produced offset the loss of bushels from ethanol production.

The instruments used also provide some insight about the dynamics between rail and truck in South Dakota and their relationships among the three commodities studied. The results suggest corn rail price has a significant relationship with both the number of cars in a shipment and the truck price, while soybean rail price has a stronger relationship with the number of cars in a shipment, and wheat rail price has a stronger relationship with the truck price. This reflects more rail demand for soybeans, more truck demand for wheat, and a mix of rail and truck demand for corn.

Chapter V. Conclusion and Recommendations

The capacity of the rail system has been called into question in recent years, particularly in the Midwest region of the United States. This includes South Dakota where crop production, especially corn production, has increased rapidly during the 2000s. Producers have converted pasture and grassland into cropland because of the increased demand for corn coming from the ethanol industry along with higher grain and oilseed prices. Corn is often trucked to ethanol plants or feedlots, but much of the excess supply is not utilized for these purposes and must be transported out of the state, mostly by rail due to its efficiency over longer distances. Ethanol plants also create more demand for transportation because the ethanol and DDGS that are produced must be transported to their final markets.

Further adding to the demand for transportation are the soybeans and wheat produced in the state. Most soybeans and wheat are transported out of South Dakota to their end users; much of this goes out by rail. South Dakota transports over half of its agricultural commodities by rail, but few studies have been conducted on rail in South Dakota since the time period surrounding the Staggers Act of 1980. The few studies that have included South Dakota are not specific to South Dakota and do not cover relatively long periods of time. Data on rail in South Dakota are also difficult to find.

Farmers, elevators, ethanol plants, and other ag-related businesses depend on reliable transportation to market their corn, soybeans, or wheat effectively. Transportation costs are often a significant factor determining the price farmers receive for their crop. Farmers may need to add storage if prices at the elevator or ethanol plant are too low. Elevators plan for shuttle facilities and increased storage to take advantage of reduced shuttle rates and prepare for delays in transportation. Ethanol plants must also plan their production and storage depending on the transportation available to them.

Trucks are the only other viable option for grain transportation in South Dakota, and many times they are actually a complement to the rail system. Trucks are not as efficient as rail over longer distances. Any shipments of corn, soybeans, or wheat going to export need to be transported by rail because of the distance to ports.

Previous research has examined grain marketing patterns and the demand for agricultural transportation. A study conducted by Informa Economics (2010) analyzed corn flow patterns and corn rail rates for seven states including South Dakota from 2000 to 2008 using Public Waybill data as one of their sources of rail data. They found that the share of South Dakota's corn production transported by rail has decreased because of ethanol production. Corn that is transported by rail is being hauled longer distances, increasing the use of shuttle trains and leading to increases in rail revenues. Informa Economics (2012) also assessed the soybean market specifically for seventeen states including South Dakota. Most of the soybeans produced in South Dakota are transported long distances by rail to export markets, particularly the PNW (Informa Economics, 2012).

Vachal (2012) conducted a survey of elevators in the north-central plains region including South Dakota. Rail held a higher share (54 percent) than trucks in the transportation of grains in South Dakota. Most of South Dakota's agricultural shipments consisted of cereal grains (80 percent), and over half of the rail shipments (65 percent) were by shuttle train. Larger shares of soybeans and wheat were transported by rail, while a larger share of corn was transported by trucks. Most corn was transported to ethanol plants, while soybeans were transported to the PNW for export, and wheat was transported to eastern domestic markets. Elevators in South Dakota listed export market demand, local road investments, local processing/feeding demand, and rail industry capacity as the most important transportation issues for the future (Vachal, 2012).

Prater et al. (2013) examined factors that contribute to changes in rail market share for transportation of grains and oilseeds in twenty-one states from 2001 to 2010. Ethanol production and increased concentration of animal feeding were found to decrease rail market share, while higher fuel costs contributing to higher truck rates, increased exports, and increased shipment sizes were found to increase rail market share.

Babcock and Gayle (2014) estimated a model of railroad grain transportation demand using rail rates, grain production, barge rates, commodity effects, region effects, and a time trend to explain tonnage of corn, soybeans, wheat, and sorghum transported by rail in the U.S from 1965 to 2011. The western region of the U.S. was found to have higher railroad grain demand. Wheat was found to have the highest rail demand followed by corn and then soybeans.

Other studies have examined the effects of ethanol production and shuttle trains in a general sense, but not specifically related to the demand for agricultural transportation. Studies specific to rail transportation and the changing dynamics of the grain marketing system in South Dakota are limited. Lamberton (1977) and Lamberton and Rudel (1977) assessed the grain marketing system and rail transportation in South Dakota prior to the Staggers Act of 1980. Qasmi et al. (2010) studied grain marketing patterns in South Dakota for the 2005/2006 marketing year based on survey responses from elevators.

Qasmi et al. (2009) examined the effects of increased ethanol production on cropping patterns and grain marketing flows in South Dakota.

Because of the importance of rail transportation of grains and oilseeds in South Dakota and because of the lack of recent studies on rail transportation in South Dakota, this study was conducted to investigate corn, soybean, and wheat rail demand in South Dakota over the time period from 1991 to 2013. Following Babcock and Gayle (2014), a rail demand model was developed. Rail data from the STB's Public Waybill Sample were utilized to find bushels of corn, DDGS, soybeans, and wheat transported quarterly. The empirical model specified three different equations, one each for corn, soybeans, and wheat. Rail volumes of each commodity were modeled as a function of rail price, stocks, ethanol production (in the case of corn), a grain price ratio, and lagged rail volumes.

Initially, OLS was used to estimate the equations. However, rail price was found to be endogenous in the corn equation, and the soybean and wheat equations tested positive for autocorrelation. The corn rail demand equation was re-estimated using average number of cars per shipment and truck price as instrumental variables for rail price in a generalized method of moments (GMM) estimation. The soybean and wheat rail demand equations were re-estimated using Newey-West standard errors to correct for autocorrelation and heteroskedasticity.

The results for the corn equation fit the closest with expectations. The signs on the coefficients fit with theoretical expectations, and all of the coefficients were statistically significant at the standard levels. One result discovered in this study is that ethanol production was found to increase the amount of corn and DDGS transported by rail. Rail volumes of both corn and DDGS were included in the dependent variable.

Increased ethanol production is expected to increase production and therefore rail shipments of DDGS, but it was expected to decrease the amount of corn transported by rail because most of the corn is trucked to ethanol plants. Based on the results obtained, it appears that the increase in bushels of corn produced in South Dakota was enough or more than enough to compensate for the increase in bushels of corn used in ethanol production so that there was still corn available to ship by rail.

Additionally, rail volumes of corn and DDGS from the previous quarter were found to be positively associated with rail volumes of corn and DDGS in the current quarter. This indicates momentum in the marketing of corn and DDGS. Both are relatively easy to store and can be transported by truck if necessary to reach their final markets. Changes in marketing conditions may easily influence the need for transportation of corn and DDGS.

The results for the soybean and wheat equations were not nearly as straightforward. Rail prices were found to be positively associated with rail volumes, suggesting issues with the data, inelastic demand, or increasing costs as a result of an increase in shipment distances. Using a grain price ratio to measure for basis effects was found to be positive and statistically insignificant because the variable did not display significant variation. Stocks were found to have a very strong positive association with rail volumes of both soybeans and wheat. Rail volumes from the previous quarter were found to be positively associated with current rail volumes and highly statistically significant for wheat but negatively associated with current rail volumes and statistically insignificant for soybeans.

These results provide further insight into the relationship between rail demand and grain production in South Dakota. Although the demand for rail depends on many different factors, the results from this study indicate that stocks available and the amount of grain and oilseeds produced are extremely important. This is especially true for soybeans. Stocks explained most of the variation in rail volumes of soybeans. This makes sense because soybeans are not as easily stored, and the proportion of soybeans transported by rail is much higher than it is for either wheat or corn. Soybeans also displayed a much stronger seasonal pattern of rail shipments, which supports the idea that most soybeans in South Dakota are transported by rail to be exported during a narrow time frame when the South American crop is not ready for export.

Wheat shipments by rail were found to be more sporadic. However, the strong explanatory power of lagged rail volumes and the positive association with current rail volumes suggest momentum swings in wheat marketing. This was the same result found in the corn model. Knowing this provides railroads with information to better prepare for making shipments on time.

Further insights were obtained when the relationships between rail price and its instruments were examined. The average number of cars per shipment was found to be negatively correlated with rail prices for corn and soybeans, consistent with the idea that rates are lower for larger shipment sizes because of improved efficiency. Truck prices were found to be positively correlated with rail prices for corn and soybeans, indicating that trucks and railroads share some cost components and behave competitively. Corn rail prices were related to both truck prices and the average number of cars in a shipment, soybeans rail prices were more strongly related to the average number of cars in a shipment, and wheat rail prices were more related to the truck index squared. These results show differences in transportation modes favored by each commodity.

Understanding the relationships between these variables, including truck prices and shipment sizes, allows elevators, other grain shippers, and ethanol plants to better plan their grain marketing strategies. When trucks are a viable option, they may choose to use truck shipments, or they may increase their storage and invest in shuttle loading facilities to take advantage of lower rail rates and an increased time frame for marketing their grain or ethanol products. Railroads incorporate this type of information into their planning strategies so that they are prepared to provide needed transportation service. Producer groups and the federal government are interested in this kind of information to ensure reliable and cost-effective transportation so that producers receive a fair price for their products and the U.S. remains competitive in the world export market.

Limitations and Recommendations for Future Research

The demand for grain and oilseed transportation is a derived demand that depends on the demand and supply of grains and oilseeds. Crop prices reflect changing demand and supply conditions, which dictate crop production and therefore necessary grain shipments. The future of ethanol production may influence these prices and so may also impact rail demand. The effect ethanol has on rail demand is more complex given the products and co-products of ethanol production. This model is a starting point for exploring the impacts of ethanol production on the railroads in South Dakota, but more research must be conducted to fully understand the dynamic relationships in the grain marketing system and the transportation needs and implications for South Dakota.

Additional research may further examine the impact of ethanol production on railroads in South Dakota. DDGS shipments were included along with corn shipments as the dependent variable for the corn equation, feed use was subtracted from stocks, and ethanol production in gallons was included as an explanatory variable. While the results obtained showed a positive association between rail volumes and ethanol production, the separate effects of ethanol production on DDGS shipments and corn shipments were not examined. The model may need to be re-specified to better define these relationships.

The rail data used in this study came from one of the only publicly available data sources for railroads. While the data are useful because specific shipments of individual commodities in South Dakota could be identified, the study could have been more accurate if the Confidential Waybill Sample would have been obtained. The Public Waybill Sample masks the railroads' contract revenues in order to protect competition. This means that the revenue data used in this study are probably not entirely accurate. However, because the purpose of this study was not to examine rail rates, the data could be used as a proxy for actual rail rates. The only problem with this is that it may be why rail prices were found to be positively associated with rail volumes in both the soybean and wheat equations, which is contrary to the negative relationship expected in a demand equation. Future research may look into obtaining the data from the Confidential Waybill Sample or perhaps finding another source of rail rate data.

The grain price ratio used in the model specification could also be improved as a measure of the variability in rail demand. Since the ratio as defined (the South Dakota grain price per bushel divided by the average U.S. grain price per bushel) does not display much variation, it was not able to explain much of rail demand and therefore was found to be insignificant and unexpectedly positive in both the soybean and wheat equations. This variable either needs to be defined differently or dropped from the model completely.

Not all factors affecting corn, soybean, and wheat rail demand could be included because the data were insufficient or unavailable. Additionally, the sample size for this study was relatively small, so including too many explanatory variables would mean too many degrees of freedom. Exports could have potentially been included as an additional explanatory variable because of the importance of rail in shipping corn, soybeans, and wheat long distances. Trends in shipment distances should be incorporated into the model to account for changes in rail prices. If accurate truck rate data could have been obtained, the data could have been included to determine the relationship, whether competitive or complementary, of rail and trucks in South Dakota. Truck data are hard to find, but they would greatly improve a study such as this if they could be found for future research.

Another important part of this study was testing the equations for significant endogeneity bias which theory suggests should be present in a demand equation. The choice of instruments is an important factor in this test. Several different instruments for rail price were examined in this study and used to test for endogeneity. The soybean equation never tested positive for strong endogeneity bias no matter which instrument was used, while the wheat equation was marginal depending on the instrument or combination of instruments used. This study explored using the average number of cars per shipment and a truck PPI as instruments, but there could be better choices for instruments. For example, Babcock and Gayle (2014) used railroad labor cost, railroad diesel fuel price, and the number of covered hopper railcars to "capture rail supply-shifting shocks to rail price". Diesel prices were examined as an instrument in this study but were dropped because the data used were highly correlated with other variables used in the equations. Other ways to define the current instruments could also be considered. For example, the proportion of shipments over 100 cars could be used instead of average shipment size to explore the impact of shuttle rates. If an equation is overidentified, the validity of the instruments can be tested, but they still need to make economic sense.

Future research may further explore the impacts of grain shuttle trains in South Dakota. This may better explain the evolution of the rail system in South Dakota. The increased use of shuttle trains has improved efficiency, allowed for lower rail rates, and changed grain marketing patterns. Shuttle trains have implications for the competition between truck and rail, for elevators who are considering shuttle loading facilities, and for farmers who are considering new production practices or making other land-use decisions.

One final consideration for future research would be the dynamics of the changing crop patterns in South Dakota and their effects on fertilizer use and other crop inputs relative to transportation needs. This would further expand upon the corn story and give more insight into transportation needs for South Dakota.

References

AMS-USDA. (2014, September 4). *Grain Transportation Report.* Retrieved from AMS-USDA: http://dx.doi.org/10.9752/TS056.09-04-2014

Association of American Railroads. (2015, May 26). *Class I Railroad Statistics.* Retrieved from AAR: https://www.aar.org/Documents/Railroad-Statistics.pdf

Babcock, M. W. (2010). Impacts of Increased Ethanol Production: A Kansas Case Study. *Journal of the Transportation Research Forum,* 49(2): 29-47.

Babcock, M. W. and Gayle, P. G. (2014). Specifying and Estimating a Regional Agricultural Railroad Demand Model. *Journal of the Transportation Research Forum*, 53(1): 35-48.

Babcock, M. W., Lu, X., and Norton, J. (1999). Time Series Forecasting of Quarterly Railroad Grain Carloadings. *Transportation Research Part E,* 35: 43-57.

Benishay, H. and Whitaker Jr., G. R. (1966, June). Demand and Supply in Freight Transportation. *The Journal of Industrial Economics,* 14(3): 243-262.

Bessler, D. A. and Fuller, S. W. (2000, March). Railroad Wheat Transportation Markets in the Central Plains: Modeling with Error Correction and Directed Graphs. *Transportation Research Part E: Logistics and Transportation Review,* 36(1): 21-39.

Brown, H. and Diersen, M. (2015, March 13). Corn Use in South Dakota. *Economics Commentator*, No. 551. Economics Department, South Dakota State University.

Cambridge Systematics, Inc. and Civil Design Inc. (2014, September). *South Dakota State Rail Plan.* Retrieved from South Dakota Department of Transportation: http://sddot.com/transportation/railroads/railplan/Default.aspx

Casavant, K., Jessup, E., Prater, M. E., Blanton, B., Bahizi, P., Nibarger, D., Hill, J., and Weingram, I. (2011). Rail Rate and Revenue Changes Since the Staggers Act. *Journal of the Transportation Research Forum*, 50(1): 55-77.

Davies, P. (2015, April). Working on the Railroad. *Fedgazette*, pp. 1-8.

De La Torre Ugarte, D. G., English, B. C., and Jensen, K. (2007, December). Sixty Billion Gallons by 2030: Economic and Agricultural Impacts of Ethanol and Biodiesel Expansion. *American Journal of Agricultural Economics*, 89(5): 1290-1295.

Denicoff, M. R. (2007, September). *Ethanol Transportation Backgrounder: Expansion of U.S. Corn-based Ethanol from the Agricultural Transportation Perspective.* Retrieved from AMS-USDA: http://www.ams.usda.gov/sites/default/files/media/ Ethanol %20Transportation%20Backgrounder.pdf

Dooley, F. (2006). *The Effect of Ethanol on Grain Transportation and Storage.* Retrieved from Purdue University Extension: https://www.extension.purdue.edu/extmedia/id/id-329.pdf

Dybing, A. G. (2002, November). *Estimation of the Demand for Grain Transportation in North Dakota.* Unpublished Master's Thesis: North Dakota State University.

ERS-USDA. (2015). *What is Agriculture's Share of the Overall U.S. Economy?* Retrieved from ERS-USDA: http://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy.aspx

FHWA-USDOT. (2015). *Freight Analysis Framework.* Retrieved from FHWA: http://ops.fhwa.dot.gov/Freight/freight_analysis/faf/index.htm

Fitzsimmons, E. L. (1981). A Statistical Sketch of the Demand for Rail Transport of Grain and Soybeans. *Transportation Journal (American Society of Transportation & Logistics Inc.),* 20(3): 59-65.

Friedlaender, A. F. and Spady, R. H. (1980, August). A Derived Demand Function for Freight Transportation. *The Review of Economics and Statistics,* 62(3): 432-441.

Fuller, S. W., Ruppel, F. J., and Bessler, D. A. (1990, December). Effect of Contract Disclosure on Price: Railroad Grain Contracting in the Plains. *Western Journal of Agricultural Economics,* 15(2): 265-271.

Hanson, S. D., Baumhover, S. B., and Baumel, C. P. (1990a, November). Characteristics of Grain Elevators That Contract with Railroads. *American Journal of Agricultural Economics*, 72(4): 1041-1046.

Hanson, S. D., Baumhover, S. B., and Baumel, C. P. (1990b, July). The Impacts of Railroad Transportation Costs on Grain Elevator Handling Margins. *North Central Journal of Agricultural Economics,* 12(2): 255-266.

Harbor, A. L. (2009, March). An Assessment of the Effect of Competition on Rail Rates for Export Corn, Soybean, and Wheat Shipments. *Journal of Food Distribution Research,* 40(1): 70-77.

Henrickson, K.E. (2011). Spatial Competition and Geographic Grain Transportation Demand on the Mississippi and Illinois Rivers. *Applied Economics,* 43(10): 1257-1269.

Huang, W. (2003, June). *Shuttle Train Adoption Strategy.* Unpublished Master's Thesis: North Dakota State University.

Hughes, S. (2015, December 3). Senate Passes Five-Year Highway Bill, Sending It to the White House. *The Wall Street Journal.* Retrieved from: http://www.wsj.com/

Inaba, F. S. and Wallace, N. E. (1989, November). Spatial Price Competition and the Demand for Freight Transportation. *The Review of Economics and Statistics,* 71(4): 614-625.

Informa Economics. (2012, July). *Farm to Market: A Soybean's Journey from Field to Consumer.* Retrieved from Soy Transportation Coalition: http://www.soytransportation.org/FarmToMarket/FarmToMarketStudy082012 Study.pdf

Informa Economics. (2010, June). *Review and Analysis of Corn Rail Rates.* Retrieved from National Corn Growers Association: http://ncga.com/uploads/useruploads/railratereportjune2010.pdf

Johnson, K.P. (1995, February). Redefinition of the BEA Economic Areas. *Survey of Current Business.* Retrieved from Bureau of Economic Analysis: http://www.bea.gov/scb/pdf/regional/proj/1995/0295rea.pdf

Kenkel, P., Henneberry, S., and Agustini, H. N. (2004). *An Economic Analysis of Unit-Train Facility Investment.* Paper presented at the Southern Agricultural Economics Association Annual Meeting, Tulsa, Oklahoma, February 14-18.

Kennedy, P. (2008). A Guide to Econometrics, 6th Ed. Malden: Blackwell Publishing.

Lamberton, C. E. (1977). *Grain Transportation in South Dakota.* South Dakota State University, Brookings: Agricultural Experiment Station.

Lamberton, C. E. and Rudel, R. K. (1977). *The South Dakota Grain Marketing System.* South Dakota State University, Brookings: Agricultural Experiment Station.

Lee, Y. and Kennedy, P. L. (2008). *An Analysis as to the Casual Relationship Between Bioethanol Expansion and Agricultural Crop Acreage Allocation in the United States.* Paper presented at the American Agricultural Economics Association Annual Meeting, Orlando, Florida, July 27-29.

Luri, M. (2015). *Drivers of Agricultural Land Use Change and Management Decisions in the Dakotas: The Influence of Climate Change and Other Factors*. Unpublished Master's Thesis: South Dakota State University.

MacDonald, J. M. (2013, July 17). Railroads and Price Discrimination: The Roles of Competition, Information, and Regulation. *Review of Industrial Organization,* 43(1/2): 85-101.

Michaels, G. H., Levins, R. A., and Fruin, J. E. (1982, May). Rail/Truck Competition for Grain Traffic in Minnesota: Implications for Rate Making. *American Journal of Agricultural Economics,* 64(2): 276-279.

Miklius, W. (1967, April). Estimating the Demand for Truck and Rail Transportation: A Case Study of California Lettuce. *Agricultural Economics Research,* 19(2): 46-50.

Miklius, W., Casavant, K. L., and Garrod, P. V. (1976). Estimation of Demand for Transportation of Agricultural Commodities. *American Journal of Agricultural Economics,* 58(2): 217-223.

Miljkovic, D., Price, G. K., Hauser, R. J., and Algozin, K. A. (2000). The Barge and Rail Freight Market for Export-Bound Grain Movement from Midwest to Mexican Gulf: An Econometric Analysis. *Transportation Research Part E,* 36: 127-137.

NASS-USDA. (2015). *Crop Production.* Retrieved from NASS: http://usda.mannlib. cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1046

NASS-USDA. (2015). *Grain Stocks.* Retrieved from NASS: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1079

NASS-USDA. (2015, April 30). *Meat Animals Production, Disposition, and Income Annual Summary.* Retrieved from NASS: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1101

NASS-USDA. (2015). *Quick Stats*. Retrieved from NASS: http://quickstats.nass.usda.gov/results/395E431E-9604-3DF3-8582-CC1A8A7A7017

Norton, J.D. (1995, September). *Assessing the Impact of Railcar Availability on Grain Prices.* United States Department of Agriculture, Agricultural Marketing Service.

Office of the Chief Economist and AMS-USDA. (2015, January). *Rail Service Challenges in the Upper Midwest: Implications for Agricultural Sectors – Preliminary Analysis of the 2013 – 2014 Situation.* Retrieved from AMS-USDA: http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5110663

Oum, T. H. (1979a, October). A Cross-Sectional Study of Freight Transport Demand and Rail-Truck Competition in Canada. *The Bell Journal of Economics,* 10(2): 463-482.

Oum, T. H. (1979b, May). Derived Demand for Freight Transport and Inter-modal Competition in Canada. *Journal of Transport Economics and Policy,* 13(2): 149-168.

Pindyck, R.S. and Rubinfeld, D.L. (1991). Econometric Models and Economic Forecasts, 3rd Ed. New York: McGraw-Hill.

Prater, M. E., Casavant, K., Jessup, E., Blanton, B., Bahizi, P., Nibarger, D., and Weingram, I. (2010). Rail Competition Changes Since the Staggers Act. *Journal of the Transportation Research Forum*, 49(3): 111-132.

Prater, M. E., O'Neil Jr., D., and Sparger, A. (2013, June). *State Grain Rail Statistical Summary*. Retrieved from AMS-USDA: http://dx.doi.org/10.9752/TS066.06-2013

Prater, M. E. and Sparger, A. (2013, December). *Grain and Oilseed Shipment Sizes and Distance Hauled by Rail*. Retrieved from AMS-USDA: http://dx.doi.org/10.9752/TS059.12-2013

Prater, M. E., Sparger, A., Bahizi, P., and O'Neil Jr., D. (2013). Rail Market Share of Grain and Oilseed Transportation. *Journal of the Transportation Research Forum*, 52(2): 127-150.

Qasmi, B., Hamda, Y., and Fausti, S. (2009, June). *Impacts of Dramatic Increase in Corn Based Ethanol Production on Grain Production and Marketing Patterns in South Dakota.* South Dakota State University, Brookings: Department of Economics.

Qasmi, B., Hamda, Y., and Fausti, S. (2010, February). *The 2005/06 South Dakota Grain Marketing Patterns Study: A Grain Elevator Survey Report.* South Dakota State University, Brookings: Department of Economics.

Sarmiento, C. and Wilson, W. W. (2005, November). Spatial Modeling in Technology Adoption Decisions: The Case of Shuttle Train Elevators. *American Journal of Agricultural Economics*, 87(4): 1034-1045.

Surface Transportation Board. (2015). *Economic Data: Waybill.* Retrieved from STB: http://www.stb.dot.gov/stb/industry/econ_waybill.html

Thompson, W. and Meyer, S. (2009). Simulated Ethanol Transportation Patterns and Costs. *Journal of the Transportation Research Forum*, 48(1): 23-38.

Train, K. and Wilson, W. W. (2007). Spatially Generated Transportation Demands. *Research in Transportation Economics,* 20: 97-118.

U.S. Bureau of Labor Statistics. (2015). *Producer Price Index.* Retrieved from BLS: http://www.bls.gov/data/

USDA and DOT. (2010, April). *Study of Rural Transportation Issues*. Retrieved from AMS-USDA: http://www.ams.usda.gov/AMSv1.0/RuralTransportationStudy.

Vachal, K. (2012, November). *Regional Elevator Transportation: Market Decisions and Rail Service*. North Dakota State University, Fargo: Upper Great Plains Transportation Institute.

Vachal, K., Berwick, M., and Benson, D. (2010). *North Dakota Wheat Transportation Knowledge for Market Enhancement*. North Dakota State University, Fargo: Upper Great Plains Transportation Institute.

Vachal, K. and Button, K.J. (2003, February). Impact of Shuttle Rates on Local Grain Flows. *International Journal of Transport Economics*, 30(1): 91-102.

Wilson, W. W. (1984, December). Estimation of Modal Demand Elasticities in Grain Transportation. *Western Journal of Agricultural Economics,* 9(2): 244-258.

Wilson, W. W., Koo, W., Dahl, B., and Taylor, R. (2008). Impacts of Ethanol Expansion on Cropping Patterns and Grain Flows. *Review of Agricultural Economics,* 30(4): 642-663.

Wilson, W. W., and Wilson, W. W. (2001). Deregulation, Rate Incentives, and Efficiency in the Railroad Market. *Research in Transportation Economics*, 6: 1-24.

Wilson, W. W., Wilson, W. W., and Koo, W. W. (1988, September). Modal Competition in Grain Transport. *Journal of Transport Economics and Policy*, 22(3): 319-337.

Wolfe, K.E. and Linde, W.P. (1997). The Carload Waybill Statistics: Usefulness for Economic Analysis. *Journal of the Transportation Research Forum*, 36(2): 26-41.

Yu, T. and Fuller, S. W. (2005). The Measurement of Grain Barge Demand on Inland Waterways: A Study of the Mississippi River. *Journal of the Transportation Research Forum*, 55(1): 27-39.

Yu, T. and Hart, C. (2009). *Impact of Biofuel Industry Expansion on Grain Utilization and Distribution: Preliminary Results of Iowa Grain and Biofuel Survey*. Paper presented at the Southern Agricultural Economics Association Annual Meeting, Atlanta, Georgia, January 31-February 3.

Yu, T., Zhang, J., and Fuller, S. W. (2006). Freight Transportation Demands on the Upper Mississippi and Illinois Rivers. *Journal of the Transportation Research Forum*, 45(2): 119-136.