RAIL CAR TRIP TRANSIT TIME AND THE EFFECTS ON GRAIN TRADING COMPANY PROFITS

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Rail Car Trip Transit Time and the Effects on Grain Trading Company Profits

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MASTER OF SCIENCE

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ABSTRACT

This examines the logistic process of a grain trading company, and how logistics affect profits. Trip transit time is the amount of times a shuttle train moves back and forth from an elevator and a destination. In the years prior to the 2013/ 2014 crop year, shuttles moved between elevators and destination nearly 3 times in a given month. When transit time dropped in 2013, this created a unique situation to be examined. It changed how grain trading companies needed to alter strategy to maintain a profit. The decrease in trip transit time affected how rail cars moved, but also altered the price paid for freight.

In conclusion, this thesis discovered that strategies on rail cars altered between the years. The strategies created opportunities for grain trading companies to change the structure of profits. This thesis also creates new opportunities for future research.

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The process of writing a thesis can be taxing, specifically when working a full time job. There were many people who helped me succeed and this section expresses my sincere gratefulness to those involved.

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DEDICATION

This thesis is dedicated to my mom and dad, Marlys and Douglas Gesme. Without you I would not be where I am today. You have been the biggest inspirations in my life. My biggest goal is to make you proud, and for you to not have to pay my rent. I would not be the man I am today without your guidance and love, and because of that, the months of work I have put into this thesis is dedicated to you. I LOVE you!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

CHAPTER 1. OVERVIEW

Introduction

Since the beginning of globalized trade and industrialization, transportation has been a key factor for the availability of trade, shaped prices, and brought the world together. Notably, we hear about the great journeys of historical figures such as Marco Polo and Christopher Columbus. In both cases, trade was the key driver that shaped the stories we are told today. In the modern world, it is seen that globalized trade is involved in everyday lives when going to the mall, local restaurants, and grocery stores. Today, companies do not normally deliver products on horseback or by foot; used are railroads, trucking, and barges. Without these forms of transportation, the public would not all be able to enjoy the food bought daily.

With product advancement and the growing world population, grain commodities have become the focal point of many research topics. Whether it be to increase profits or to hedge risk, the area has been widely reviewed because its implications on the markets are quite large. Although food may not always be a topic on the nightly news, food is essential for everyday lives. These commodities all go through a logistics process.

This thesis reviews the logistic process for a grain-trading company and examines the profit-maximizing point for elevator production. These terms, along with the factors that influence the prices paid for products bought at the grocery store, are discussed further in this chapter. This paper also focuses on the particular risks involved with the logistic process as a whole. Grain elevators ship their products to end-point destinations where it is either used as a product within the company or is sold to others for their own uses. The overall goal is to find a profit-maximization point for the elevator level while mitigating the risk based on expected production and demand. While most elevators deal with multiple products, the model portrays a grain trading company that handles both corn and soybeans.

The Logistic Process

While crops are grown by local and global farming operations, the distribution of these crops is made possible by local and globalized elevators. While the farmers grow their crop, they do not always have adequate transportation methods to get their product to the mass public, and the movement of product is where an elevator or plant fits into the logistic process. The product is then shipped from the elevator location to either a domestic or international destination. Each piece in the process has its purpose and this section explains, in more detail, what the logistics process means to the model.

The Farmer

The first step in any commodity purchase or sale is the decision to plant a certain crop. Farmers are under increasing pressure to plant crops which will yield the most profit based on their soil composition and their area while also finding a buyer. There are many different types of farms to consider: hobby, family owned, and large-scale operations. Barring the size and composition of an elevator, affects the crops that are planted and their potential targets. In all cases, the famer’s decision about what to plant affects the rest of the logistic supply chain in many ways, including the price we pay at the local grocery store. Most decisions about what to plant are made by farmers’ assumptions and estimations on what will be best for themselves. These options become more efficient by the contracts provided by local elevators as well as the futures markets which are available to the public. In the model, farmers have the right to sell to different operations or to sell to a competitor. The formulation for whether the farmer will sell is discussed further in this thesis.

The Elevator

The elevator has been a key contact of sale for local farmers since 1842 when the first known elevator was built by Joseph Dart and Robert Dunbar (LaChiusa). The elevator's purpose is to hold, store, and ship the grain products to domestic and international destinations where the goods will either be made into their end-product uses or traded. Grain elevators hold the key to shipping products by trucks, rail, or a barge system. For most buyers of end-product use, they cannot identify local farmers specifically to grow, sell, and deliver to the end-product location. The elevator comes into effect because it is the link between the farmer and the global market. Successful elevators are located where they can load the product on either rail or barge, meaning that the availability of transportation separates them from local farming operations. Elevators are the focal point of this research because the model will examine profits at the elevator level. We also assume that the elevators in this research are all owned by the same company, meaning that profit and losses as well as whether to keep an elevator open will come from one executive's decision. It is important to as most operations will experience times where the elevator is losing profits, although it is far less desirable to shut down than to still trade. These situations are examined later in the paper.

Transportation: Rail

With the increased transportations abilities, the demand for such transportation has increased as well, especially in regions where agricultural commodities are not the only key driver for business. An example would be North Dakota in 2014; the recent oil boom affected many users of the Burlington Northern-Sante Fe (BNSF) railroad. In the newsletter *Feedstuff* (Fatka) noted the pain felt by many larger producers of grain-made products. These pains included multiple rail delays that caused businesses which did not plan for the delays to schedule product shipment and then, in turn, to face the penalties when they could not deliver. Ordering rail is especially painful because it can happen up to a year in advance. The elevator needs to consider thousands of potential risks involved with the process leading up to shipping. These risks are not always easily identifiable, which makes ordering rail cars especially difficult and tedious. If 1,000 railcars are ordered for the year and only 500 are needed, you now have demurrage charges from the railway for having your cars sit; if you order too few cars, you have to buy more on the secondary market, which is extremely volatile, or short your customer, which can end with extensive legal punishments.

Demurrage is defined as the charge associated with the railway holding onto a certain car over the time it takes to deliver. An example of demurrage would be that a railcar owned by company A returns to the rail yard responsible for sending the car to company A's loading location. If Company A is behind on production or has no room to take the car, the car sits at the rail yard, and the company is charged, normally daily, for the car to sit until it is needed. Movement of the railcar may seem to be a very simple task for company A to plan and bring the car in; on the other hand, the risk factors involved with production and having a supply affect how soon a grain trading company can bring this car in to ship a product. The transit time is a focal point for the following research and shows how much transit time can affect profits at the elevator level. Trip transit time in this thesis refers to the amount of trips a shuttle train makes over an on month period. Rail-car ordering is a strategy in this thesis which will be shown as a decision variable later.

Problem Statement

Risks involved with the production of crops, the shipment of those crops, and the outlining procedures have led to multiple headaches for grain-commodity trading companies. For the most part, companies have a plan for their transportation and effectively administer their plan plant wide. Not all of these steps may be fully understood, or they are planned for a perfect situation. The 2014 rail delays showed, full circle, what happens with poor planning as well as poor plan execution. It might be said that the shortcomings of the rail system were the root cause and that planning for those situations can be documented and learned for future use. Rail delays were documented as a key factor for profits and losses (Fatka) (Wilson, Dahl and Carlson) (Wilson, Carlson and Dahl). Companies reported losses in the millions due to delayed shipping, which resulted from the loss of business transactions as well as penalties for late shipments.

Rail-car velocity held a key role with the explanation about why such problems exist: the simple reason of not being able to ship the purchased product to a destination that would pay you back. You would not get paid before preforming a service. The same applies to not shipping products to your users. This delay starts a chain reaction at any elevator or plant location because most, if not all, do not have unlimited storage. If the elevator tops out its storage, then it can no longer accept new product to be placed in storage. If this product is not contracted, you lose business even if the product is contracted, you are now paying to keep the business which, in turn, can affect future business. You also have to worry about shutting down elevator operations until the shipment can be made, meaning that you are paying your fixed costs with no production. All of these factors are due to the loss of shipping capabilities.

Who is Logistic Problem Affecting?

The effects of rail-car delays are felt at all levels of the logistic process, going all the way back to the farmer. When companies have to hedge the risks for their shipment and pay more for transportation, the price the farmers receive for the grown crop is also affected. Although these prices fluctuate, the elevator has to stay competitive, prices are volatile for both the farmer and the end user, meaning the prices the farmer is paid, and the price the end user has to pay to buy the commodity from the elevator create opportunities for the elevator. Every level of the logistic process is affected by one step in the process, which could be specific to one key area. Volatile prices also mean that if the crop yield for a certain year is smaller than average, the elevators have smaller amounts to buy and sell, which also affects prices. The effects are a classic example of the supply-and-demand model you first learn in an introductory economics classes with more complicated implications than the typical examples of a college student buying either pop or pizza. When it comes to agricultural products, substitutions for some products are not always long-term solutions, which then affects the entire market. For now, we focus on reducing the risks involved at the elevator level in order to explain the risk and to maximize profits.

How Are We Going to Fix It?

Although the answers to certain problems may be simple, the effects of other processes significantly sway the decision-making process for any elevator. It is hard to find an answer for a situation if the probability for that situation is risky. The goal of this thesis is to show the major effects on profits that an elevator sees within a given year (2014). We use a Manufacturing Resource Planning (MRP) model to show a base-case result which reflects an average year; we then show how rail-shipment changes in 2014 affected the elevators' profits or losses. Rail issues show how key areas may need further research and what areas at the elevator level should be monitored more closely. Parts of the research depend solely on the data provided while other sections can have predictability with the information provided by key contacts in the logistic process. While the data and models can provide useful information, it is also important to consider the opinions of the contacts who have seen the distributions in transportation and the factors that predict a large swing in the supply of reliable transportation.

After a case has been made and the model format has been explained, the optimization procedures are discussed. For this paper, we use @risk to run our model with a certain number of iterations and simulation packages. @risk gives us certainty that the number provided for the expected values of risky variables will give us confidence that values can explain real-life situations. The risk optimization and procedures are based on the link from economic theory to results.

Economic Theory

In economic terms, we develop a profit-maximization function. We are looking at each elevator's revenue in terms of the crops sold and traded, and the expenses which would include variable and fixed costs at each location. Elevators look at profits in the sense of their margin from selling a product over the course of a given time period. This margin is associated with the amount that the elevator can purchase from the farmer and for what price, then sell back to domestic and international locations for a, hopefully, higher price to cover a grain trading companies variable and fixed costs at a per-unit basis. If an elevator gets a good deal on one bushel of corn for a price of 1$ and sells the corn for $20, the elevator would, in turn, have a revenue of $19 if there were no costs, other than the amount paid to the farmer, associated with making the trade. The issue then becomes the per-unit costs associated with purchasing that product. These costs include the amount paid to the commercial workers who purchased the corn, the amount given to the plant operations to load and store the corn, and many other fixed and variable costs. This cost means that the elevator would have to work with larger quantities in order to reduce its per-unit costs so that the elevator have a positive margin for its product. Fixed costs vary by elevator; for example, the fixed cost to run an elevator is $100,000 a day. Therefore, your revenue of $19 has now become a negative profit of $99,981. If that same deal were multiplied by 1,000, you are still losing $81,000. This example is very simplistic, but it gets the point across that the elevator needs to pump through the product volume that it is buying and selling and that, when that process is halted, it costs the elevator large sums of money. In order to show a successful elevator's operation, we make the typical assumptions for profit maximization. These assumptions are defined later in the thesis.

Organization

This thesis consists of six separate chapters with each leading and explaining the link to each other. Chapter 1 is a brief introduction to the subject and why it affects local and global agriculture. It also gives someone who has little information regarding the logistics process a brief explanation about how it works for a grain elevator. Chapter 2 evaluates what has been done in the past and how it applies to current research. Chapter 2 is an important part to kick start future research because it gives us a starting point for what works and what does not. Chapter 3 evaluates economic theory and gives us a base for how to evaluate optimization procedures as well as results to give real-life implications. Chapter 4 is a review of how the model is structured and how that structure gives us the results we want, as well as how it defines economic theory. Chapter 5 shows results compared to the base-case result for a normal year. This chapter also gives us real-life implications for how risk variables affect empirical model. Chapter 6 describes what was done, how what was done will affect the public and private sectors, and what can be done in the future.

CHAPTER 2. LITERATURE REVIEW

Introduction

In order to fully understand the logistic process and to develop a thesis that adds value to an industry with so much risk, a logistics model needs to have the structure of past research that supports the model's format and explains any new process that is developed. The logistic process used with grain marketing involves many specific issues, especially when rail delays occur and cause a loss in product value. In order to understand the chapters following this Literature Review, selected topics with recent research are used to aid the process of developing a model that has substance and value. Those categories range from issues with grain transportation, inventory stocking and problems, MRP modeling, and risk in the supply chain modeling. Figure 2.1 explains the steps of how each fit into the model. We also discuss the mechanisms available with rail-car ordering as well as the issues associated with the rail industry.

Grain transportation has given us an outline of the problems specific to grain handling and marketing, the focal point of this thesis. In order to fully understand why there are problems with the current system, it is important to understand what types of transportation and issues are outlined in the research and the everyday life of a logistic coordinator for commodity merchandising.

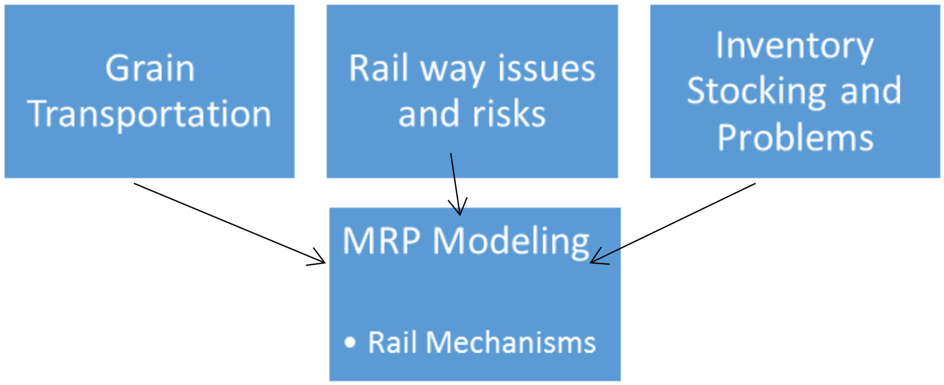


Figure 2.1: Literature Review Table

Risks with supply chain management give us an outline for what kind of risks a normal supply chain can see and how supply chains have been used before. While some risks are not modeled the same way, their impact can be developed to be more suitable for an MRP model. This chapter is also important because it should give us a grasp about what should be defined as a stochastic parameter. Within the logistic process, especially one dealing with rail usage, there are many risk-defined variables.

Inventory stocking and problems give us an idea about what methods were used for storage and how those storage issues can be modeled. This chapter is important when counting on storage capabilities to provide value for the logistics process. Inventory is a key component to reduce risks. Inventory management, along with other strategies, have to be modeled to provide an accurate portrait of the full logistics process.

All of the above categories lead to the development of the MRP model. This section gives us an idea about how to model an MRP to gain the most useful information to provide accurate results. This section reviews multiple articles that were written using the MRP model as well as specific cases where the MRP model was reviewed as a model of substance. All the research and modeling contained in this thesis fringes on a model with accurate and stable results; the study depends on assumptions and the hypothesis of risky variables. We also discuss basis risk and values.

Grain Handling and Transportation

This section looks at articles related to grain marketing and transportation as well as various articles explaining the issues involved with commodity-related companies, in particular. The first two articles go through the strategies involved in the grain's logistics and supply chain to either export destinations (Wilson, Carlson and Dahl) or general disruptions of a single market (Wilson, Dahl and Carlson). In order to fully grasp the subject matter of both articles, you have to understand the responsibilities of managing both domestic and international grain-logistics pipelines. Trading has risks of its own, even after the trading has been done, the grain has to be shipped to end users. Any cog in the puzzle that is not moving properly affects the timing and, in the end, can lead to lost business or hefty costs associated with late delivery. Both articles mention the variability of grain logistics. Some mechanisms in the articles that have meaning to the research conducted in this thesis are explained.

Grain logistics have many risks, but there are various unknown factors that can rely on predictions from outside sources, such as the United States Department of Agriculture (USDA), or simple word of mouth. "Yearly supplies of grain commodities are unknown in advance of harvest and deliveries into the system within the year are highly variable" (Wilson, Carlson and Dahl 1). This statement is not shocking to most grain-trading companies. Each farmer or contact has the right to sell or not sell a product to grain-trading companies or elevators. This aspect of the grain-logistic process is one that needs to be included to capture the uncertainty of the supply for the company in question.

Rail/vessel transit time is a topic in both articles. “Sales are made for a shipping period, although the timing of the vessel arrival is uncertain” (Wilson, Dahl and Carlson 6). Transit time is a main point of research as well as part of the fabric that will lead to more understanding about how it affects the entire supply chain. “Sensitivities are run to demonstrate a naïve strategy in which a shipper specifics a want date without considering railroad performance” (Wilson, Carlson and Dahl 14). With experience and proper modeling, the goal of this thesis is to develop a way of planning around this naïve approach so that grain-trading companies can have a base case for how important the strategies are around the logistic process of grain trading.

Grain-trading companies are not the only members of the agricultural community facing risk with logistics. “U.S. railroads originated 24,194 carloads of grain during the week ending December 13th (2014), down 6 percent from last week, up 17 percent from last year, and 18 percent higher than the 3 year average” (United States Department of Agricultre 1). The important numbers above are the 17% increase from the previous year and18 percent higher than the 3 year average. This increase is due to the recent letdowns in railroad shipping that have gained vast attention from the country and large elevators. There are many sources that can be used to explain how demoralizing problems with logistics can have on business. “Several National Grain & Feed Assn. (NGFA) member companies reported costs to their individual firm’s ranging from $10 million to $20 million during the October to March period” (Fatka 4). This impact in monthly costs averages around $1.5 million to $2.9 million on the individual firm level, per month, between October and March. This type of issue reaches the elevator’s profits and reflects the types of prices that farmers get for their crop. If elevators cannot plan their railcars efficiently, the customer base will eventually move to a more stable price. Figure 2.2 is from the December 2014 USDA Grain Transportation report.

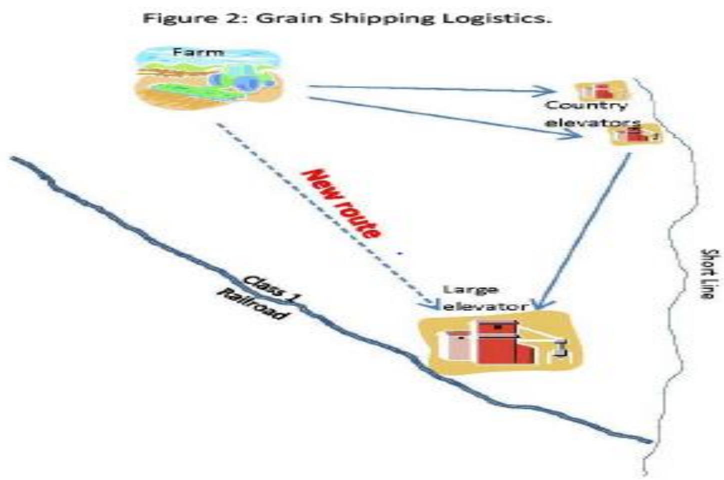


Figure 2.2: Grain Shipping Logistics

(United States Department of Agricultre 3)

"Railroads in pursuit of efficiency started to run larger capacity cars favoring grain shipments from larger shuttle-loading facilities" (United States Department of Agricultre 3). This type of structure means more cost, initially, for large elevators and long-term costs for the farmer. The farther an elevator is from a farm operation, the more it costs to get the product there. Competition among elevators affects the prices the farmer receives, and the country elevators lose/gain based on structuring and planning their logistic process. In the grand scheme of things, the market is moving toward a more centralized process, meaning larger and fewer elevators. Figure 2.3 shows the number and capacity of U.S. elevators (USDA Grain Transportation report circa December 2014). This graphs shows the elevators located in the United States as well as storage capacity. The largest volume is located in the Midwest which is expected.

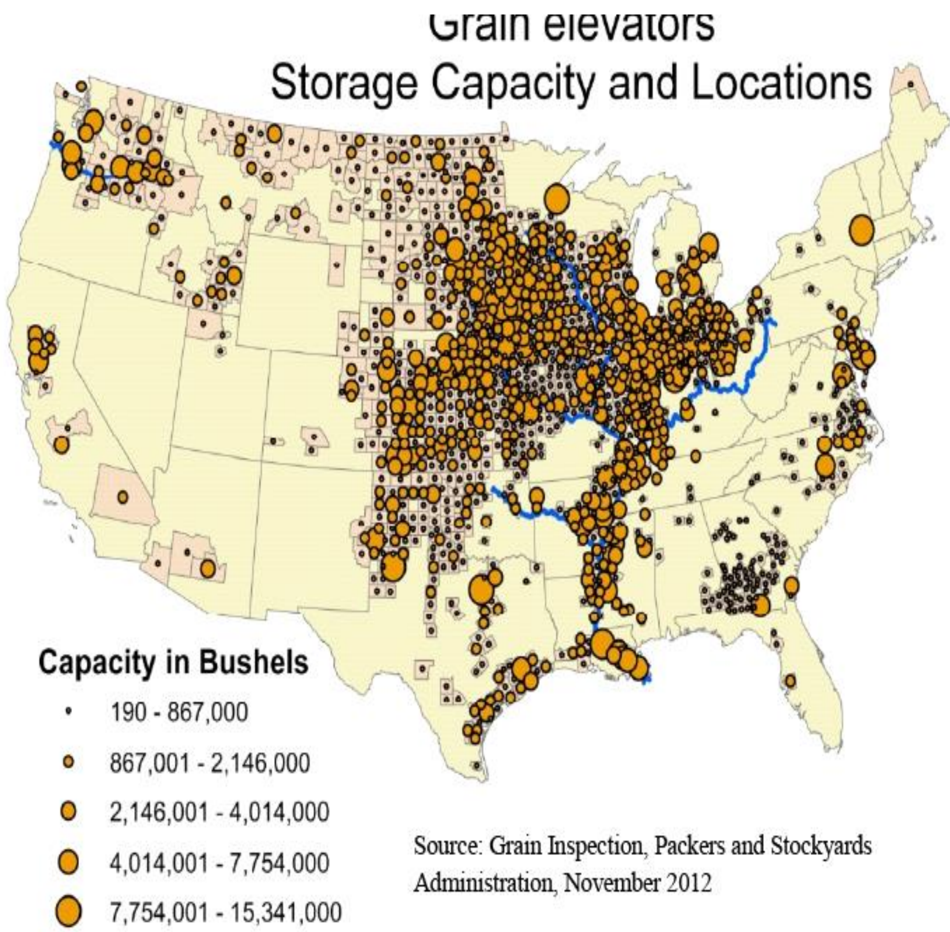


Figure 2.3: Grain Elevators' Storage Capacity and Locations

(United States Department of Agricultre)

The locations where the largest capacity of elevators are located at either a domestic or international trading point. The majority of the elevators are located in the Midwest because these states are the major grain producers. The locations of the successful elevators are not always the closest ones to the farm, but have now been drawn to where it can ship product internationally as well as domestically efficiently. Elevator locations lead to the most profitable business', and more elevators mean that grain trading companies can maintain and sell inventories effectively, which is directly correlated with the elevator's ability to ship the product.

The logistic process is set up in ways that most can understand, although, in the case of most businesses, the areas shown on a roadmap have many risks involved with production. When examining the execution of trade at the plant level, it now becomes a model of extreme volatility. Merchants need to pump vast amounts of product through the elevator at one time in order to turn a profit for a grain trading company due to the fixed and variable costs. This process is not conducted by one individual, instead being done by a team devoted to overseeing the incoming and shipped grain, but this team has its risks as well: human error. The life of an elevator would become easier if prices did not fluctuate and if the margin at which elevators can sell were profitable; however, the world does not rotate around merchants' needs.

A merchant can be described as someone who buys and/or sells products made by others in order to earn a profit. Merchants are in charge of earning a profit (i.e., margin) for either themselves or a company. A margin is simply defined as the ratio of profits gained compared to the costs that occur with a sale, which, in the model, would be the profits gained from selling the commodity compared to the cost of purchasing the item. Purchasing and selling commodities starts as a simple process of who is the buyer and who is the seller. Realistically, we have hundreds of risks associated with commodities which cannot be accurately measured or used in the model, even though it holds great value in understanding these risks so that we can understand how it could affect the outcome of an economic model. Now, we look more closely into the profits and losses to explain what composes the risks and how understanding each risk affects the critical thinking of the model developed in this thesis.

Profits stem from the merchant team's ability to purchase a commodity at a price where the team can, in turn, sell the commodity at a higher price and have a positive margin. These prices are available through many sources, some of which are free (USDA) and some of which require payment (brokers or custom information). In either case, the availability of information has become the spearhead of decision making as the search for the lowest or highest price expands. Having information first is ideal for planning ahead, but that information does not always come free and may not be legal; nonetheless, information drives prices and helps force competition among various individuals and companies. Having different information also sparks specialization for various positions in a company. While most information is made public, some is not public until the right buyer or seller is found. This is true for both grain trading and rail ordering which are discussed later in this chapter. While information is important to plan your purchase and sale, it is also important to build strong relationships with your customers and suppliers while delivering a quality product in a timely matter. This delivery can depend on geographical locations, and it may include trucking, rail, and barge delivery options; the method depends on your customer. Freight is also scheduled to make sure that delivering a new product and selling a purchased product do not disturb each other. There is limited space for unloading and loading the three different transportation types, meaning that the delivery and shipment of products cannot occur at the same time. This also means assigning priorities to the shipments and the inflow of products in order to meet the demand and not incur penalties such as demurrage.

The costs associated with an elevator range from the products which are purchased to the costs for powering the elevator every day, in other words, the models variable and fixed costs. The fixed costs are defined as ones that do not depend on the day-to-day operation but, instead, on the long-term costs associated with running the elevator. Examples of fixed costs include the rent due for the elevator and land, this cost is subject to some debate because common economic theory states that there are no fixed costs in the long run. In the models case, we assume that any cost which cannot be changed within the evaluation period is a fixed cost; these costs include rented space and any expenses involved with storage expansion or construction. Variable costs depend on moving the product through the elevator. An example would be the cost associated with the merchant spending the time to purchase the product, drying a wet product, and paying for the electricity or gas used to power a loader, the list could go on, but the general idea is the costs that grow on a per-unit basis.

The combination of profits and costs is the key to running a plant or elevator. The margin gained per product affects many decisions, including whether an elevator should stay in operation. These transactions and decisions are just one part of the entire logistic process. We went from a simple transaction of purchasing and reselling a product to decisions about how much to buy and whether the elevator is profitable. Understanding the decision-making process for a single elevator can involve manipulating many different processes which all need to come from an educated team in order to fully decide what is best for the company. After these plant operations are decided, they need to be reevaluated constantly in order to change with different market conditions, making the model a highly complicated one.

Grain transportation is a process that has its own hidden risks while accompanying evidence of the discounts and premiums associated with the commodities traded. Product safety is a huge component for the entire logistics process, specifically with the product's transportation. With outbreaks of E. coli and other crop diseases, a single outbreak that is tracked to a plant or elevator leads to a revenue loss and, in some cases, the loss of the business. Infestation can occur in so many different phases of the process that pinpointing the cause becomes a close to impossible task. For this purpose, the transportation process is not only loading a hopper and sending it on its way, but also involves tests for safety and readiness to board. Safety is among the most important steps at any elevator because safety affects business in the most direct way. If your product is associated with an outbreak, your demand would, therefore, decrease. While grain trading companies plan their shipments, they also need to keep the availability of transportation in mind; managers also need to verify that inventory levels are kept low while maintaining a positive balance to hedge the risk. If one piece of this process is halted, it affects the remaining steps in the process. If it takes too long for a car to unload, we delay the rest of the plan's production. In some extreme cases, the plant needs to shut down and/or trading has to stop, affecting profits and raising costs. These factors work together to create a margin.

Rail Issues and Risks

When meeting with a supply chain coordinator or grain merchandiser for a day, you, undoubtedly, discuss the topics regarding risk. Without risk, there would be no need for planning because there would be consistent and solid prices all the time. Risk is both a tool of destruction and a tool for profits. Many recent articles have focused on risk in the supply chain process (Heckmann, Comes and Nickel) (Mangla, Kumar and Barua) (Nooraie and Parast) (Qi and Lee). Understanding how risky the logistic process can be is not a lesson that takes long to understand. What becomes challenging to vindicate is how logistics should be used to develop a model that is structured around profits.

"In the context of supply chain risk management, events are characterized by their probability of occurrence and their related consequences within the supply chain" (Heckmann, Comes and Nickel 2). The quotation above would mean that a discrepancy in the way something is modeled also affects the rest of the supply chain. For example, if a rail delivery is running late, it will also affect the late penalties. The probability of penalties increases when the rail-transit time is affected. The type of model required is one which can switch gears to more adequately adapt to each chain at each cog in the process.

(Nooraie and Parast) Provide a guideline for how both supply and demand risks fit together. Grain transportation would not be possible without farm operations providing the product. Even that step in the process involves risks, such as the probability of the farmers selling you their crop or if they can get that crop to you on time. The MRP model includes the probability of the farmers selling which will, in turn, fuel the rest of the supply chain. Nooraie and Parast used three different methods to approximate future demand: forecasting, benchmarking, and market analysis. Each has its unique adaptation and use for research. Through this thesis, which fits best for the MRP model.

Qi and Lee (2014) used a model which described two scenarios which we can interpret to fit to the model. Qi and Lee's paper examines a firm with two suppliers: one that is unreliable but cheap, and another one which is reliable but expensive. The firm then decides to mitigate the risks associated with the risky supplier by holding an inventory. In the case, this would represent storage and storage costs for the commodity. This type of inventory stocking risk is extremely pertinent to grain merchandising because most elevators have invested in larger and more accessible storage. If storage were not an important factor for grain merchandising, then all of the elevator locations would be roughly the same. In actuality, the largest elevators are located at points with easy transportation. This ease of transportation and mitigating the risk by investing in storage have allowed some companies to flourish and grow during high-risk times while others fail. Adapting the policy around reducing risk keeps business alive and the current customers happy.

Mangla, Kumar, and Barua (2014) stated, “In the modernized world, supply chain management is to be one of the key areas in order to improve the efficiency of business.” (.p 7) Their article used a Monte-Carlo-simulation approach to manage the risks associated with supply chain management; their methodology is similar to our MRP model. Their paper examined the operational risks associated with a company’s shop-floor level of production which has similarities to the elevator level of production. Each level of the production cycle has risks, and those risks lead to the probabilities, or risks, in the future of the supply chain. The decision comes down to how accurate you can be without including every risk variable. How do you decide which ones to include and which ones to omit? This question is answered in later chapters; for now, we examine the specific issues that revolve around the railway.

The market demand for railcars fluctuates with the demand of the product being shipped. Rail mechanisms are discussed later in this chapter, but those mechanisms are used based on the expected product demand. The issue involved with planning for demand, especially with commodities, is evaluating the expected crop production over the course of a year. Large fluctuations in crop production affect prices and the product’s demand. The 2013/ 2014 crop year is a prime example of miscommunication and poor planning that lead to dismantling a market; this situation reached and affected prices worldwide, specifically in North America which projected its total losses due to the railways at upwards of $5 billion. We can examine the statistics and point to positions where planning and preparation aid all users and producers in the logistics process, remembering that not all issues can be changed, but the issues can be understood with better information. Many railways have a system of guaranteeing movement. “CP earlier this year circulated a proposal for a new allocation policy which would guarantee movement for companies booking 112 car unit trains. Trains of 56 cars would come from a general allocation on a first-come first-served basis, and cars in the 1-25 range would be auctioned off" (Gray 4). This type of guarantee could have value for individuals who use a large number of cars. On the surface, it seems like an attractive deal, but what guarantees are there? Right now, you have the option of booking these trains; even if they cannot move the product, you, as the product shipper, pay the price. This movement guarantee needs to have specifications to verify that, if the railway does not move a product, the premium for ordering the cars is paid back.

The rail industry is not like the option market or futures because there are no guarantees for prices you pay and because there is no guarantee about a product for which you pay and plan. We also come back to the issue of not having enough information. The United States has the USDA which is spearheaded to provide information for producers who can efficiently decide on the year's production, meaning that competition can thrive. "Third quarter results were released on Oct 21, 2014, with the earnings per share of CP (Canadian Pacific) up 26% and CN (Canadian National) up 21% compared to a year earlier. CP indicated that they had delivered the strongest results in company history, while CN had their highest third quarter results in company history" (Gray 5). It is hard to understand from a producer side seeing how slow product was being moved, but the railway is still making profits. Looking at a larger view, we can understand that the slow transit time was caused by more than just deficiencies in the rail industry. Canada had a record harvest in 2013/2014, totaling 90,293 kt, which was a factor for the decreased transit time. Neither side of the spectrum plans based on record-breaking harvests and, instead, portrays "most-likely" scenarios which were not predicted as a record-breaking harvest. Rail companies do not deal directly with farming operations, instead working with the elevators and grain-originating companies that directly pay the rail companies. These factors are a mix of risk ingredients that made the 2013/2014 crop year a disaster in Canada.

The U.S. railways also had deficiencies and had a drop in transit time for grain commodities during the same time period. While the factors affecting the deficiencies are somewhat different, the profits were nearly identical for each quarter, averaging around 20% (Gray). One problem that arises is oil drilling in the Bakken. The pressure to move oil cars severely outweighed the pressure to move grain which, in turn, decreased rail-transit times, producing similar results as the CP and CN rail deficiencies did for Canadian grain producers. Ideas for fixing the problem have been sweeping national and international headlines. Railways have made investments to improve the process and to help the economy; this action is taken to prevent further involvement from the government.

One thing is for sure: it will take cooperation from both sides of the logistic process to fix the issues. All the issues come back to not having enough information and understanding from both sides. Looking at the railway deficiencies, some factors that affect rail-transit time are completely outside the companies' control. When thinking about the number of railcars moving throughout a given day as well as the possible breakdowns and traffic build up, it is easy to understand how the rail industry does not perform to customer demands, which also illustrates why there are no guarantees. On the same note, the railways have been making profits with the need for more transportation. The 2013/2014 production year is an example of how the increased expense for reliable transportation can affect the costs associated with grain logistics.

Plans of action are set for simple routines, such as a tornado drill or a fire drill; everyone knows where to go and be in order to prepare for an emergency. Successful business is tailored around planning based on market observations and data, and it seems that most individuals plan to prevent future occurrences after a large-scale failure. While 2013/2014's rail-transit time decrease was hard to predict, it was an occurrence that could not be anticipated. For the most part, planning would come with the assumption of worst-case scenarios; planning also would have to be modified based on the specific situation, and for the most part, it became an example of most companies losing money because of assumptions that did not come true; this situation was blamed on the railways. Eventually, rail movement became a cutthroat business to ship a product, emptying a lot of pocket books. A plan needs to be in place for all spectrums of the severity of a process which, in this case, would be the elevator's logistics process. Planning by the elevator could have helped immensely with the transportation issues, but now, we get back to the issue of information and how available it is. For now, this debate is outside the abstract of this thesis, instead, we examine the issues that plagued 2013 and 2014, showing how much they affected the profits, to justify the predicted economic losses.

Railroad Mechanisms

There are multiple rail-car options available to companies shipping a variety of products. For grain shipments on the railway, you have two options. One is the single-car programs where railcars are offered by the railway for a certain shipment period during the month: 1) first period 2) middle period and 3) last period. Ordering in three periods is a great option for companies that may not need the type of rail volumes that a larger elevator requires. The second option is destination-efficiency (DET) or shuttle trains which can ship over 100 cars during a given time period. Shuttles are the primary option for elevator locations that wish to ship to export destinations as well as domestic destinations that serve a widespread area. Shuttles also give increased capacity for the movement of product. This increased capacity adds to the purchasing power of a grain trading company.

Table 2.1: Railroad Shipping Options

COT Programs	***Description***
Individual car orders ***Monthly*** ***Yearly***	Single-car ordering allows you to place a bid on the primary/secondary market for cars that are needed in the short term. Problems arise when others place a higher value on railcars than you do.
DET ***Shuttles***	Allows the purchase of a 110-car train that is ordered from 4 months up to several years of guaranteed cars. Problems would include not being able to ship 110 cars in a given month.

There are many mechanisms of shipping products by rail. Rail options include the market-based certificate of transportation (COT) reservation, pulse COT, or lottery, and the options can include cars under contract of up to 110 cars for up to several years. This shipment is not segregated to include only typical traded commodities but includes anything that can fit in the railcar. Looking specifically at the BNSF website, there is a list of ways to ship products by rail which includes single and the shuttle rail processes. Each rail mechanism is examined to ascertain the benefits and disadvantages for customers in need of rail services, as well as an examined look of the secondary market for rail cars. Both the railway auctions and the secondary market hold a key role in the logistic process.

Table 2.2 examines each rail road mechanism and its description. Table 2.2 provides a starting point to the logistic information provided in this thesis.

Table 2.2: Railroad Mechanisms

Rail Road Mechanisms	***Description***
Market-Based COT	Ordering according to a weekly schedule per month. Bids for cars are every month and are awarded to highest bidder. Car placement is guaranteed.
Pulse COT	Preorders can be made upwards of 14 weeks in advance. Once the need is known, the bidder places a reservation, and available cars go on a first-call, first-served basis. Car placement is guaranteed.
Lottery	Bidders enter a drawing for available cars; the winners are drawn at random. No car placement is guaranteed.

(BNSF)

Single railcars are available for both yearlong and monthly terms. First, we examine the yearly single-car order. In order to obtain a railcar for use, you need to be involved with the primary auction available with the primary railroad which owns the rail space. Companies can become large enough to purchase their own private fleet; this option incurs a charge to ship and does not guarantee shipment, but the option does guarantee cars. Other companies need to participate in auction-based bidding for railcars over the month. For the most part, this process is efficient process and has been proven with economic game strategy; the meaning behind game strategy is that the individual who values the product the most wins the bid, which is economically efficient.

The individual(s) who win(s) the bids for cars offered by the selected rail company has a COT; the COT is the right for rail-car use. This certificate gives the holder the right to utilize the railcars over a certain time period. For elevators, railcars would be used to bring a load out so that it could be made ready to ship the commodity to the end user's destination. This certificate of transportation is not a guarantee for a timely shipment but, instead, the right to use the railcar when it is readily available. This issue is key for understanding why rail-car transit time is such an issue. Rail-car bidders order what they feel the elevator will need based on the assumptions about how many trips they can get a month. If it is assumed that a railcar is shipped and can return in one month, the grain trading company will bid on cars based on company needs and the availability of shipping for that transit time in a month. If that time is cut in half, you are short railcars for your projected demands, and you have to tap resources on the secondary market or order other shipment methods. This shortage creates an issue on the side of elevators that can come as a sense of blame that is directed towards the rail industry, but in reality, logistic issues are a combination of risky business and a gamble that does not pay out. In this situation, proper planning could solve the problem whether the rail industry provides the expected service or not. Although poor performance, more than likely, results in a large expense for the elevator, poor railway performance is not unexpected and can be planned for accordingly.

For the most part, single-car ordering per month is a key method of logistic planning for smaller operations to fill orders. Single car ordering is efficient, in the economic sense, because the highest bidder is the one who values the railcars the most. The only issues involved are the rail-car specifications which are not guaranteed and which would include a focal point of this study, rail-car transit time.

There are also multiple-car term options for rail-car ordering that were introduced in the 1990s; these options help grain-trading companies mitigate risk. "Shipper-owned or -controlled railcars are leased to the carrier in return for a negotiated fee and a specified number of guaranteed loadings per month" (Wilson, Priewe and Dahl 527). We focus, specifically, on the shuttle and DET program which guarantees attractive specifications. This type of agreement works for both the shipper and the carrier because it is a guarantee for the availability of cars, but this arrangement comes with some speculation about performance. If the grain trading company cannot ship cars per the orders, it has penalties which would include demurrage while, if the shipper does not perform, the shipper has the right to defer the contract. Deferring creates informal checks and balances for both the shipper and the carrier, which have advantages over the bid of railcars with the monthly COT program. Railcars ordered as part of a shuttle incur no demurrage cost if they are shipped within 24 hours of the railway's placement of these cars. They are also a way for one elevator to ship a product to one destination over the time of the COT. This deal is attractive when the transit time is favorable and when the product can move more than once a month.

The pooling process of ordering multiple long-term railcars gives the shipper the price for the duration of the contract and the amount of guaranteed loads a month, allowing the shipper to plan merchandising decisions for the long term. The issue then becomes a long-term plan which is unfeasible, in which case a decision to order monthly COTs becomes a wise decision as you order what you need for the month.

DET shuttle trains have a few constraints:

- A 110-car train is comprised of four monthly or a year-long Certificate of Transportation (COT).
- All COT units that are combined to create a DET must have the same shipping period.
- A DET may be split enroute for unloading at multiple destinations.
- Dedicated locomotives
  (BNSF)

Specifically, the shipping specifications involved leave room for explanation and define the model's parameters. If you are shipping a 110-car train, you need to ship all the cars within the same shipping period, but each car can have a specific destination that is different than the others. Excess cars give a shipper the ability to sell excess cars on the secondary market or to ship a percentage of owned cars to different customers which can be beneficial. Secondary cars can also backfire if the rail market does not demand freight or if customers do not demand product. Secondary rail markets are focal point for this study.

We cannot forget that these programs are made not only for grain, but also for any product that can be shipped via railcar. "Increased demand to ship coal, oil, intermodal containers, sand, gravel, and a combined record harvest of corn, soybeans, and wheat in the United States put added demands on the rail network." (Economist 3). Oil in North Dakota's Bakken region demanded much of the rail during 2013/2014. For states such as Minnesota and North Dakota, where the primary method of shipping is rail, the farmers and elevators were left with little choice about how to deliver products. The USDA website showed that prices for grain commodities in these regions were lower and, in particular, were decreased due to the higher shipping costs paid by the elevators and the low supply of quality storage. While a long-term contract offers shippers the right to defer their contract, they are still in the hole when it comes to shipping products to the buyers. In times of a shortage, the secondary market offers shippers rail-car use at a high premium.

The secondary rail market is an option where the owners who have the right to use railcars can sell guaranteed shipping to others for either a premium or discount based on market values. This market is a direct view about how well or poor the rail market is doing because the premium is high when carriers are performing poorly; when the carrier is performing at a satisfactory level, there are discounts for railcars. Trucking is a valuable option when shipping a product short distances but can be ineffective when shipping from the Midwest to the coastal regions where the product is shipped internationally. “They [trucks] are usually less costly than rail or barge within about 250 miles between origin and destination” (Economist 5). This observation can be seen with many elevators located in the Midwest where the majority of the shippers only have two shipment options: truck or rail. This competition also plays a part with grain shippers’ decision-making process about whether to enter the secondary rail market. Secondary markets are highly volatile; are based on the supply and demand for railcars; and can range anywhere from $7,000 per car to an extreme discount. There is a premium when railcars are not in supply but demand is quite strong while a discount exists when the supply is quite high with a nonexistent demand. In either case, secondary markets are easy way to determine the strength of the rail-car market and how performance is being evaluated at the shipper level.

Figure 2.4 shows the dependency values of railcars per state between 2009 and 2012 (Economist).The two highest states during this timeframe were North Dakota and Montana; rail cars for each of these states is easily explained because of their distance from the major water sources that would allow elevators to ship by barge. All these factors play into the dependency from grain trading company on the secondary market during times of great delay by the rail industry. Companies also have the option to own private cars which provides the certainty of having a car to load. These private cars are owned by an individual or leased long term for use over many years. Rail cars are also not guaranteed to be delivered in a certain time period because they are still included as freight-related transportation. Whether you own the railcar or not, the transit time is at the discretion of how quickly the railway can ship and provide the railcars to the grain trading company.

Figure 2.4 Rail Cars per State

(Economist)

Figure 2.5 shows the BNSF railway system in the United States. The origin elevators and destinations for our model fit BNSF well, which is why it can be used as the primary railroad and credits the use of the BNSF tariff and charges. The BNSF also allows for sale in the secondary market. Not all rail ways allow sales in the secondary market, which secondary markets added a unique decision variable to this thesis. The BNSF also services export and domestic locations which handle both corn and soybeans. The reasons above lead this thesis to use the BNSF railway as the primary rail market. Other rail ways were considered, but the BNSF met the needs of this thesis the best.

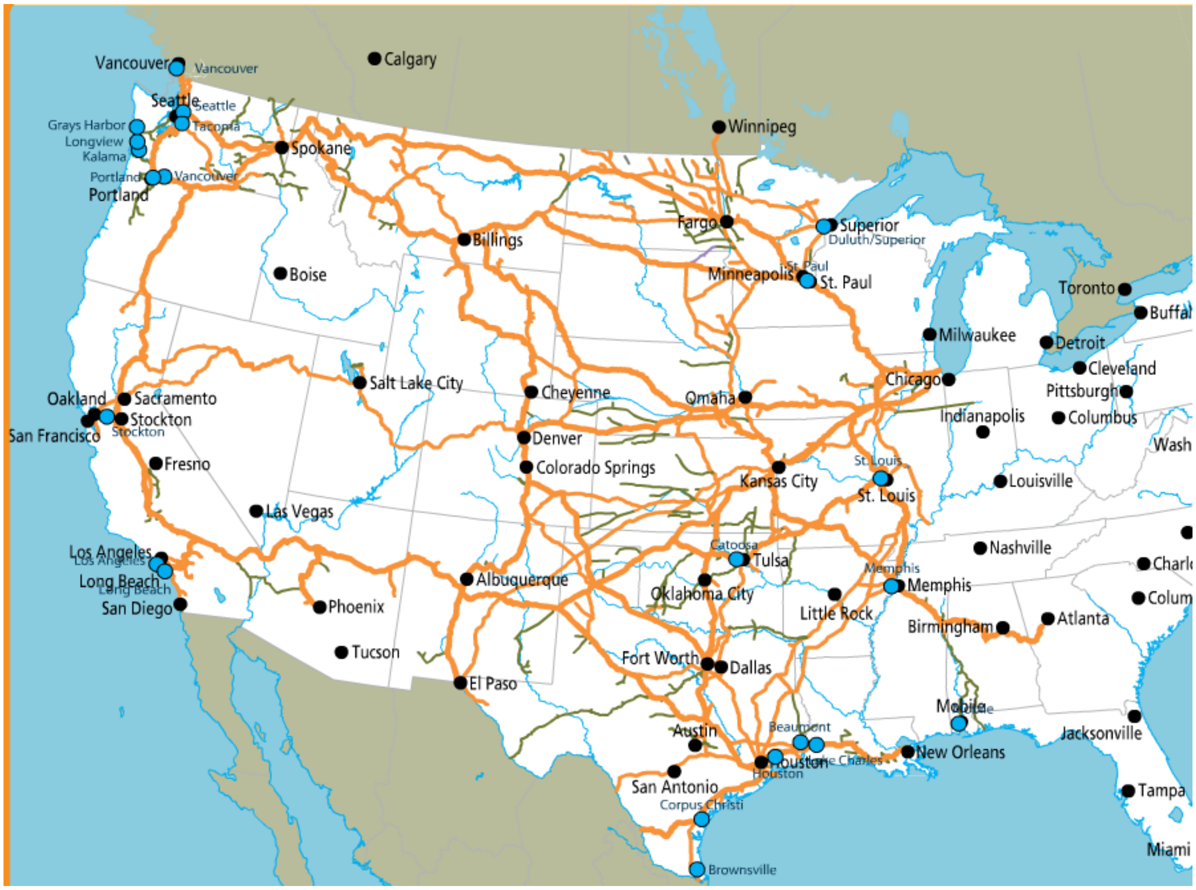


Figure 2.5 BNSF Rail System

(BNSF)

Inventory Stocking and Problems

Inventory is a key part for any logistic model, especially with the risks associated with not carrying inventory. Companies now invest time to hash out the optimal inventory level in order to mitigate risks. Many articles have been written regarding the importance of inventory planning (Bensoussan, Cakanyildirim and Sethi) (Geunes, Ramasesh and Hayya) (Stowe and Su). Inventory is a key risk reducer because of the ability for not having to purchase items on the open market and having excess on hand in order to meet your demand. “In general, however, the central focus of inventory models has been the optimal tradeoff between different types of costs such as ordering, inventory holding and storage costs” (Geunes, Ramasesh and Hayya 237). Because grain trading companies includes all of these costs, these papers may not portray the optimal model of rail-order quantity for an elevator, but it provides feedback about how a model involving these costs should be structured. While Geunes, Ramasesh, and Hayya examined the losses associated with a military unit not having radar tubes in stock, this thesis can relate with the commodity product. When an elevator cannot meet the demand with current purchasing, storage has a pivotal role in the logistics process. Likewise, when commodity prices are too high, loss can be reduced by using stored product which constitutes a risk-mitigating behavior.

Stowe and Su (1997) also looked at inventory as a risk-mitigating behavior that was originally not planned around risk, but its purpose and substance should be derived from risk. “The conventional approach is particularly unsatisfying when we consider that financial economists approach other corporate finance decisions with models that account for risk in an economically meaningful way, but do not do so when modeling inventory decisions” (p. 42). This approach does not provide accurate results. The first case studied involved the probabilities of each state were 25%; while this probability may be realistic, it is not probable when dealing with grain commodities. Over the course of a month, you can have many swings in demand and supply, barring many different economic and noneconomic events. This thesis focuses on inventory risk factors from the beginning to the end of the logistic process.

MRP Modeling

MRP is used to structure the model and the outlying information in the chapters to come. In order to understand why and how MRP is used, we need to look at past examples and research (Horvat and Bogataj) (Ballou) (Horvat and Bogataj) (Koh and Saad). “The purpose of MRP, from a logistics viewpoint, is to avoid, as much as possible, carrying these items as inventory”

(Ballou 317). Ballou is speaking about the products within the supply chain process. Inventory is an essential part of grain merchandising, but it does not take much to know that products sitting in storage do not make money while waiting to be shipped. Inventory is a means to mitigate your risk, meaning that you have to meet the demand for the product you are shipping.

Table 2.3: MRP Model Benefits

MRP Modeling	*Description*
Production Planning	MRP allows a grain-trading company to set relative values for a product to bring in and out over short- and long-term scenarios.
Storage Capabilities	MRP allows for parameters on storage for buffer-zone practices, as well as allows for the adaptation of risk.
Risk Factors	With the help of computer software, MRP can give certain values risk or expected values which, in turn, changes our decision variables based on the percentage confidence in numbers.

The MRP model is useful because of its adaptation to risk, such as the model portrayed by Koh and Saad (2003). Their model was developed to overlook a MRP model with certain variables, such as tools, labor, and capital, as a multi-level demand system. Like the proposed model, Koh and Saad included process steps which, in turn, affected the next step. Tools affected labor and capital, and labor and capital affected the product which, in turn, would affect customer satisfaction. Uncertainty is the root cause of any planning system, and in the case, uncertainty affects every step of the logistic process. The model includes a multi-level system that leads from one cog in the system to another one. This relationship is important to model and is adopted when using an MRP model.

With every model, there are errors with the way it has been used in the past. One paper, in particular, is used to identify problems for the model and to help build upon to add to the literature (Lagodimos). The focal point of that paper is the optimal level of customer service as well as how an MRP model can be changed or alternatives can be used to increase customer service. A company's policies need to be set so that the company protects its assets and keeps business alive, which also includes customer satisfaction. The overall goal of a successful logistic policy and process should keep the customer happy while protecting the company's stake in the market. Not all plans are optimal for both logistic policies, but there are ways to come close to reaching goals while having a standard practice of business. Obviously, these plans need to be updated periodically because the business environment is always changing; in an economic sense, risks are changing.

MRP is a sufficient structure for the model about grain logistics based on the purpose and mechanics of this thesis. Ballou (1992) describes MRP as "a formal, mechanical method of scheduling whereby the timing of purchases or output from production feeding operations to meet master production schedule requirements is determined from offsetting the requirements by the length of the lead time" (Ballou 534). With grain merchandising, you should have a general concept of when the raw commodity products will be needed based on past research and events. You have the contracted times for rail usage, and that has become the center point of this research. You are also aware of your storage and capacity limits in the short run, allowing you to plan for fluctuations based on reports and past research. The difference between the start of your logistic process and your end-point production is the uncertainty involved with the processes you have to complete in order to meet the production's end point. The purpose of the MRP model, then, is to find an optimal time, T*, where your product arrives at each cog in the process. If a product arrives early, you incur a storage cost while, if a product arrives late, you incur a late charge. This thesis focuses on reducing the risks associated with the elevator level of a grain trading company while meeting the demand and maximizing profits.

Basis Values and Risk

Grain-trading companies are profit maximizers but still have to adhere to risk because it is part of everyday life. "In a basis transaction, a merchandiser makes a purchase or sale of grain and hedges it with an offsetting futures transaction, then waits for a favorable move in the basis to occur" (Lorton and White 8). Basis provides a value that has a relationship with the futures and the flat price on the market. In some cases, an elevator offers a flat price for commodity products or offers a basis value which is the amount under or over the futures value based on preconceived market conditions. "Hedging involves the exchange of flat price risk for basis risk, i.e., the risk of changes in the difference of the price between the commodity being hedged and the hedging instrument. Such price differences exist because the characteristics of the hedging instrument are seldom identical to the characteristics of the physical commodity being hedged." (Pirrong 13). Basis values are the link between flat price values across the county because they are both based on the futures price and the local cash prices at the origin. In general, you see basis values at the export or domestic locations to be more favorable for grain trading companies shipping to end destinations. The favorable basis is due to the shipping costs incurred to get this product from the origin to the destination. "Because basis at different locations is the measurement of local prices against the same reference futures price, the discussion of comparing basis is synonymous with the discussion of comparing local prices" (USDA 31).

Basis is a way to compare prices at different locations, but it is also a way for farmers and elevators to reach price agreements for their crop. Futures and cash prices can be extremely volatile, but the basis can remain very similar through times of extreme volatility because a change in futures can be offset by a near equal change in the cash price. Basis is key for this thesis because it is a main factor for the profit-maximization function.

Summary

Understanding the key factors in this chapter leads to the variables that are added to the model. This knowledge also gives an idea about how a model with substance needs to be created for a grain-trading company which is making decisions about product shipment or rail trading. Previous studies provide stepping stones to create new research ideas.

CHAPTER 3. THEORETICAL OVERVIEW

Introduction

Theory is the key to driving results and describing how those results affect the modern world. Theory provides an understanding about why decisions or projects are made as well as how the model is developed to solve problems. Agriculture is shrouded in risk-taking behavior because the values involved are not known, but risk can be measured based on market conditions in the form of public and private information. Agriculture is an interesting subject when speaking in terms of economic theory because the answers are not always defined by strictly focusing on one aspect of a model. This chapter illustrates how grain-handling companies must manage inventory levels in order to supply customer demands and needs while also managing profits and costs. Theory helps us answer why decisions are made to drive results; in the case of an agricultural elevator, decisions to run, ship, store, and sell products are all determinant variables about how successful an elevator will be.

This chapter discusses how logistical models can drive results to cause an elevator or group of elevators to make decisions about the profit-maximizing point of the determinant variables. We also examine the theoretical framework behind an MRP model and how an MRP is affected by risk. Because risk is such an important factor in driving accurate results, it is also discussed independently from the model and how risk brings the link between the MRP model and grain logistics in general. This chapter examines how the MRP model helps to explain the events that occurred in 2014 as well as what has changed to help both the railway and elevators run more effectively in order to move products to the destinations. Because theory drives results, it is important to understand every aspect of the logistic process and how theory relates to the application of the model.

Overview of the Supply Chain Models

Supply chain models can be simple or extensive, depending on how the model is used. Supply and demand rely heavily on the fluidity of product movement which is not unique to agricultural firms, meaning that the use is specific to the particular industry. The general concept surrounding a supply chain model is the product movement through a facility. There are also focal points for research that can be manipulated to match the model's specific needs, such as a reorder point. "The central focus of inventory models has been the optimal tradeoff between different types of costs such as ordering, inventory holding, and shortage costs. These in turn mainly depend on the decisions pertaining to when the inventory should be ordered (reordered)" (Geunes, Ramasesh and Hayya 5). Now being viewed is a model that considers the costs associated with moving a product, a crucial part of a profit-maximization problem. Ahumada & Villalobos (2009) speak about the difference with perishable and nonperishable foods, which is another aspect of supply chain planning because not all products have a long enough shelf life if the shipment is not made. Perishable foods need to be handled differently than nonperishable foods which, in turn, can add more costs.

Ahumada & Villalobos (2009) also mention the main functional areas of an agro-supply chain model (ASC) that relate to any firm using a supply chain model: production, harvest, storage, and distribution. While non-agricultural firms do not have harvest, their concerns are focused on production, storage, and distribution. Making an item should relate to the expected demand, meaning that, if demand for a product reaches 0, the item's production should end. Storage is the application of a risk-reducing behavior by firms and agribusiness industries; storage is discussed in more detail later in this chapter. Distribution is focused on as the point of sale for a profit-maximizing firm. An MRP model captures all the characteristics of a supply chain model.

MRP Model

Manufacturing resource planning models have been used for many years with the logistic process for manufacturing resources. MRP specifically gives the ability to introduce risk to the supply chain model and helps us see these risks take numerical form within the model. Many papers have been written to describe the use of this model within supply chain logistics (Horvat and Bogataj) (Koh and Saad) as well as used by many companies dealing with supply chain management. Specifically the paper written by Lagodimos (1993) examines the buffer policy. This strategy is extremely important to understand because it is the main reason for using an MRP model, as it is a variable that can be predetermined to come to work backwards from expected values of risky variables to give us confidence in the results we get from the MRP model. MRP allows us to use stochastic and nonrandom variables to show expected and what if situations that will help us understand and answer questions based on how the model is developed. In the case we will examine critical variables of the supply chain, effects of stochastic variables which are displayed in the model, and the role they play in explaining results.

Critical Variables

In order for the MRP model to run, there have to be three sets of variables, stochastic, non-random, and decision variables, with corresponding parameters. Stochastic variables give us the what-if situations, allowing us to manipulate a situation and to see how other variables and decision variables are affected. This section is also where the "buffer policy" is examined in Figures 3.1 and 3.2.

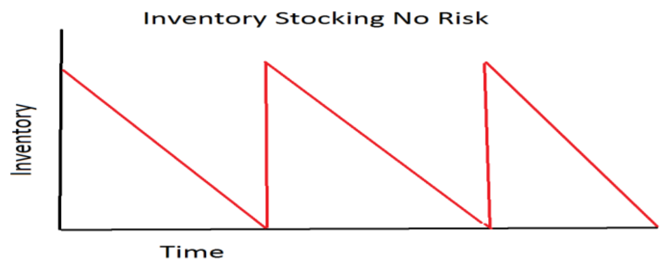


Figure 3.1: Inventory Stocking: No Risk

Figure 3.1 depicts an inventory-stocking model that simply reorders the need for sale and has no need to carry inventory over time. This is a depiction of a company that would have no expected risks with inventory planning because the business has known needs and known inventory needs, meaning that the company can draw its inventory values to 0 to keep from incurring any additional storage costs. This model type would be shown in entry-level classes to obtain an understanding about the basic structure of a logistic model, but not one that would satisfy and draw accurate results for the complexity of many, if not all, supplier logistic models.

A more accurate model, specifically for agri-business, would show a carry of inventory in some/all months to mitigate risk. A visual example is shown in Figure 3.2.

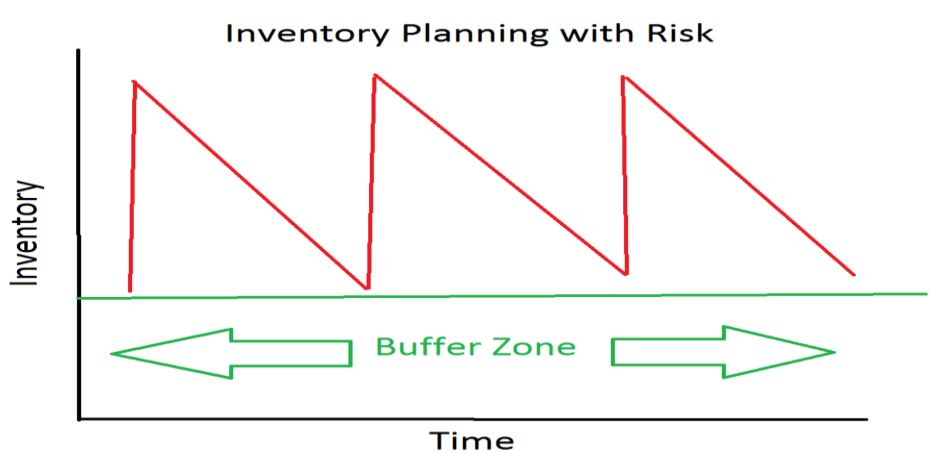


Figure 3.2: Inventory Planning with Risk

With this type of inventory planning, a firm is holding inventory to avoid being susceptible to risk in the marketplace. This risk can be various factors that affect how a business can keep the product flow stable. Without this product flow, customer satisfaction drops along with productivity for other facets of the company. This behavior has costs associated with holding inventory, but the general conception is that the buffer zone reduces unknown externalities which can, in turn, lead to more long-term stability. The MRP allows us to include these risky variables to develop a model that provides a buffer zone and can, in fact, help manage what that buffer zone should be. We need to describe these risky variables so that they can explain the relevant results of the model.

Risk and Critical Variables: The Link between Supply Logistics and Grain Logistics

The critical variables for the model all relate to the prices paid for grain commodities. Below are examples of the basis values for both corn and soybeans with the origins and destinations that are displayed in the model. The data are provided by using the DTN prophet by subtracting posted cash prices for each location from the futures price for the given time period in which it was located (DTN Prophet). First, we illustrate the destination basis which examines the competition among terminal elevators to receive product.

By looking at the following figures for the destination basis, it is obvious that prices for selected commodities are affected by the demand and supply among other factors. Prices are shown by the changing basis values that vary daily in order to influence markets to either hold or move products while seeking profit. Export and domestic locations also remain competitive with each other without equal basis values. Export and domestic are not the same; the difference is related to the expenses for moving a product to each destination. The Pacific Northwest is considerably farther for a farmer in the Midwest to deliver to than a local elevator; therefore, location is a key driver for the bid posted at these destinations.

The railways are key in moving these products because shipping by truck or barge is either not possible or very costly. Tariff rates are made for certain destinations either to capitalize on excess profits or to influence increased travel. Comparing basis values from the destination to origins, the values change in similar directions, indicating a correlation for the basis values. These correlations are examined later, but visually, correlations can be seen in the figures below.

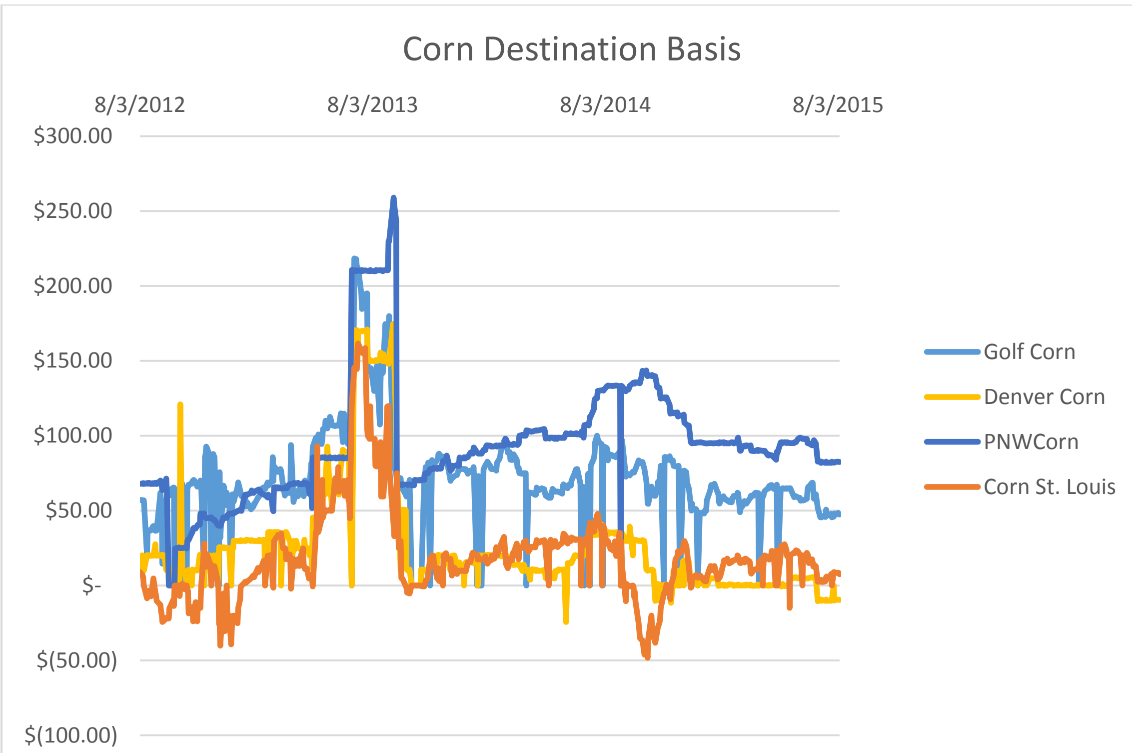


Figure 3.3: Corn Destination Basis

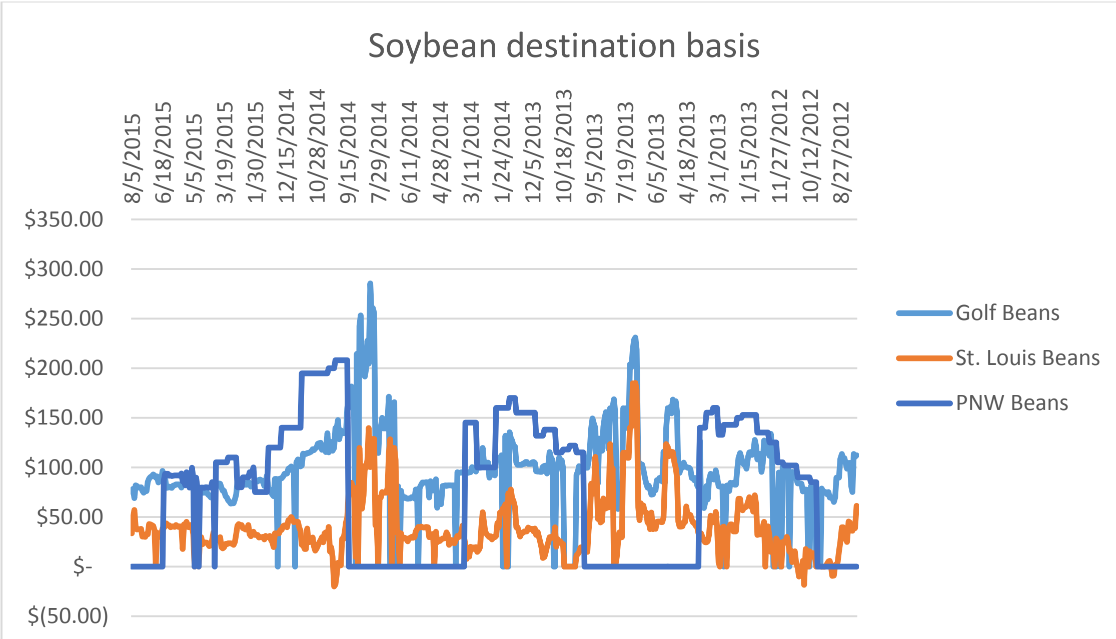


Figure 3.4: Soybean Destination Basis

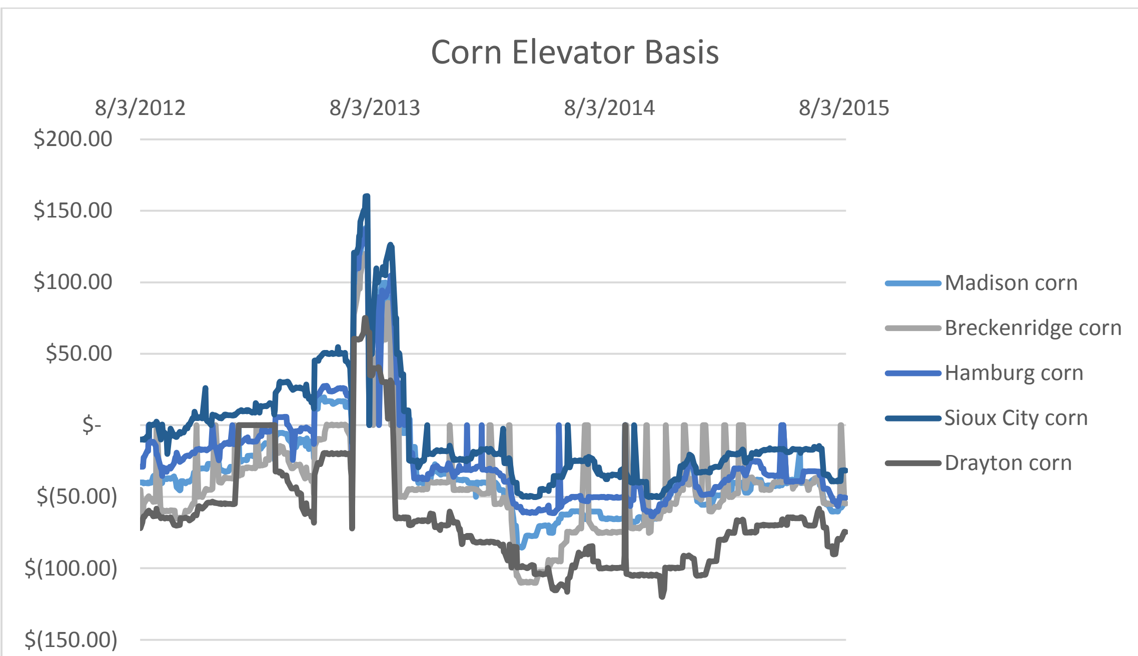


Figure 3.5: Corn Elevator Basis

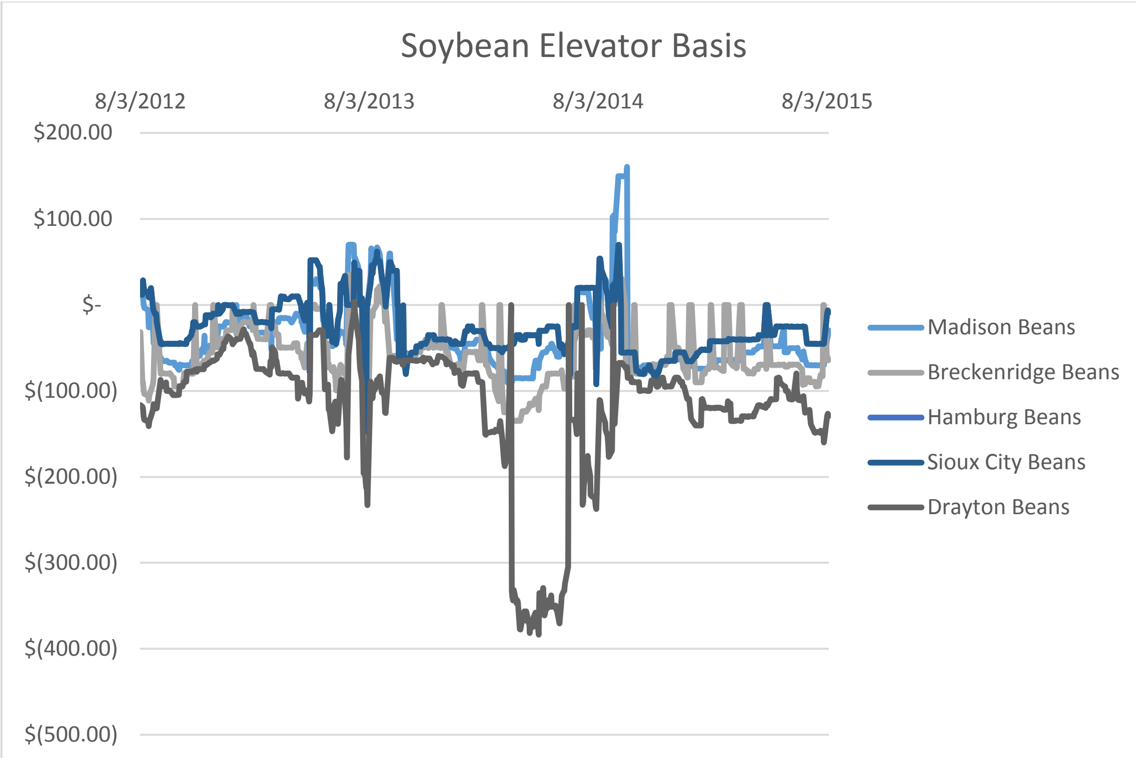


Figure 3.6: Soybean Elevator Basis

The basis values at the origins follow similar paths of the respective destinations. While destination elevators have to entice the origin elevators to sell and ship a product, local elevators have to sway farmer interest to deliver a product in order to meet the end-use demand. Elevators have various basis values during a year, giving to the link between risk and grain logistics. The buffer zone becomes incredibly important for the study because storage can help to mitigate risk and to increase profits in months where the basis value is unfavorable. Purchasing excess corn or soybeans in months when the basis values are favorable means fewer purchases at unfavorable prices. An elevator which purchases and fills storage in a month offering 70 under futures reduces its risk of purchasing at higher prices if the following months values are 40 under futures. The elevator also runs the risk of storing an overvalued product which, in turn, means the merchandiser is purchasing product at a lower value with less storage capabilities.

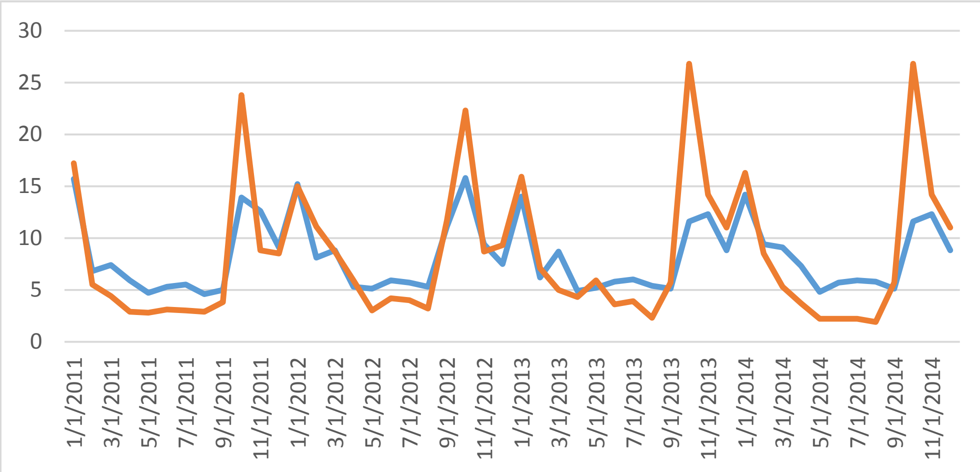


Figure 3.7: Farmers' Sales by Month

Farmer sales also play a large factor with bids. This is due to the availability of storage and the ability to move product from the farm. The majority of a farmer's yearly sales happen during harvest. Sales during this period are due to the ease for some farmers to move the product from the farm to their local elevator for sale. Others have storage capabilities of their own, which is why grain sales do not total 100% of harvest for corn and soybeans. This factor is another reason why origins and destinations offer varying basis values to entice farmers to deliver products. This value has to offset the storage value for farmers to carry over time until delivery. An elevator needs to operate during the entire year, meaning that these basis values have to relate to the origin's ability to ship a product. Harvest creates an increase for transportation, but domestic and export markets demand product year round, which we can now link to increases and decreases in the basis values.

Supply Chain Summary

Because grain elevators are designed to move a product, their process from production to distribution is a prime study example for an MRP model. Logistic planning stems from the expected production which, in the case, is the supply and demand (S&D) numbers on which each commodity-trading company spends so much time. Defining what farmers have planted determines the amount of volume that is expected to come through the door and that needs to be moved to the end-product destinations. We have a base understanding which relates to the MRP model, includes each step in the farming process, and shows how elevators make decisions about profit maximization and how they can effectively move the product. Now, we examine how the theory applies to the application of the model.

CHAPTER 4. EMPIRICAL ANALYSIS

Introduction

This chapter examines the empirical model that will be used in this thesis and why it is set up in such a format. The empirical model will link the theory behind grain logistics, and the real life application. Explanation of the relevant data and variables used is important to understand why certain aspects are used, and why others are not. The preceding gives us the "what" and "why" surrounding the empirical model. It will be structured by an examination of the basic structure of the model itself, which would include the steps involved and where those steps are located and how they fit in to the overall process.

Next we examine the model to be used which is the MRP model. This step explains why an MRP model is a valid fit into the research process and why it was chosen over others. This section also explains how this model gives us results that will be useful. Then, we examine the data that is used to develop and give values to the model. Data is the most important aspect of this chapter as the data used directly affects the interpretation of the results later. The data section of this chapter will explain the data used for this model. Finally we examine the simulation and optimization principles of the maximization problem. This section will link the use to a basic structure with model details and data which progress into the results section and allow us to understand what the results mean based on the principles described in this chapter. Simulation and optimization principles gives us the key to understanding what results mean to us and how they are important based on the data used.

Basic Structure

The model will include 1 elevator representing 5 locations throughout North Dakota, Minnesota and Iowa which are placed in areas served by one rail way, the BNSF. These locations were selected due to their location near soybean and corn farming business. There are multiple choices for each elevator to ship to, which include domestic and export facilities. The model will combine these destinations into one model as their prices and information are identical to each other. But for all inclusive information, origins and destinations are listed below in table 4.1.

The basic structure of this model includes all the key points that particularly affect the profitability of the grain trading company. This model will focus on three main points on the logistic process which will be explained at each step along the way. Those steps include the producer level which to us is the farmer who is growing corn or soybeans. The next step includes the elevator, which will be the level we are analyzing for profits and losses. Last we examine the destination of the product be it either domestic or export. Each step in the model directly affects the decisions of the grain trading company who owns the 5 elevators, as well as the profits and losses shown at the elevator level. The time frame of this model will be a 12 month period between August of 2012 and ending in July of 2013 this time frame was selected as it will show one year of normal behavior before the logistics issues presented in the crop year 2013 and 2014. A diagram below shows the supply chain model from start to finish and includes key steps which will be discussed in this chapter.

Table 4.1: Origins and Destinations

Origins	Destinations
Madison, MN	New Orleans (Golf)- Export
Breckenridge, MN	St. Louis- Domestic
Hamburg, IA	Pacific Northwest (PNW)-
Sioux City. IA	Export
Drayton, ND	

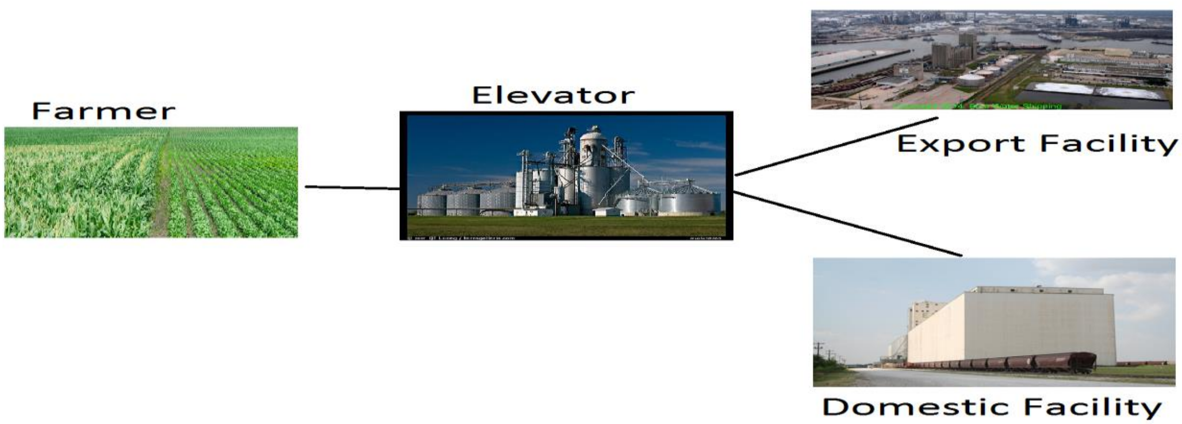


Figure 4.1: Flow Diagram

At the farm level, farmers grow their product for sale in a global market but often sell their products locally. This sale locally is more often done through a local elevator then other options available. The logistic process starts at the farm level as it is the beginning stages of the major costs derived at the elevator level. There are many options available to the producer as there are a variety of crops which can be grown for sale, but these options are limited to the demand for product within certain geographical regions.

In the Midwest the two major crops grown for sale are corn and soybeans as there usage is not limited to only there use for food. Corn can be made for many different uses such as animal feed, ethanol, corn oil as well as the corn we get from the grocery store. Soybeans are grown for their oil values as well as the importance in feed rations. Farmers have to weigh their options before each planting season in order to make a profit on their acreage planted which means they need to have certain market information to make key decisions come planting time. Elevators can offer forward contracts which offers some reassurance on which crop to plant as it is a guarantee to buy a certain amount of production at a certain price.

Farmers also have the option of selling on the cash market which means they deliver at the current market price which is more risky but can be beneficial if prices rise from the option of solidifying a forward contract. Most farmers will in fact use both of these tactics to have some guaranteed profit while also having product to sell if prices rise, which can be tricky if prices fall, in which storage will need to be used or sell the product for a price lower than anticipated. All of these decisions the farmer makes directly affects the elevator as it needs to plan based on expected crop. Not all farmers guarantee their output to a single elevator but instead look for solid relationships and what will make them the most profit. The elevators responsibility now from the producer side of the logistics process is to market and build relationships with local farmers and sellers in order to keep business operations running.

The elevator is the focal point of this study as it is the link between producers and the wholesale producers who sell to the general public. It has been said earlier in this thesis that the existence of the local elevator is made possible by the ability of the elevator to transit the farmer's product to the global market. This step in the logistics process is the focal point of this thesis as it is the first link to the farmer who grows the crop and helps shape what types of crop are planted and in turn sold to the general public. Elevators decide what they bid based on their expected demand for the product just as the farmers plant based on their expected demand. The elevator also holds the key contacts for end user production which means that the hold the key of delivering products to the right places, for the right price. The elevator makes its profits by buying from the farmer in a local setting at a price they can turn around and sell at to earn a margin on the product.

A successful elevator has 3 major components that lead to its success. The first is a marketing and trading team to build relationships with the local farmers in order to gain business and volume of the product in which they are trying to re-sell. Without the relationships, and elevator would not gain business over a market with competition and in turn, shut down. The second is a facility that is able to unload and load shipments efficiently and have storage capabilities, which without, the elevator would not be able to hedge risk and have no room to take new orders. More often than not, an elevator will buy a product and not have a specific destination at the time of unloading to be able to ship the product. They will need to place the newly purchased product in storage as an inventory to sell at a later date. Without efficient unloading and loading capabilities, the elevator will run at a rate that may slow down the rest of the elevators process. The third component that makes an elevator successful is its access to modes of transportation. If an elevator is subject to only one mode of transportation, it is now bottlenecked to the health of that transportation, much like the Midwest in 2013 and 2014. Because a larger company will not function from only one elevator, the research will focus on the operations of 5 elevators and the profits of losses combined. There will be decisions made at this level which will decide whether a plant needs to sell primary cars, or ship. Profits and losses at the elevator level will be combined to show a total profit and loss for a company, which will lead us to show how a grain trading company will order shuttle cars to meet the demand for owned elevators.

The last step that will be examined in the model will be the destination markets for the corn and soybean product. For the purpose of this study, there will be multiple options available to the elevators which will include domestic locations, which could be a food processing plant or a whole sale producer, or the corn and soybeans could be sent to an export destination for trade internationally. These decisions add the availability of trade for the elevator. Prices at each location may be similar, but they could also be different which means the decision will come down to which earns the most profit. If prices are similar, the decision then comes down to the costs of shipment to each destination or where the demand is coming from. Posted prices are not the only deciding factor in where a product is sent either domestic and internationally. This option of selling to multiple destinations will add value to the research but it is also not the most realistic. Any more than 3 might complicate the model, which is why it was decided to only include 3 major buyers at this time.

Each of the steps above lays out the model framework that is examined. First, the farmer which has variables depicting its right and willingness to sell to the elevators presented in a formula of farmer sales per month given by the USDA. Next you have the elevator level which will include 5 elevator specifics like storage and rail space and their profits or losses incurred over the given cycle of the model. Lastly, we have the end user destinations which include 2 domestic destinations which will be either a food processing or wholesale distributing location, and 1 export destination which will bring the product to the global market. Each plays there part in the main point of research which will be the profit or loss at the elevator level and make decisions for each single elevator as to what the next plan of action is. For simplicity, the elevators were lumped together in the model as if they were one. What this means is capacity is multiplied by 5.

The MRP Model specification

This paper uses an MRP model which stands for Manufacturing Resource Planning. The MRP model has been described in previous studies, but will be examined more closely in this chapter and how it will help us gain relevant and useful results. The goal of the MRP model is to move inventory so as not to incur excess cost as well as to keep some inventory to mitigate risk. Storage in the case refers to the corn and soybean product the elevators are buying from the farmers, and selling to their customers domestically and internationally. Below, you will see the details for the MRP model that this thesis runs, and an explanation of the variables used and why they are important to find useful results.

Strategies in the rail markets play a key role in the MRP model. They will be a decision the grain trading company will need to decide upon in order to create a true profit maximization point. Each market has varying bids that range in value which is related to the commodities in which inhabit them. Below is the values depicted graphically of primary and secondary rail car market values.

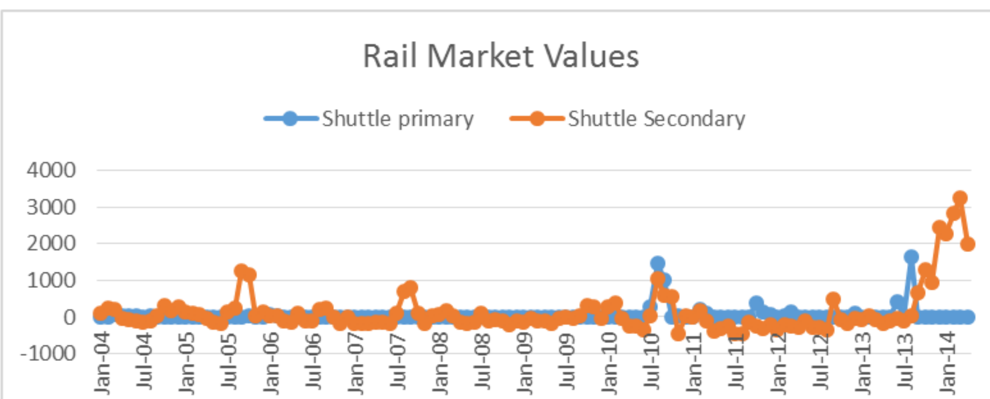


Figure 4.2: Primary and Secondary Rail Market Values

(BNSF) (TradeWest Brokerage Co.)

You can see that the variable used for primary and secondary market values must have a stochastic representation as its value is not constant. You can also see that the majority of swings in prices correlate back to times of harvest in the United States. The years 2013 and 2014 saw the biggest swings in prices that have been seen dating back to 2004. During this time the trip times were also much lower which defines the negative correlation between the secondary market and BNSF trip times. Below we will examine the strategies the grain trading company has when deciding a profit maximizing point.

There are three strategies used which include:

1) $Q_i > Ed_i \quad then\ S = Q_i - Ed_i$ (Eq. 4.1)

Q is equal to the quantity of rail cars ordered on the primary market, Ed is the demand for rails per elevator. This means that if Q is greater the Ed, the grain trading company will sell in excess of demand on the secondary market.

2) $Cs_i - Qp_i < Sp \quad then\ Q\ sold\ to\ S$ (Eq. 4.2)

Cs is equal to crop shipment price, Qp is equal to the rail car shipping costs, Sp is equal to the rail car premium if sold on the secondary market. What this means is if the profit from shipping product is less then selling cars on the secondary market, the grain trading company will trade there COT's on the secondary market.

3) $Q_i < Ed_i \quad then\ Q_i = S - Ed_i$ (Eq. 4.3)

St. Profit Maximization

In this situation, the elevator location has not ordered enough cars to meet demand, which means it will orders cars on the secondary market in order to meet demand if secondary market values allow for profit maximization. These three strategies will be presented through the MRP model.

The MRP Model specification: Farmer sales

Figure 3.7 shows us the average farmer sales for corn and soybeans over the past 3 years, and is rather predictable. This variable is important as it affects how the elevator determines the amount of crop to purchase over the course of each month while also creating storage opportunities by purchasing in months where farmers are more willing to sell their crop. The model takes into consideration how much farmers are historically willing to sell over the course of a 12 month period and determines how much it can purchase in a given month while still meeting this constraint of staying within the amount the farmer is willing to sell. Trading companies can also contract bushels for certain months but may have to pay a premium to influence the farmer to store until a time where the elevator will take in the product for shipment.

Model Specification

Variable/ Parameter Definition

Index

M The index for month (1,2…12)

I The index for destination (1,2,3)

Parameters

Store	Amount of Storage
Farmdel	Farmer Deliveries
ShuttleS	Shuttle size
ShuttleM	Shuttles a month
ShuttleY	Shuttle capacity a year

Stochastic Variables

BasisDe	Basis at destination
BasisEl	Basis at Elevator
PrimCost	Rail cost
SecCost	Rail cost secondary market
Transtime	Transit time/Velocity

FarmSale Farmer sales

Non-Random Variables

T Tariff for destination

D Demurrage based on transportation

F Fixed Costs

Decision variables

CropShip Corn/soybean Shipped

CropPur Corn/soybean Purchased

RailSec Rail cars secondary

RailPrim Rail cars primary

Railsold Rail cars for sale primary profit

Railsoldsec Rail cars for sale secondary profit

Revenue and Cost Specification

Primary Revenues = $\mu_m = \sum_{I=1}^{3}((\text{BasisDe}_{mI} - \text{BasisEl}_m) * \text{CropShip}_m = 1\mu_m$

Or $\sum_{m=1}^{12} ((\text{RailSec}_m - \text{RailPrim}_m) * \text{Railsold}_m) = 2\mu_m$ (Eq. 4.4)

If $1\mu_m < 2\mu_m$

Secondary Profits = $S\mu_m$

$(\text{RailPrim}_m + \text{RailSec}_m) - \text{CropShip}_m) = \text{Railsoldsec}_m$

If $\text{CropShip}_m < \text{RailPrim}_m + \text{RailSec}_m$ (Eq. 4.5)

Then $\sum_{m=1}^{12}((\text{RailPrim}_m + \text{RailSec}_m) - \text{CropShip}_m) * \text{SecCost}_m$

$$\text{Cost} = \alpha_m = \sum_{m=1}^{12} \begin{matrix} ((\text{RailPrim}_m * \text{PrimCost}_m) + (\text{RailSec}_m * \text{SecCost}_m) + \\ (T_I * \text{CropShip}_m) + (D * \text{Railsold}_m) \\ + F + (\text{CropPur}_m * \text{BasisEl}_m) \end{matrix} \quad \text{(Eq. 4.6)}$$

Objective Function

$MaxP(\pi) = \sum_{m=1}^{12}(\mu_m - \alpha_m) + S\mu_m$

St. $\text{Store} \leq 147400000$

$\text{CropPur}_m \leq \text{Farmdel}_m$

$\text{ShuttleS} \leq 110$ (Eq. 4.7)

$\text{ShuttleM} \leq 50$

$\text{ShuttleY} \leq 200000000$

$\text{Railship}_m + \text{Railsold}_m + \text{Railsoldsec}_m \leq \text{Railprim}_m + \text{Railsec}_m$

Constraints

The constraints of the MRP model reside with the elevators owned by the grain trading company. Each has its own place as well as constrains the profit maximization model. The Parameters included are in the table below.

Table 4.2: Constraints

Constraints	*Definitions*
Storage Capacity	This would be the onsite storage each individual elevator holds. Each elevator has its own capacity which will be reflected in the model. Our max storage is 147400000.
Farm deliveries	This would be the availability of farmer crops in the year. This constraint is included as a stochastic variable as farmers will deliver over a 12 month period, and not all in one month. So our purchases cannot exceed this amount.
Shuttle capacity	Each elevator has a capacity of elevators it can hold at its location. In this case, all elevators selected have capacity of at least 110 cars which would be the size of a shuttle car train. This will also affect the amount of capacity that can be shipped at once.
Shuttles a month	Because an elevator can load a shuttle train in roughly 15 hours. A limit of 10 per elevator will be made available if purchased
Shuttle Capacity a year	A shuttle elevator can ship out roughly 30-50 million bushels a year. So the maximum capacity for our elevator to ship will be set at 200 million for simplicity purposes.
Rail usage	The last constraint is making sure that we do not either ship or sell all our primary rail in our primary profits in excess of what we own. It also states that you cannot sell more in our secondary profits along with our primary profits in excess of rail owned each month.

Export and domestic demand is not listed as a constraint, as destinations have posted bids nearly year round. These bids may not be profitable for the origin, as the bid may be one to take the destination out of the market as their needs are met. This now brings the whole logistic process into play, as the farmers supply depends on the expected demand of the elevator, as the elevators provide a supply based on the demand of the end users. This correlation is the most important as it directly affects every other aspect of the model. The demand for a product affects its supply and together the supply and demand affect the prices. Without this price and without the profit, there would not be the work put in to create it in the first place.

Stochastic Variables

Stochastic variables are ones that change based on many different factors in the market as well as past performance. Especially in agriculture, the variables involved are highly correlated with each other, meaning the swings in prices affect the usage and prices of others. All the prices included in this model are expected to have a certain degree of correlation meaning we need to be careful to examine these prices both together and separately in order to grasp the weight shifts in the market and how they affect each other. The list of stochastic variables includes many prices which are most certainly influenced by many factors and carry much of the risk in this model. With risk you have a model that will not provide exact answers, which is not the goal of this thesis. The goal is to show probable values and how those values are affected by swings in expectations which explains either future, present or past events. The list of stochastic variables used in this model include the cash and basis values for the elevator and destinations listed in our model specification, Farmer deliveries, rail costs in both the secondary and primary market, and trips per month for shuttle cars on the BNSF rail way.

Because stochastic variables in the model take on sporadic values between maximums and minimums, the values are inherently correlated amongst each other. Each elevator as it is seen below has an extremely high positive correlation with each other, what this explains is that when prices for one commodity goes up, it can be expected that the other commodity follows in similar fashion. This is important as the model needs to have risky variables that move in similar fashion to each other. This correlation between each elevator is shared with the destinations given in the model, near a perfect correlation.

Correlation	Madison Corn	Madison Beans	Breckenridge Corn	Breckenridge Beans	Hamburg Corn	Hamburg Beans	Sioux City Corn	Sioux City Beans	Drayton Corn	Drayton Beans
Madison Corn	1.0									
Madison Beans	0.9	1.0								
Breckenridge Corn	1.0	0.9	1.0							
Breckenridge Beans	0.9	1.0	0.9	1.0						
Hamburg Corn	1.0	0.9	1.0	0.9	1.0					
Hamburg Beans	0.9	1.0	0.9	1.0	0.9	1.0				
Sioux City Corn	1.0	0.9	1.0	0.9	1.0	0.9	1.0			
Sioux City Beans	0.9	1.0	0.9	1.0	0.9	1.0	0.9	1.0		
Drayton Corn	1.0	0.9	1.0	0.9	1.0	0.9	1.0	0.9	1.0	
Drayton Beans	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0

Figure 4.3: Elevator and Destination Correlations 2012 - 2013

Some correlations that will be brought up specifically and explained will be the PNW and system trip times per month for the BNSF and the primary/ secondary rail market values. Also examined, are the correlations in corn and soybean sales, compared to trip times and the secondary and primary market values.

Corn sales and Soybean sales are highly correlated which is relatively easy to explain. Harvest for corn and soybeans in the US are done in fall, which is when the majority of farmer's delivery product to their local elevators when the markets carry value does not persuade them to store their product. Farmers also may have contracted acres which are delivered during similar times. This would explain the high correlation, but what is more interesting is the correlation of crop sales with the BNSF trip transit times, and the primary and secondary market values. Corn sales have a negative correlation with both the system and PNW trip transit times, this can be explained as the more sales made by farmers to local elevators, the more shipments that have to be made. When these shipments are made the rail road's become more congested and in turn, trip times decrease. Soybean sales has little to no correlation with the system trip time, but it does have a negative correlation with the PNW trip times. This is explained as soybeans are often sent to the PNW to export markets before traded locally to domestic markets.

Correlation	corn sales	soybean sales	SYS	PNW	sec	primary
corn sales	1.000					
soybean sales	0.759	1.000				
SYS	-0.170	0.048	1.000			
PNW	-0.526	-0.375	0.803	1.000		
sec	0.163	0.219	-0.820	-0.686	1.000	
primary	-0.151	0.169	0.608	0.493	-0.536	1.000

Figure 4.4: Crop Sale and Rail Correlation

The most interesting correlation and a focus in this paper, is the correlation between trip times per month and the primary and secondary rail market values. The primary markets have a positive correlation with the BNSF trip times per month. The BNSF is in the business of moving product from point A to point B, the cars that are sold at a premium; IE above tariff prices when primary markets are 0, when it is expected that cars will be ordered by the businesses that use them. You can see in the data that cars are sold at a premium before harvest for shuttle values because that is when companies will want to lock in cars for the upcoming harvest.

Secondary market values however have a negative correlation with the BNSF trip times. This means when trips times per month are high, secondary market cars are sold for low premiums or even discounts. Secondary rail is not highly demanded when primary cars will satisfy orders. When trip times are low, secondary markets are high because the demand for these cars are high. This correlation is a large part in the decision making process for the grain trading company, as secondary market value can be sold at such large premiums that selling the freight becomes more profitable then selling the commodities that the freight carries.

Decision Variables

Decision variables in the case are the decisions the grain trading company makes in order to maximize profits. These values will be adjustable during the optimization. A list of the decision variables is below in table (4.3).

Table 4.3: Decision Variables

Decision Variables	*Definitions*
Corn/ Soybean Purchased	This is the amount of crop to purchase over a month to meet demands or storage minimums
Corn/ Soybean Shipped	This is the amount of crop shipped based on purchased and stored crop.
corn	This would be the difference between the amount of crop purchased and shipped over a given month.
Primary and Secondary Rail Market	**Primary Market**- The primary market value is the decision on the number of shuttle trains to order over the course of one year. This value will be a constant **Secondary Market**- This value represents the number of cars ordered after primary cars, this number is a reflection on shipment only during the month it was ordered and not the duration of a full year.

Decision variables are imperative to research and will give us the ground work to defining a base case for the empirical research. The sensitivities; which will be discussed later in this chapter, relate back to these decision variables and how they change with fluctuations in the random and non-random variables. They also lead us to answers given in the objective function.

Rail Car Markets

There are two markets for rail cars which include the primary and the secondary markets. Primary markets would be the market based bidding and lottery for rail cars direct from the rail way service provided in the area. The secondary market includes the sale of owned COT's or private cars from the owners of the right to use the car. The secondary market are shuttles purchased for a given month and are for one trip, while primary cars are ordered for year long commitments.

The primary market in rail has daily bids for certain car units. The terms/ guarantees of these cars are given on the BNSF website:

- All COT Units combined to create a DET/shuttle must have the same shipping period
- A DET may be split enroute for unloading at multiple destinations
- Dedicated locomotives
- Loads in 24 hours

(BNSF)

The list does not include delivery time but only the units ordered. Transit time is crucial to customer satisfaction as well as its effect on price. Late delivery on product leads to discounts on prices which then leads to decreases in profits seen by the grain trading company. Primary cars have no pre advice, and begin to accumulate demurrage until the buyer ships the rail car. The secondary market has its own set of terms which include:

- Trip incentive for the account of the seller
- There is no fuel Surcharge protection
- Weekend load for account of buyer if available on the trip provided
- Buyer to bill the train and receive the EDI payment
- Sellers call, Five day pre-advise on shuttles placement
- Existing tariff rate at time of shipment

(TradeWest Brokerage Co.)

What this means is the seller of the rail guarantees shipment placement and pre advises buyer 5 days in advance of placement of the shuttle. The bidding for these rail cars can be done through private negotiations between companies, or through brokerages. Bids are posted and purchased based on market needs and purchased much like commodities. These rail cars ship on the same rail ways, but differ from primary cars as they have guarantees of shipment applied to them. This guarantee is the source of the premium in times where primary rail car trip times are low.

Figure 4.5 shows us distributions used for our random rail values used in the base case. These values affect the models decision variables greatly by the costs of shipping product, and the amount of product that can be shipped. The primary rail car market and trip transit times where provided by the (BNSF). Secondary rail car market values were provided by (TradeWest Brokerage Co.).

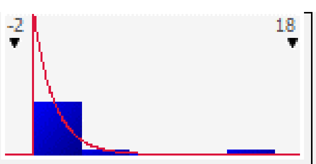
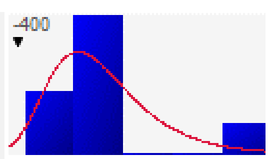
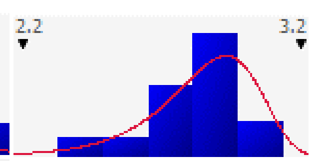
Name	***Primary***	***Secondary***	***Transit time***
Range	Data elevator Mad!EQ3:EQ18	Data elevator Mad!ER3:ER18	Data elevator Mad!ES3:ES18
Best Fit (Ranked by AIC)	RiskExpon(1.4362,RiskShift(-0.095745))	RiskExtValue(-118.01,168.15)	RiskExtValueMin(2.9224,0.14732)
Function	0.788387972	-162.5447772	2.992098267
AIC	47.8594	207.5703	-5.6664
Minimum	-0.0957	-Infinity	-Infinity
Maximum	+Infinity	+Infinity	+Infinity
Mean	1.3404	-20.9556	2.8374
Mode	-0.0957	-118.0128	2.9224
Median	0.8997	-56.3847	2.8684
Std. Deviation	1.4362	215.657	0.1889
Graph			

Figure 4.5: Primary, Secondary and Transit Time Batch Fit Results

Data: Nonrandom

There are some variables in the model that do not change throughout the optimization. These variables include Tariff values, demurrage and fixed costs. The tariff and demurrage charges were provided by the (BNSF), and the fixed cost was given a value of 50,000 as an assumption for the elevator. Specifically tariff and demurrage costs have a high impact on the model, as they determine a part of the overall cost.

Data: Stochastic

The stochastic variables used in this thesis; aside from the rail related variables, include the basis at the elevator and destination, and farmer sales which is given as a percentage. Basis values were provided by DTN and a private source for PNW basis from Tempte (DTN Prophet) (Tempte). Farmer sales was given as a percentage for the years 2011 – 2014 which was key in defining the distribution of how much is available to the elevators. Farmer sales was provided by the USDA NASS (National Agricultral Statistics Serice).

An example of basis distributions are given in Figures 4.6-4.7 which are for July of 2013. These values are the key driving force in revenues and cost for the model and are key to linking results back to sensitivities.

This distribution is important because it derives the price paid by the elevators for the corn and soybeans which is then shipped. Without this key starting point there would not be product available for sale. Basis values have been explained in this thesis before, we notice that the prices in figure 4.5 have a mean value less than that of the destination basis in figure 4.7. This is to influence movement from the grain trading company to their destinations which in tur7n earns a profit. We will see later on that the costs associated with shipping to a certain destination influences what basis value is bid at each destination in (4.8).

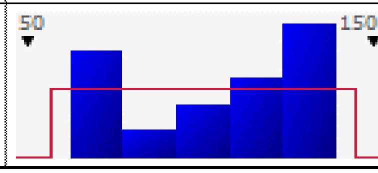
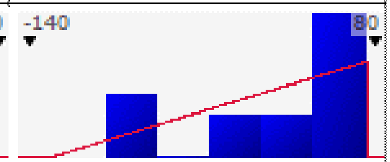
	CornM0713	BeansM0713
Range	Data elevator Mad!C3:C18	Data elevator Mad!D3:D18
Best Fit (Ranked by AIC)	RiskUniform(59.357,143.243)	RiskTriang(-119.84,70,70)
Function	108.2541697	-58.33368059
AIC	137.8837	148.8434
Minimum	59.3571	-119.8412
Maximum	143.2429	70
Mean	101.3	6.7196
Mode	59.3571	70
Median	101.3	14.3968
Std. Deviation	24.2157	44.746
Graph		

Figure 4.6: July 2013 Elevator Basis Distributions

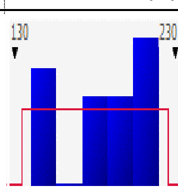
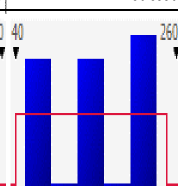
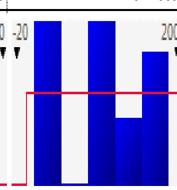
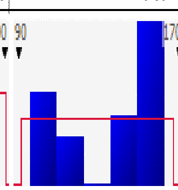
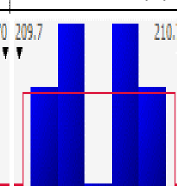
	cornG0713	beansG0713	Beanst0713	Cornst0713	cornpnw0713	Beanspnw0713
Range	Data elevator Mad!E3:E18	Data elevator Mad!F3:F18	Data elevator Mad!G3:G18	Data elevator Mad!H3:H18	Data elevator Mad!I3:I18	Data elevator Mad!J3:J18
Best Fit (Ranked by AIC)	RiskUniform(137.400,223.800)	RiskUniform(46.467,242.53)	RiskUniform(-1.6667,196.67)	RiskUniform(93.560,165.640)	RiskUniform(209.74667,210.65	N/A
Function	194.5099681	73.3519188	29.13629477	147.4447731	209.8073038	---
AIC	138.7696	173.8336	174.2014	141.8119	1.7877	N/A
Minimum	137.4	46.4667	-1.6667	93.56	209.7467	N/A
Maximum	223.8	242.5333	196.6667	165.64	210.6533	N/A
Mean	180.6	144.5	97.5	129.6	210.2	N/A
Mode	137.4	46.4667	-1.6667	93.56	209.7467	N/A
Median	180.6	144.5	97.5	129.6	210.2	N/A
Std. Deviation	24.9415	56.5996	57.2539	20.8077	0.2617	N/A
Graph						N/A

Figure 4.7: July 2013 Destination Basis

Farmer's sales derives how much product can be purchased by the grain trading company every month for 12 months. These values take on different values every year in terms of a percentage. This makes them random and subject to a distribution, and an example of this can be seen in figure 4.8 which shows the distributions of corn and soybean sales for the months of July.

The amount of stochastic variables in the model then draws questions to how these variables move with changes to each other. Correlations are shown in figure 4.4, but these are condensed values. This model will break these data points down to a month by month analysis. A full listing of all the stochastic variables used in the base case are in Appendix B. A full listing of all the correlations for the base case model are given in Appendix C.

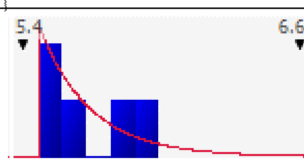
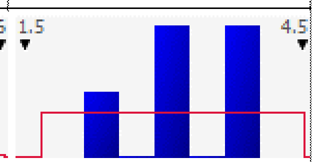
Name	corn sale0713	soybean sales 0713
Range	Data elevator Mad!K3:K18	Data elevator Mad!L3:L18
Best Fit (Ranked by AIC)	RiskPareto(25.916,5.5000)	RiskUniform(1.7500,4.4500)
Function	5.578974657	2.007752527
AIC	4.8849	19.9325
Minimum	5.5	1.75
Maximum	+Infinity	4.45
Mean	5.7207	3.1
Mode	5.5	1.75
Median	5.6491	3.1
Std. Deviation	0.2298	0.7794
Graph		

Figure 4.8: Corn and Soybean Sales July

Simulation and Optimization Procedures

The model will be maximizing profits for a grain trading company purchasing and selling corn and soybeans. Because nearly every variable associated with the buying and selling of crops is stochastic there has to be a way of taking risky variables and simulating them with adjusted decision variables to come to a maximizing point. The @risk function through excel will allow this model to have stochastic cells for a profit maximization that change based on a distribution. Because this model will use data over a 12 month period, there are many variables that are shown as stochastic. Batch fitting allows us to take all of these variables stochastic values and show how they correlate with each other. This is key because we want randomness in the values that affect the outputs, but if correlation exists, we want the values of others to change if they correlate amongst each other which in turn gives us more accurate results.

After the Batch fit has been done, we will input the corresponding @risk values into the cells they belong to for each month. Once this has been completed and the link between revenue and cost cells has been made, we can run the optimization procedure through the use of risk optimization. This is run much like an optimization through excel where you have an objective cell, adjustable cells and constraints that affect what point is a profit maximization. What differs now is the use of the stochastic variables which can affect what value or adjustable cells take in order to maximize profits.

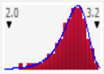
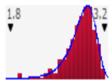
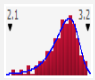
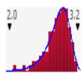
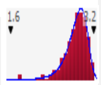
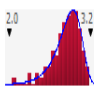
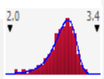
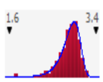
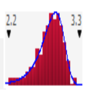
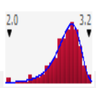
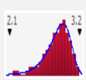
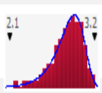
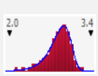
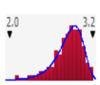
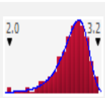
The optimization has many choices to select within risk optimization to come to clear results. First is selecting the number of trials in which it changes values of the adjustable cells. In the model optimization is ran as a timed trial which will change the values continuously until it is stopped manually. The point of stopping the risk optimizer will be when the results have flat lined and the optimizer has not found a more profitable option over a certain time. The second choice is the amount of iterations in each trial, which is the amount of times it adjusts the stochastic variables within a trial to show us the distribution of the target cell within those adjusted cell values. This is key when you introduce stochastic variables to a model, and in the case will be set to 100. The final selection is how the model will report statistics as either a mean of each trial or a maximum. What this means is that if the model through each iteration brings back a mean values of 1 will its maximum is 4 the mean statistic for the model would be 1 or if you choose to see a trials maximum, you would see 4. We have selected mean as it will give us a better indication on a most likely scenario. (Palisade)

Base Case: Introduction

The base case will examine the choices made in the entirety of a grain trading company overseeing 5 separate elevators collaboratively to see the rail usage over the 12 month period. What this means, is the amount of storage and rail space will be taken into one model to display the overall results of what a single freight trader will order for their grain trading company. It also shows us and helps us interpret the results on how rail transit times and rail car prices affect how a grain trading company orders cars. The base case examines the variability of the 2012 and 2013 crop year as this year is more representative for years past than 2013 through 2014. We expect the results to be largely influenced by many risky factors that include basis values, but specifically we are looking at the impact of three variables on how adjusted values are selected. These three variables are shown in figure 4.5.

The primary and secondary rail market values and transit time values are of particular interest as it can be clearly seen in figure 4.7 that the secondary rail market values become volatile after the 2012 through 2013 crop year, which also relates back to the decreasing transit times in the same time period. For this reason we conduct the base case with values that are most common in the past few years. This will also allow us to compare and show how the sensitivities affect the profit maximizing point. Below is an outlook of the transit time inputs used in the model. Notice, the distributions of each month in the base case are very similar which means planning based on these inputs will be a lot less complicated and secondary rail cars will be ordered much less in the base case year. It is important to understand that the shipping capabilities for the model fringe on this statistic so it will be examined closely.

Table 4.4: Transit Time Inputs

Name	Graph	Min	Mean	Max
Transit time / August		2.18127	2.83801	3.19121
Transit time / September		1.96044	2.83701	3.17696
Transit time / October		2.17179	2.83803	3.16421
Transit time / November		2.10943	2.83738	3.16259
Transit time / December		1.79996	2.83339	3.16029
Transit time / January		2.09453	2.8375	3.15435
Transit time / February		2.12938	2.83768	3.22316
Transit time / March		1.77141	2.83422	3.20539
Transit time / April		2.24456	2.83924	3.23018
Transit time / May		2.01911	2.83678	3.1944
Transit time / June		2.19058	2.83821	3.16224
Transit time / July		2.19883	2.83855	3.17847
Transit time / August		2.14393	2.83831	3.24551
Transit time / September		2.13207	2.83726	3.17188
Transit time / October		2.0193	2.83729	3.16914

There are many other inputs used to come to a profit maximizing point that include the basis values at the elevator and destination, futures values, primary and secondary rail market values, and farmer sales for both corn and soybeans. Each effect profit and will be examined in the next section on sensitivities.

The main function of the base case is to set a value for the primary rail market shuttles ordered to meet expected shipping during the course of a year. The 2012 - 2013 crop year is a good representation of rail market function as its distributions in rail transit time are similar to years before that, which is seen in figure (4.2). Because of this, we can assume a grain trading company will use the 2012 – 2013 values to estimate its projected use of rail cars during the course of a given year. Also, because a grain trading company will order primary rail cars for a full years use, this primary rail value given in the base case will be held as a constant so that we can examine how our sensitive values then affect profit maximizing points. It will also help us explain how certain shuttle elevators could have lost money cited in (Fatka).

Sensitivities

Sensitivities in the model will include many factors, as there are many variables included in the model. The largest expected is the basis values which affect profit by the amount the commodities can be sold for. This is probably the largest sensitive variable for a grain trading company every year as it is the main profit driver. Although this is important, it is not the primary focus of this study. We are focusing on the impacts of changes in rail markets and transit time which are in fact correlated with basis values at each elevator. A list of rail related sensitivities are below in figure 4.9. What this table shows is the name of the variable from the base case in the left column, along with the range of the mean profits in the right.

It is easy to see that rail markets have a high influence on profits even in years of predictable values. This is an important factor in this thesis as these values go through a drastic change in the 2013 and 2014 crop season with the decreased transit times and high variability in the secondary market. Sensitivities explain how shocks in the market affect profits which is important in researching externalities like the rail transit time change in 2013 and 2014.

Name	Elevator 1!S77 Profit Range of Mean	
Rail car cost Secondary / June	$	15,187,680.00
Rail Car cost / March	$	14,708,250.00
Rail Car cost / September	$	14,068,940.00
Rail Car cost / April	$	13,479,590.00
Rail Car cost / January	$	13,042,490.00
Rail Car cost / February	$	12,692,950.00
Transit time / February	$	12,365,960.00
Rail Car cost / June	$	11,977,690.00
Transit time / January	$	11,902,350.00
Rail Car cost / July	$	11,837,370.00
Rail car cost Secondary / August	$	11,472,880.00
Rail car cost Secondary / October	$	11,454,480.00
Rail car cost Secondary / January	$	11,434,030.00
Transit time / May	$	11,433,840.00
Rail Car cost / September	$	11,215,230.00
Rail Car cost / August	$	11,009,540.00
Rail Car cost / November	$	10,990,380.00
Rail car cost Secondary / April	$	10,821,930.00
Rail Car cost / December	$	10,765,130.00
Transit time / April	$	10,490,980.00
Transit time / September	$	10,438,900.00
Transit time / August	$	10,045,340.00
Rail car cost Secondary / September	$	10,034,100.00
Transit time / July	$	9,975,760.00
Transit time / March	$	9,891,873.00
Rail car cost Secondary / August	$	9,594,841.00
Rail Car cost / August	$	9,491,382.00
Rail car cost Secondary / February	$	9,397,077.00
Rail car cost Secondary / November	$	9,365,418.00
Rail car cost Secondary / March	$	9,250,238.00
Transit time / October	$	9,135,849.00
Transit time / November	$	8,557,661.00
Transit time / September	$	8,296,287.00
Rail Car cost / October	$	8,268,030.00
Rail Car cost / May	$	8,244,391.00
Transit time / June	$	8,138,971.00
Rail car cost Secondary / December	$	7,773,237.00
Rail Car cost / October	$	7,549,626.00
Rail car cost Secondary / October	$	7,461,848.00
Rail car cost Secondary / May	$	7,387,499.00
Transit time / October	$	7,050,056.00
Transit time / August	$	6,548,146.00
Rail car cost Secondary / July	$	6,369,554.00
Rail car cost Secondary / September	$	5,985,760.00
Transit time / December	$	5,075,348.00

Figure 4.9: Rail Sensitivities

Summary

Theory drives the development of the questions asked to further research, but the numbers give a visual representation that drives results and change. The variables involved are used as they are theoretically assumed to show changes in the market, which now shows the link between the theory and model specification. Supply and demand is an economic theory as well as profit maximization, but teamed with the data and variables included in a structured model, it can streamline change and develop future research. The following chapters will examine the results of the model portrayed in the current chapter, and will link the theory, with its more practical uses.

CHAPTER 5. RESULTS AND ANALYSIS

Introduction

This chapter presents results from the base case and other analysis conducted. Chapter 5 is important as it gives explanation through the use of economic theory, and the empirical model. The base case is presented as well as input comparisons between the 2012/13 crop year and 2013 crop year, sensitivities and effects on the market. In order to understand the shifts in payoffs from year to year, economic theory is applied to results and is discussed later in this chapter.

In the 2013/14 crop year, railways experienced decreases in transit time due to compounding factors. Those factors affected grain movement that in turn related to unreliable transit as well as a premium to secondary rail car values. Those premiums shaped the payoff structure for a grain trading company deciding on strategies of ordering in the primary market. The base case examines how a grain trading company would make decisions on rail cars to order for the 2012/13 crop year, we then show how that strategy changes when stochastic variables are changed. Inputs for the model include rail car values for both primary and secondary markets, basis values for the elevator and destination markets, futures values, farmer sales and tariff values. Decision variables include how much commodity to purchase and sell and to either of the three destinations, the amount of primary rail cars to purchase, and how many secondary cars are bought or sold. The three destinations that are being sold to are the PNW, Gulf and St. Louis, of those three the PNW and Gulf are export destinations, while St Louis is a domestic destination.

The base case as described in chapter 4 is reviewed first to give a representation and base for the results presented in this chapter. The base case is a profit maximization and solved through Risk Optimizer with numerous inputs and constraints shown in chapter 4. One of the decision variables that is focused on is the rail car primary shuttle COT's ordered. Two sets of sensitivities are done, the first is where the primary rail COT's ordered in the base case is held as a constant. This is done to show how a grain trading company who places there order for a yearlong commitment would have to adjust their strategies after the fact to return a positive payoff. This is important to understand as it has real world applications to how strategies change during the year. The second is a simulation run with the 2013/14 values for every variable, and define how strategies change from year to year. The first set of sensitivities is considered fixed as the strategy chosen does not alter year to year, it shows how a grain trading company that makes long term decisions are affected in the short team by externalities. The second set of sensitivities is adaptive, where the model allows the grain trading company to alter its strategy with changing market conditions. The structure of this chapter shows the base case first as it draws comparisons between sensitivities and the 2013/14 crop year. Second the sensitivities on the base case which will show how a grain trading company's payoff structure would have changed. Lastly, the 2013/14 crop year simulation shows how overall strategy would have changed had a grain trading company been prepared for the stochastic variables experienced in the 2013/14 crop year.

The comparison in crop years is done to illustrate how input values change from year to year but specifically between 2012/13 and 2013/14. This comparison is specifically important as 2012/13 is the base case year, and 2013/14 is when the railways experienced decreased transit times. An in depth look at these years helps the understanding of the sensitivities that will be run in this chapter as well. These comparisons lead to the sensitivities that are conducted from the base case. Because nearly every variable in the model is stochastic, they all can have an effect on payoffs based on their distributions.

Base Case

Payoffs and decision variables are very similar to what is expected for a group of elevators belonging to a grain trading company. In this section, we examine the main components of the base case. This includes input variables, decision variables, and a summary of results. Each section of the base case gives a better understanding to when sensitivities are conducted.

The base case was run with the stochastic variables from the 2012/13 crop year to display a typical scenario for a grain trading company. The grain trading company had decision variables which included the amount of corn and soybeans to purchase, the amount of primary and secondary rail to purchase, and the amount of primary rail to sell on the secondary market in order to maximize payoffs. When the model is run in risk optimization, the results are show in table 5.1 below.

Table 5.1: Base Case Key Results

Description	***Units***	***Result***
Corn Sold	Bushels/ year	85,561,214
Soybeans Sold	Bushels/ year	9,915,188
Primary Purchased	Shuttle Trains / Year Long	9
Secondary Rail Bought / Sold	Shuttle Trains/ Year Total	49 Bought / 16 Sold
Percentage of time Inadequate Primary Rail	Percent time Secondary cars used/ year	16%
Mean Payoff/ St. Dev	Dollars /year	Mean Payoff = $120,233,000 St. Dev = $5,582,266

Table 5.1 shows the key results from the base case and how strategies on rail cars affected payoffs. Each of the results are discussed in further detail in this chapter, but key results for the base case show that the amount of primary cars available was sufficient for shipping 84% of the time throughout a year. This means the volatility in profits was more than likely caused by the prices of commodities.

Inputs in the model include basis price for the elevator and each destination shown in chapter 4. The model portrayed these basis values was a revenue per bushel as well as revenue per rail car for each destination from the elevator. An example of the August and September numbers is below. Figure 5.1 shows both the revenues from selling rail cars as well as the revenue from the sale of commodities. The figure also is the deciding factor on when to use rail cars, or when to sell them on the secondary market. This is done by showing the max revenue from the sale of owned rail cars on the secondary market, compared to using owned rail cars to ship soybeans or corn. In both August and September, the grain trading company does not sell any rail cars, but instead uses them for shipment of owned crop. In the base case, no months had rail cars that were sold as primary payoffs. This statistic is not firmly stating that a grain trading company does not sell any secondary rail, but that the primary function of the rail owned will be used to ship owned product. Once product has been shipped, excess cars are sold on the secondary market and shown as secondary payoffs, which is seen below. Differences in these graphs will be discussed in this chapter to explain the situations that happened in the 2013/14 crop year.

Revenues			
Rev Gulf Corn/car		3731.38	2852.12
rev basis		112.96	86.31
Rev Gulf Beans/car		7881.47	4647.47
rev basis		238.67	140.67
Rev St Louis Corn/car		852.85	1786.88
rev basis		25.78	54.08
Rev St Louis Beans/car		1714.83	3288.89
rev basis		51.86	99.56
Rev PNW Corn/car		4174.06	2384.29
rev basis		126.35	72.12
Rev PNW Beans/car		913.56	1478.63
rev basis		27.53	44.65
Max Rev corn/car		4174.06	2852.12
Max rev basis		126.35	86.31
Max Rev soybean/car		7881.47	4647.47
max rev basis		238.67	140.67
Max Revenue Crop		7881.47	4647.47
Rail Market Revenue		-322.99	37.73

Figure 5.1: Revenue per car at Destination and Rail Market Revenue

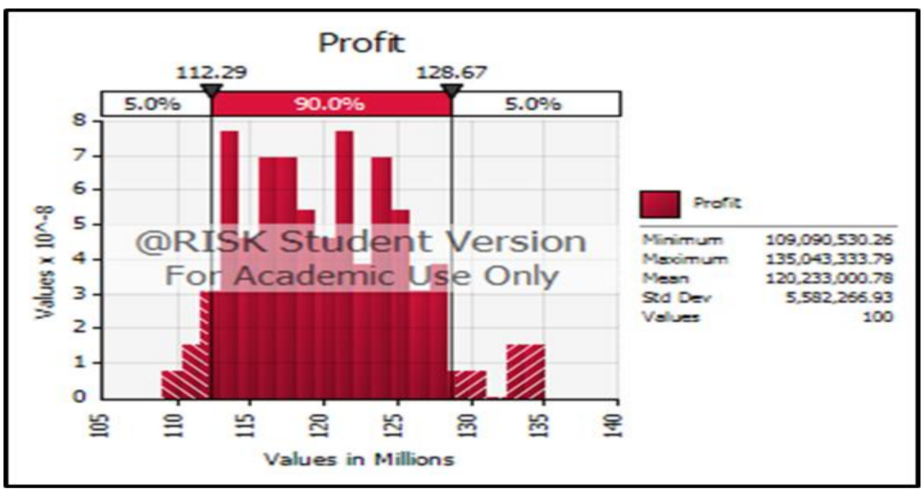


Figure 5.2: Base Case Payoffs

Examining the payoffs from the base case; based on the input and decision variables above, it can be seen in figure 5.2 that the payoffs from the elevators ranged from 109 million to 135 million in the base case year. That number can be seen as very representative of what would like to be seen from shuttle elevators dealing with massive quantities of grain month to month over a full crop year. To average payoffs, each elevator in the model roughly made $24 million dollars over a 12 month period based on the mean value. This is very representative of the base case of the 2012/13 crop year. Payoffs are derived from the margin of selling crops from the grain trading company to a destination, less the cost of acquiring rail cars; which includes the tariff and COT values, as well as purchasing the grain for sale and fixed costs. This payoff does not include operating and capital costs from the business.

An important aspect of payoff and the number one driver in revenues and costs is the amount of crops purchased and sold for each month. The optimal value for how much of a commodity to purchase is dependent on constraints to the grain trading company. A company under profit maximization determines the optimal quantity and value of an output in order to gain the most payoff, and outputs are dependent on inputs. For a grain trading company this would be deciding how many bushels of corn and soybeans to purchase from farmers and at what value to then sell purchased commodities in order to maximize payoffs, the three destinations being the PNW, Gulf or St Louis. The grain trading company is constrained by how much can be bought from the farmer as well as how many bushels can be shipped from the elevator. If constraints are met, it then needs to be decided at what value products can be moved from origin to destination in order to make profit. If the grain trading company has multiple options, it selects the option with the highest opportunity of payoff based on a revenue and cost analysis. Thesis results show that a grain trading company has another option to maximize payoffs, which would be to sell the transportation itself.

Figure 5.4 below gives a representation of bushels bought and sold over each month. Through this figure, at certain times of the year are more profitable when crops are stored for future use. This relates back to the buffer stocks where a trading company holds inventory to manage risk and to maximize payoffs. Particularly in the summer months, each crop has an influx in shipped product compared to purchase, which is due to the amount of storage owned. In both cases for corn and soybeans, we can see that just before the start of March, that both experience points where shipping exceeds purchases, which means there was a carry/inversion in the market for these months from February and January forward. This is illustrated in figure 5.5 where the months preceding February had the most shipping of any month and required all the primary rail. These months are important because a grain trading company can expect with volatility that these values are affected.

The revenues show how the grain trading company comes to a plan on decision variables based on expected revenues. These revenues depend on the stochastic variables described in chapter 4, and the revenues predict how the grain trading company alters the decision variables to reach a profit maximization. Below in figure 5.3, the tornado graph for the variables that most affect payoff is shown. The tornado graph analysis is important as it shows the variables can be changed for sensitivities in order to show how they may change payoffs in years that alter from the base case, all of which are related back to the stochastic variables which gives a reason to include them in the model. Without stochastic variables, there would be no need to see ranges in payoffs as a firm value can be used in its place. With a distribution of variables, it can be seen that most likely situations occur and how those situations alter business strategies.

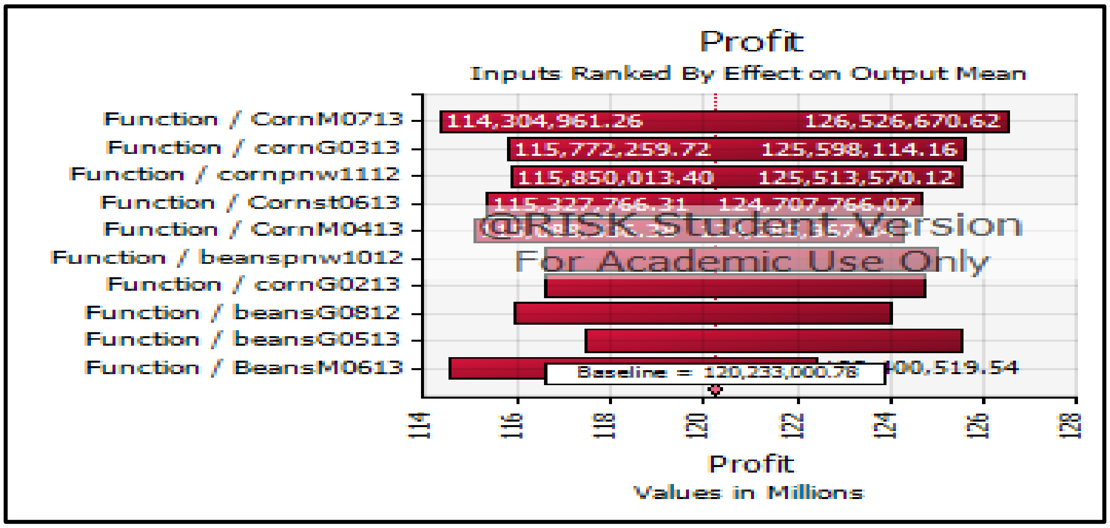


Figure 5.3: Tornado Graph from Base Case

Based on the results of the tornado graph for the base case, the commodity prices had the most effect on the alterations in payoff for the base case. For the average grain trading company, this is on par with what is considered average and expected risks coming into a crop year. Figure 5.3 shows the variables that most affect payoffs in the base case. Basis at the elevator and destination are representative of the market and how these values specifically affect payoffs in the base case, meaning in both cases the most influential swings were used for this figure. Primary and secondary rail is examined to show volatility in the base case and are compared to the sensitivities that are run with the 2013/14 crop year later. Transit time as well is comparative with the 2013/14 crop year distribution. The below values are outputs from the base case. Each show the mean, st. dev, minimum and maximum payoffs from changes in volatility amongst these variables through iterations in the @risk model.

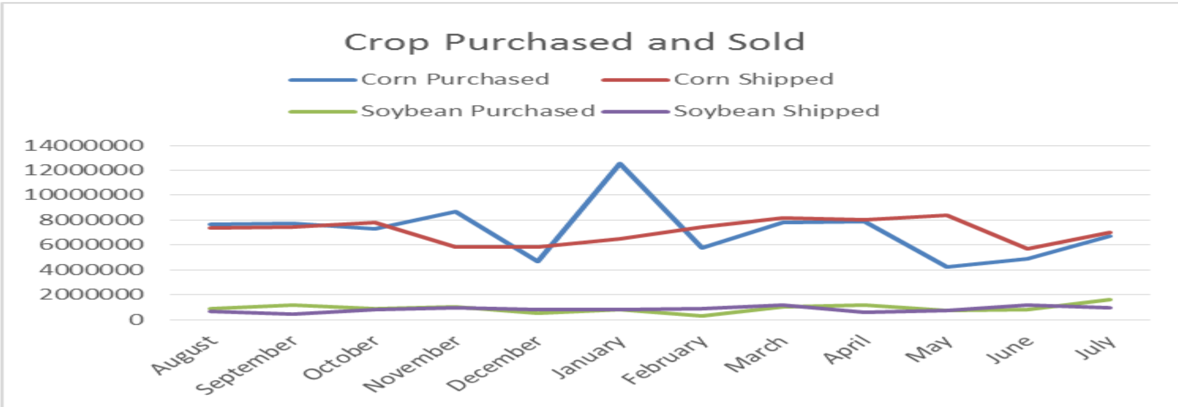


Figure 5.4: Crop Purchased and Sold 2012 – 2013 bushels/month

Figure 5.4 gives a graphical representation of the amount of corn and soybeans bought and sold each month over the base case year. From December to February, a large portion of corn was purchased in order to ship out later. This was due to an inversion in the market which meant that the prices in the months after February were not as favorable as purchasing more between December and February for storage.

Figure 5.5 below shows a graphical interpretation of revenues and costs for the base case. One thing to note is the amount of secondary payoffs earned. The reasoning behind these amounts are explained by the secondary rail markets in 2012/13 and 2013/14 which were not as volatile as the preceding year. This means that the grain trading company did not sell on the secondary market to make a profit compared to shipping commodities. This base case showed the value of shipping product higher than selling rail cars, so in turn more cars are used to ship product.

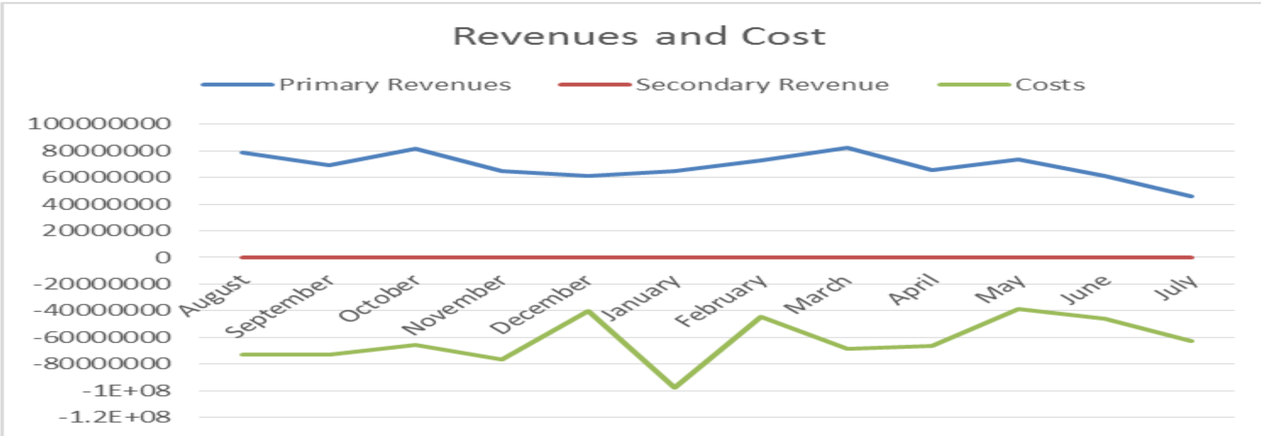


Figure 5.5: Revenues and Cost Base Case

Base Case Stochastic Variables

This section examines the variables that most affected the base case. This was done by running simulations in the base case model and showing how payoffs fluctuated with changes in stochastic variable values. This section is not a sensitivity where changes to the model are made, but is a test to show how the variables used in the base case affected payoffs. The base case is the most likely situation run to show an optimal solution, which can then be altered. Risk is already involved with the base case and this section explains what made the base case payoffs what they were. First a review of the stochastic variables which derived the revenues and costs, this is followed with an examination on the strategy variables in the model that relate to rail. Both sections will define the base case payoffs with more than just a number.

Table 5.2 shows the key variable impacts on payoffs in the base case. The table is important due to its comparative abilities when showing the 2013/14 crop year comparison. It can be seen that the elevator and destination basis values are the most influential components of payoff for the base case. It is also important to notice that the secondary rail values and transit time also have a large effect on payoffs. The values for each are consistent for the base case and in terms of payoff do not decide whether a grain trading company will make or lose money, but it is imperative for comparative values when the sensitivities are run. Table 5.2 shows how the five stochastic variables given in the table affected payoffs. This shows the variability in each distribution for each stochastic variable.

Table 5.2: Base Case Payoff Distribution

Case	*Mean Payoffs*	*St. Dev*	*Minimum Payoffs*	*Maximum Payoffs*
Elevator Basis Corn	$120,200,728	$5,870,060	$114,304,961	$126,526,670
Destination Basis Gulf Corn	$120,870,644	$5,515,681	$115,772,259	$125,598,114
Primary Rail	$120,180,957	$105,924	$120,087,595	$120,220,000
Secondary Rail	$120,170,556	$4,407,920	$117,596,451	$124,356,351
Transit Time	$120,143,589	$4,582,826	$117,466,812	$124,270,654

Figure 5.6 below shows the sensitivity tornado for the table 5.2 above. This gives a visual representation of how much each of the variables affects payoff. Showing the variability begins to paint a picture of what grain trading companies are most concerned with planning year to year.

It is important to note that the most sensitive variables in the base case do not alter the grain trading company's payoffs as profound as a positive and negative payoff. This says that the base case years values were stochastic in nature, but values were predicted well enough to make decisions that ended with the grain trading company earning a positive payoff. In fact the most extreme range in payoffs is roughly 12 million which is a 10% swing in the mean payoffs. Considering grain trading and the risks involved, a 10% swing in expected payoffs is not uncharacteristic. Other comparative results are presented in table 5.3 below, including rail cars purchased in the primary and secondary market, rail cars sold in the secondary market, and transit time. Table 5.3 also begins to show the sensitivities that were run on the base case.

<u>Function Definition</u>

CornM0713 = Corn price at Elevator

Transit time = Transit time to destination

Secondary = Secondary rail market

CornG0313 = Corn price at Destination

Primary = Primary rail market

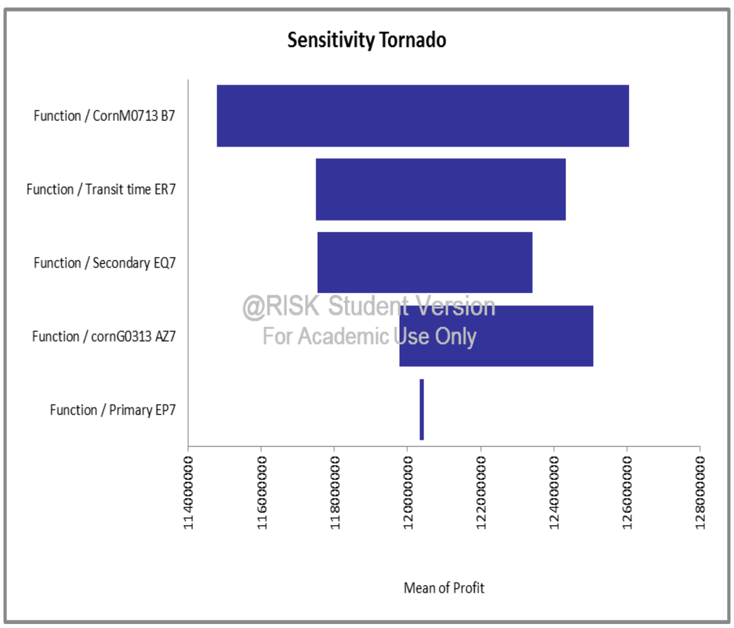


Figure 5.6: Tornado Graph of Key Base Case Variables in 2013/14 Crop Year

Table 5.3 below shows the key logistic results from the base case, sensitivity S7 which is the change from the 2012/ 2013 transit time, to the 2013/ 2014 transit time and the 2013/ 2014 crop year simulation. Sensitivity S7 is when the model was re run with the trip transit time distribution from the 2013 / 2014 crop year. These values aid in drawing conclusions of the findings in this thesis. Each simulation shows how these results changed when key variables where changed. Each paint a picture to the decisions made when situations are put in front of decision makers.

Table 5.3: Key Logistic Results of Base Case, Constrained and 2013/14 Crop Year Simulations

Decision Variable Description	**Units**	**Base Case**	**Sensitivity S7 Transit Time in 2013/14**	**2013 Crop Year**
Primary Shuttles Bought	Shuttles/ Year long	9	9	38
Primary Rail shuttles Sold on Secondary Market	Shuttles/ Year	16	0	75
Secondary Cars Purchased	Shuttles/ Year	49	106	12
Percent of Time Inadequate Freight	Percentage/ Year	16%	66%	9%
Corn Sold	Bushels/ Year	85,561,214	85,561,214	9,057,643
Soybeans Sold	Bushels/ Year	9,915,188	9,915,188	2,921,521
Mean Payoffs *St. Dev*	Dollars/ Year	$120,233,000 $5,582,266	$123,037,551 $5,759,725	$202,510,930 $190,645,068

A key statistic is the probability of primary rail being inadequate for shipping rail cars. This characteristic describes when a grain trading company would have to order on the secondary market in order to meet shipping demands. These values are seen in table 5.3. In the base case the probability of inadequate cars was 16% meaning each elevator meet freight demands with primary rail 84% of the time. The 16% that is not met was not a major factor of cost for the base case year as secondary rail market values were available. The probability of inadequate rail cars in the sensitivity S7 was much different than the base case. The probability of inadequate rail cars when the grain trading company ordered 9 primary shuttle cars for a yearlong commitment was 66% which is up from the base case value of 16%. This means on average the grain trading company would have to order additional rail cars 8 out of 12 months. This statistic explains why a grain trading company would have lost money if strategies are made based on the 2012/13 crop year, then in turn experienced the variability of the 2013/14 crop year. The 2013/14 crop year's strategy helped make the possibility of inadequate primary cars less than the base case. This was due to ordering 38 primary shuttle trains for the years, then selling in excess of need. The logic behind this decision is explained later.

Sensitivities on Base Case with 2013/14 Crop Year Values

This section examines the first set of sensitivities run on the base case. This case is the fixed or constrained case where certain decision variables are held constant to instead show how payoffs change when key stochastic variables are changed. This section is important because it shows how a grain trading company would be affected when changes in expectations on markets occur. Each sensitivity was run by changing the distribution of each variable run individually to reflect the value of the 2013/14 crop year. Once the value was changed, the model was iterated 1000 times to show how payoffs changed.

Table 5.4 defines the sensitivities run for the fixed strategies. Each sensitivity is given as a symbol like S1, followed by its description. This table is referenced in this chapter with the use of the symbols. Table 5.5 shows the results of the sensitives described in 5.4. The comparative results are the payoffs, standard deviation of payoffs, primary and secondary rail numbers, corn shipped, soybeans shipped and the rail transit time used in each case. The first column in table 5.5 is the base case from the 2012/ 2013 crop year. It is shown first to compare to the other sensitivities run.

Table 5.4: Sensitive Description

Symbol	*Description*
S1	Change in elevator basis to match what would have been seen in 13 – 14.
S2	Change in the corn futures prices that would have been seen in 13 -14.
S3	Change in the PNW basis value. Because it is a large factor for the base case results, the PNW is the representative case for all the destinations.
S4	Change in the soybean futures prices that would have been seen in 13 -14.
S5	Change in the primary rail market value to represent values in the 13 -14 crop year
S6	Change in the secondary rail market values to represent values in the 13 -14 crop year.
S7	Change in the transit time per month which the values of which are reflected for the 13 – 14 crop year.
S8	Addition to S7 where we changed transit time. We will then include in this sensitivity the distribution used in S6.
S9	Reducing the St Dev of Farmer Deliveries, and inducing 60% contracting from the base case.

This section describes each sensitivity done on the model individually and explains the economics which can explain the differences that are seen from the base case. Each sensitivity is broken down into what was done, how it was done, and what it means. In the end, this draws closure on the 2013/14 crop year and how a grain trading company could have been impacted if long term decisions on primary shuttles where made in the 2012/13 crop year.

The first sensitivity was changing the elevator basis levels to match that of the 2013/14 crop year. This was done by replacing the distribution for the 2012/13 crop year with the distribution from the 2013/14 crop year for the 12 months that the model was run for. When this was done, payoffs increased by nearly $20 million over the 5 elevators based on this sensitive test. Corn shipped over these months increased as well, while soybeans decreased but only slightly. One important statistic in this sensitivity test is the standard deviation value which remained similar to the base case. The value of the st. dev is close to 5.87 million which means that the payoffs for this case are not extremely volatile.

Table 5.5: Recap of Constrained Sensitivities Run on Base Case for 2013/2014

Case	*Description*	*Mean Payoffs*	*Std. Dev*	*Primary Rail/Year long*
Base Case	Base Case Results	$120,233,000	5,582,266	9
S1	Elevator Basis	$139,920,752	5,870,060	9
S2	Corn Futures	$127,611,506	5,510,417	9
S3	PNW Basis both Corn and Soybeans	$158,819,457	7,515,681	9
S4	Soybean Futures	$120,200,505	5,482,119	9

Table 5.5: Recap of Constrained Sensitivities Run on Base Case for 2013/2014 (continued)

Case	*Description*	*Mean Payoffs*	*Std. Dev*	*Primary Rail/Year long*
S5	Primary Rail	$120,047,083	5,540,177	9
S6	Secondary Rail	$126,132,394	7,226,335	9
S7	Transit Time	$123,037,551	5,759,725	9
S8	Transit & Secondary	$101,085,494	17,465,470	9
S9	Farmer Deliveries	$143,421,671	9,384,526	25

Case	Secondary Rail/shuttles year bought	Shuttles Sold on secondary per year	Corn Shipped/bu	Soybean Shipped/bu	Transit Time Average
Base Case	49	16	85,561,214	9,915,188	2.9
S1	49	16	85,561,214	9,915,188	2.9
S2	49	12	85,561,214	9,915,188	2.9

Table 5.5: Recap of Constrained Sensitivities Run on Base Case for 2013/2014 (continued)

Case	*Secondary Rail/shuttles year bought*	*Shuttles Sold on secondary per year*	*Corn Shipped/bu*	*Soybean Shipped/bu*	*Transit Time Average*
S3	49	37	85,561,214	9,915,188	2.9
S4	49	27	85,561,214	9,915,188	2.9
S5	49	22	85,561,214	9,915,188	2.9
S6	49	38	85,561,214	9,915,188	2.9
S7	106	0	85,561,214	9,915,188	2.2
S8	106	0	85,561,214	9,915,188	2.2
S9	0	49	168,897,217	5,842,783	2.9

A real world look at these numbers say that in 2013/14 the grain trading company purchased commodities at a lower price than the base case year. Based on other circumstances in 2013/14, this makes sense when the grain trading company has higher cost of transportation. Because of this tradeoff, the price paid to the farmer is lower because the process to the end user has increased costs. Other sensitivities show this; but the main fact of this sensitivity is that compared to the base case, the first sensitivity showed that the grain trading company is paying less for the crops purchased. This can be seen by the increased payoffs in the sensitivity run in table 5.5 under S1.

The second and fourth sensitivities are run on the futures values for both corn and soybeans and are examined together. Similar to all the sensitivities, this test was run by taking the distribution of futures values in the base case, and placing the distributions from 2013 2014 in its place. The approximate value in table 5.5 is 127 million for corn and 120 million for soybeans. St. dev does not alter in either case meaning the value is representative. Futures values help us to define the cash value with the change in basis for the elevator and destinations. If payoffs decrease because of a change in futures, it's reasonable to assume that this is because the futures price dropped. A drop in futures price would be because of a devaluation in the product. Each step of the logistics process for the grain trading company has an effect on this futures price. In order to influence shipment during the 2013 – 14 crop year, prices paid at the elevator would have had to decrease because the transportation costs increased, and the rail transit time decreased. Corn futures would have decreased from the base case, with soybeans remaining similar to the base case. For the purpose of this thesis, futures values are run to show an overall change in prices from year to year, it can be seen that the prices of commodities would have decreased from the base case to the 2013/14 crop season.

The third Sensitivity changed the PNW destination basis for both corn and soybeans to match that of the 2013 -14 crop year. Seen in table 5.5 shows that this variable had a high impact on how much payoff could be earned with this change in sensitivity. The mean payoffs were $158,819,457 which is a nearly 40 million dollar increase in mean payoffs, and the st dev was 7,515,681. What this means is the distribution in the base case for PNW basis is higher than the sensitive case. Although slightly more risky, its return on payoffs are higher

Basis values at destinations should influence shipment to them based on the difference in the price paid at an elevator and the transportation costs for a grain trading company to ship that product there. What this sensitivity change shows is that the basis value for the PNW increased between the base case and the 2013 -14 crop year. What this shows is that the destinations had to increase the basis values to receive product. If this is a direct cause of the rail delays of 2013 -14; is up for speculation, but the similarities and argument of this thesis shows that there is correlation between transit time and rail market values with basis values at both the elevator and the destination.

The 5th and 6th sensitivities have to deal with the rail car markets, both primary and secondary. Like the other simulations, we replaced the distributions in the base case for the rail markets, to ones that were experienced in the 2013 – 14 crop year. The primary rail market changed the mean value to $120,047,083with a St. Dev of roughly 5.5 million. On the other side of the spectrum, secondary rail changed the mean payoffs to $126,132,394 with a st. dev of roughly 7 million. What this shows is the values in the base case for the rail ordered COT's did not change enough to make a difference in strategy or payoffs. This is not surprising as the main function of the railways COT's is to move product. The secondary market did affect payoffs based on the sensitivity from the base case. It increased the standard deviation by nearly 50% but also increased the mean payoffs. The reason behind this, was that in the base case, the grain trading company ordered enough rail cars as to not buy from the secondary market. This means that any excess would have been sold for additional profits. The increase in payoffs is explained by the strategy used in the model which was to order enough rail cars to not be subject to ordering secondary cars but instead have the ability to sell a few when not used for shipment. The grain trading company purchased enough in the primary market to satisfy its needs of shipment and sold remaining cars on the secondary market. This sensitivity shows that the secondary rail market values increased substantially from the base case year.

Looking at the rail markets in figure 4.2, it can be seen that the secondary rail market values in 2013 -14 where much more volatile. The suggestion that the sensitive cases S5 and S6 make is that the rail values increased from the base case. S5 mean decreased from the base case which shows that the value of the primary market increased which increased costs but by a fairly small amount. This is representative as over the 2013/14 crop year there was an extreme need for reliable shipping without paying for the secondary market prices. In the base case, the grain trading company ordered enough cars to satisfy its shipping demand given the transit time. So the value in S6 shows how the small amount of secondary cars would have affected the grain trading company with more volatile prices.

S7 was the examination on trip transit time from the base case, which was done by changing the distribution of this stochastic variable in the model to match what would have been seen in 2013 -14. The mean payoffs turned out to be $123,037,551with a st. Dev of 5,759,725. One key output from the sensitive test done is the amount of secondary cars ordered over the year which averaged 106 shuttles over the year. This sensitivity is the focus of this thesis as the transit time in the base case was 2.9 trips per month average, while 2013 2014 was 2.2 average per month. What this shows is that if the company wants to continue on pace with the base case that it has to order multiple shuttles on the secondary market. The secondary rail market values in this case were kept as they were in the base case, and even so the mean payoffs did not alter much. If the rail values for the 109 shuttles ordered were as volatile as they were in 2013 – 14 the average payoffs could have been much less. This test is done in S9.

S8 showed how a grain trading company payoffs would have been affected if both the rail transit time and the secondary markets were changed to reflect that of the 2013/14 crop year. Mean payoffs changed drastically to equal $101,085,494 with a standard deviation of 17,465,470. Primary rail ordered was kept constant at 9 and the secondary market value equal to that in S7 which is 106. What this sensitivity shows is that a company that planned on the base case year for the amount of primary rail to ship would have then been held to ordering in the secondary market to ship the remainder of product. The secondary market was much more volatile and skewed to result in high positive numbers which meant each of the 106 shuttles ordered by the grain trading company would have been added cost. This added cost averaged 20 million over a 12 month period. If a grain trading company relied on secondary rail cars instead of primary cars, this payoff could have been much less. These results solidify the interpretation on the adaptive sensitivity run on the 2013/14 crop year run later in this chapter.

S9 was on how mean payoffs and other variables are affected when we introduce contracted bushels and forward sales. What was done in this case is that at least 60% of the purchases and sales in the base case is contracted at the basis value in the first month plus the futures for each of the months in the 12 month period. Also, the farmer cash sales is not relied upon as much so there is lowered variability in the farmer deliveries. The mean payoffs were $143,421,671 with a standard deviation of 9,384,526. Primary rail ordered for the case was 25 with an amount of 49 shuttles sold on the year. The biggest change is the amount of Corn shipped over the year which totaled 168,897,217 bushels, while soybeans decreased to 5,842,783 bushels. These payoffs are explained due to the fact that it is much easier for a grain trading company to plan its logistics. In this case the grain elevator would buy 25 shuttle trains for use and sell any excess cars on the secondary market. They have this strategy because of the 60% guaranteed commodity being brought into the elevator for sale. This also makes sense with the purchasing power of the elevator. With 60% of the commodities available going to the elevator already, it gives the grain trading company an advantage of passing on business that is not favorable seeing it still owns a sizable amount of its monthly consumption already. It also means with more contracted bushels that the logistics in and out of the elevator is much better planned.

This is due to the reduced uncertainty of farmer deliveries. The standard deviation is high in this case due to the fact that any given month rail cars not used could sell at either positive or negative values. If COT's are not sold they sit on demurrage, if they are sold they are seen as a gain which explains the higher payoffs in this sensitivity.

S9 shows that contracting some of its expected commodity purchases from the farmer is a better strategy for the grain trading company over a year. The reason behind this is the grain trading company can lock in prices that they might expect to see and store and sell to earn a payoff. If a grain trading company relies on month to month changes in prices, they are subject to the market which in turn can be more profitable in certain months, but can also be devastating if the market turns. Due to contracting, the grain trading company had much more purchasing power over the year which means more shipped product, which that change can be seen in the primary rail ordered.

The sensitivities gives a scope of what was important to understanding what went wrong in the 2013 – 2014 crop year. The base case showed results that were representative of a normal year as there was a steady flow of crop from the farmer, to the grain elevator, to the end users of the product. Running the sensitivities, a few things became imperative to this thesis; rail transit time fluctuations determined the strategy, and secondary rail market values determined profitability of the grain trading company.

Rail transit time in the base case is predictable and can be seen in figure 4.5. This changed drastically in S7 and the distribution can be seen below in figure 5.7. What the figure shows is that the value in 2013 -2014 was skewed to a mean that was closer to the minimum then the maximum. This affects how the grain trading company orders rail cars over the year. A grain trading company would not have known that the transit time would have been skewed this much, so in this case, they would have ordered the amount seen in the base case. The amount ordered in the base case would not have been enough meaning the company would have had to order on the secondary market to meet shipping demand.

The secondary market in the base case took on values that were not extremely volatile. Figure 4.5 shows the base case volatility in the secondary rail market. Take that compared to the sensitive case which is shown in figure 5.8, where the mean value is 1500 dollars per car ordered or sold on the secondary market. How this affected payoffs would be that a grain trading company would make decisions on how many primary rail to buy. A company that made extra payoff in 2013 -2014 ordered primary rail in excess of what they would need and sold any extra rail cars on the secondary market for additional payoffs. A company that possibly lost money, ordered just enough rail cars to meet expected shipping with transit time that was predictable, but when that transit time became extremely volatile, they had to order on the secondary market in order to meet expected shipping. This scenario of losing payoffs is one that is likely and makes sense when examining grain trading behavior. If a grain trading company is required to meet a shipping constraint and primary rail does not cover this, secondary cars must be ordered and this could mean that the grain trading company lost payoffs in order to meet a shipping constraint. It is also reasonable to say that some grain trading companies made more money than expected based on their strategy for rail ordering and how much they can sell on the secondary market.

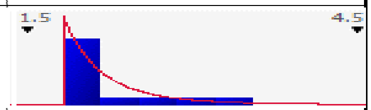
Name	Transit time 2013 - 2014
Range	Sheet2!DU3:DU18
Best Fit (Ranked by AIC)	RiskPareto(5.3530,1.9000)
Function	2.431293098
AIC	9.1264
Minimum	1.9
Maximum	+Infinity
Mean	2.3365
Mode	1.9
Median	2.1627
Std. Deviation	0.5515
Graph	

Figure 5.7: Transit Time 2013 - 2014

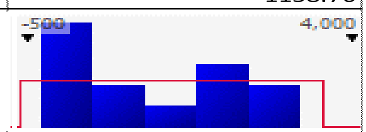
Name	Secondary
Range	Sheet2!DT3:DT18
Best Fit (Ranked by AIC)	RiskUniform(-477.34,3536.7)
Function	1355.957891
AIC	220.9365
Minimum	-477.3438
Maximum	3536.7188
Mean	1529.6875
Mode	-477.3438
Median	1529.6875
Std. Deviation	1158.76
Graph	

Figure 5.8: Secondary Rail Values 2013 - 2014

2013/14 Crop Year Comparison to Base Case

This section changes all the stochastic variables in the model to more accurately reflect the 2013/ 2014 crop year from the values in the base case of 2012/13. There were numerous changes between these two crop years which include a decrease in the basis price offered at the elevators, an increase in the basis price at the destinations, decrease in trip transit time, and an increase in secondary rail market values. The stochastic values from the 2013 / 2014 crop year replaced the values from the base case to create the adaptive sensitivity. The amount of crop available to purchase between the years was more, but did not affect how much the grain trading company could purchase in the region the 5 elevators were located, this was due to the primary method of payoffs the grain trading company used in the 2013/14 crop year and is discussed in this section. Comparisons to the base case to the 2013/14 crop year are significant. When the stochastic variables from the base case are transposed with the stochastic variables from 2013/14, it shows the cases made and validation of variation in this year. In this section is the changes in payoffs, change in purchases and selling by the elevator and changes in strategy for rail car purchases. The comparison in this section will give more understanding to the sensitivities presented in this chapter. Comparisons of stochastic variables between the 2012/13 and 2013/14 crop year are in table 5.6.

Table 5.6: Variable Distribution Changes from 2012/13 to 2013/14

Variable	*2012 Crop Year*		*2013 Crop Year*	
	Mean	St Dev	Mean	St Dev
Corn Basis Elevator	-8.12	39.90	-36.55	57.98
Beans Basis Elevator	-27.18	31.84	-40.15	42.54
Corn Basis Gulf	81.02	39.43	81.75	37.69
Beans Basis Gulf	99.87	32.40	103.40	32.26
Beans Basis PNW	127.22	24.23	143.71	33.33
Transit Time	2.89	.12	2.27	.14
Secondary Rail Value	-53	194	1755	1072

Table 5.6 draws comparison from the base case to the unconstrained simulation where a grain trading company can alter decision variables to adequately plan for stochastic variables related to the 2013/14 crop year. Key points are derived from this table which include the elevator bid to farmers, basis values at destinations, transit time and the secondary rail market value.

Table 5.6, the basis bid from the elevator to farmers weakened and became more volatile. What this shows is the price paid to the farmer in the 2013/14 crop year became less than the base case. This can be explained multiple ways, but what links the table is the basis values and volatility at the elevator; which changed drastically, and at the destinations between crop years which remained close to unchanged for corn. There are many explanations that can be made as to why this happened, but this thesis suggests the burden of the decreased rail time fell on the elevators which move the product, and because of it, decreasing prices paid to the farmer to still turn a profit on corn, which the amount of corn shipped in 2013/14 decreased from the base case nearly 75 million bushels. Soybeans at the elevator and destination changed roughly the same amount in opposite directions. This value became more optimal to ship more soybeans, but as it will be seen, the values in the secondary market were more adventitious to sell cars instead of use them to ship product. Soybeans sold also decreased, roughly 6 million bushels from the base case year.

Transit time and secondary rail values also have a link to the prices paid at the elevator. Transit time for a shuttle train averaged 2.9 trips a month in the 2012/13 crop year, but then decreased to 2.28 in the 2013/14 crop year. Because of this change, a grain trading company whom planned on roughly 3 trips a month would make purchase schedules to adhere to this value as it's a primary constraint. When that constraint is tightened, other forms of transportation must be used which included the secondary market on rail. The secondary market made the most dramatic shift of any variable averaging 53 under tariff for rail cars in the 2012/13 crop year, to 1755 over tariff in the 2013/14 crop year. This difference also came along with extreme volatility in the market with st. dev in 2012/13 at 194 and increasing to 1072 in 2013/14. Looking at the table above, you can link the lower prices paid by the elevator, to the change in structure of the rail ways during this time.

Table 5.7 shows the comparison of key results from the base case of the 2012/13 crop year, and the simulation of the 2013/14 crop year. These values explain how strategy changes from year to year and why grain markets are so volatile. These results are explained in this section and give numbers a real life application to the profit structure of a grain trading company between the 2012/13 and 2013/14 crop years.

Table 5.7: Comparison of 2012/13 and 2013/14 Crop Years

Variable	***2012/13 Crop Year Base Case***	***2013/14 Crop Year***
Mean Payoffs	$120,233,000	$202,510,930
St. Dev of Payoffs	$5,582,266	$190,645,068
Primary Rail Ordered	9	38
Secondary Rail Ordered	49	0
Secondary Rail Sold	16	75
Corn Shipped	85,561,214	9,057,643
Soybeans Shipped	9,915,188	2,921,521

The results for the adaptive sensitivity of the 2013/2014 crop year give a clear understanding of how a profit maximization works, but the results may not be realistic. There are 3 important changes to review. The amount of primary rail ordered changed from 9 primary shuttles to 38. This change was due to the decrease in transit time between years. The grain trading company would have ordered more than needed to ensure proper shipment of product, or sell on the secondary market. The drastic change in secondary rail market values led the grain trading company to change its strategy of earning its revenue. The number of secondary shuttles bought on the secondary market changed from 49 to 0. This would mean over the 2013/ 2014 crop year the grain trading company did not subject themselves to the volatility of the secondary market through purchase. What can be seen is they benefited from purchasing more primary rail then needed and sold them on the secondary market, the secondary rail sold increased from 16 to 75 which means more shuttles where sold over the course of the year for profit. The sales in the secondary market are the primary function for revenues in the adaptive sensitivity, this can be seen by the decrease in the amount of corn and soybeans shipped between the years.

These results may not be realistic with the strategy for a grain trading company. The base case showed that the primary revenue for a grain trading company comes from the use of rail cars for shipment of product. The model is a profit maximization, so in the adaptive strategy it chose the best strategy for the time it was run. Neglecting shipment from elevators for a long period of time may result in loss of customer base among many other externalities. The distributions in the 2013/2014 crop year are also specifically experienced in those years, while the years after are similar to the base case. The results of the adaptive sensitivity are however, comparative and significant for the interpretive abilities it gives. The grain trading company that would have been long rail cars in 2013/ 2014 would have benefited, while being short lead to loss.

Figure 5.9 shows the payoffs from the 2013/14 crop year run through @risk's risk optimization. Comparing results in 5.9 to figure 5.2, it can be seen there is a large swing in results which brings the scope of this thesis full circle. Payoffs in the 2013/14 crop year case had an average payoff of roughly 40 million per elevator. The most important aspect of this story is the extreme ends of the spectrum, with a St. Dev of nearly the full amount of the mean at roughly

190 million. This means that the payoffs gained in the 2013/14 crop year were incredibly volatile and have wide ranges. At a minimum of negative 120 million, that would average out for each elevator to lose 24 million dollars a year. This is largely based on the strategy the grain trading company took in order to maximize the mean payoffs in the 2013/14 crop year. The comparison of payoffs is important as it shows differences in how changes from year to year can affect payoffs and how those variables are altered. More importantly is what lead to these results, which is shown with the amount purchased and sold.

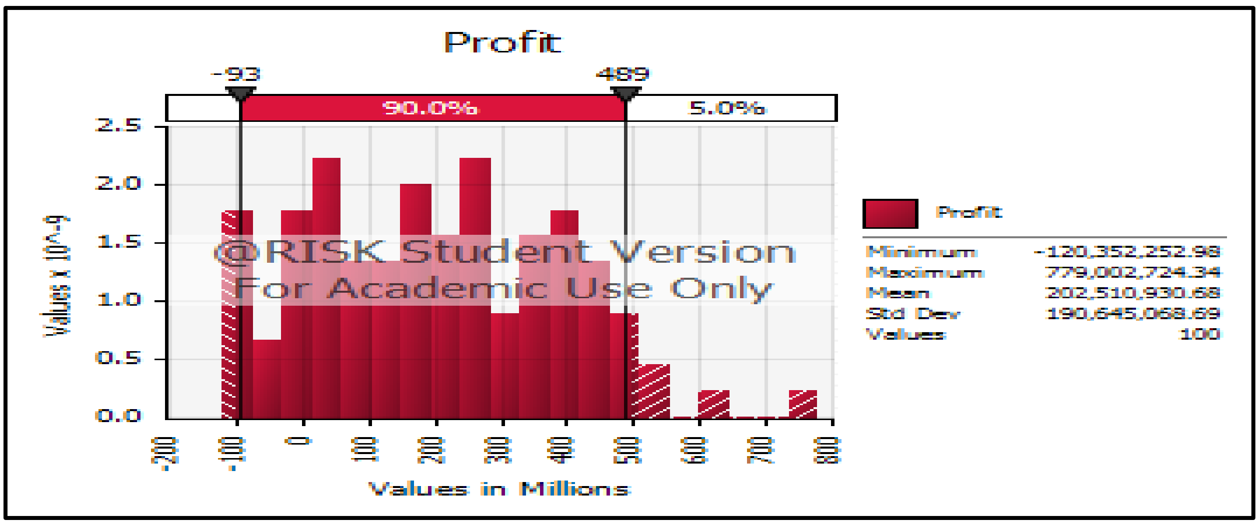


Figure 5.9: 2013/14 Profits

Figure 5.9 in comparison to 5.2 gives an understanding to the structure of strategy for the 2013/14 crop year. 5.2 was far more consistent, while 5.9 is much more sporadic. This had a lot to do with the ability to ship product each month, as well as the changes in cost of shipping the product. It is seen in a few months there was an inversion in the market during this time period as most of the purchasing is done in select months with shipments going out over the year. It is also not surprising to see the amount of corn and soybeans shipped over the year was far less than in the base case, which is explained by the decrease in transit time paired with the increase in the secondary rail car market value. For a grain trading company to ship additional cars then what is owned, the value of shipping had to be greater than the cost which in some cases could have made the decision to ship a difficult decision as the ranges reached upwards of $4000 of cost per rail car.

Figure 5.10 shows graphically the revenues and costs associated with the grain trading company over the 2013/14 crop year. Comparing this to Figure 5.5 it can be explained that an optimal situation for a grain trading company in the 2013/14 crop year and how that differs from the base case year. The strategy of the grain trading company in the crop year of 2013/14 differs greatly from the base case due to the consistent payoffs from trading in the secondary rail market which can be seen comparing figure 5.10 to figure 5.5. Compared to a year earlier, the grain trading company purchases 38 COT sets for a yearlong commitment and sells roughly 75 total shuttles over the year. What this means is the grain trading company ordered 38 shuttle trains to cycle through their plant for a yearlong commitment. Throughout the 12 month cycle, when those shuttles returned to the plant, an individual shuttle of 110 cars was sold 75 times throughout the year. Meaning on average 7 per month.

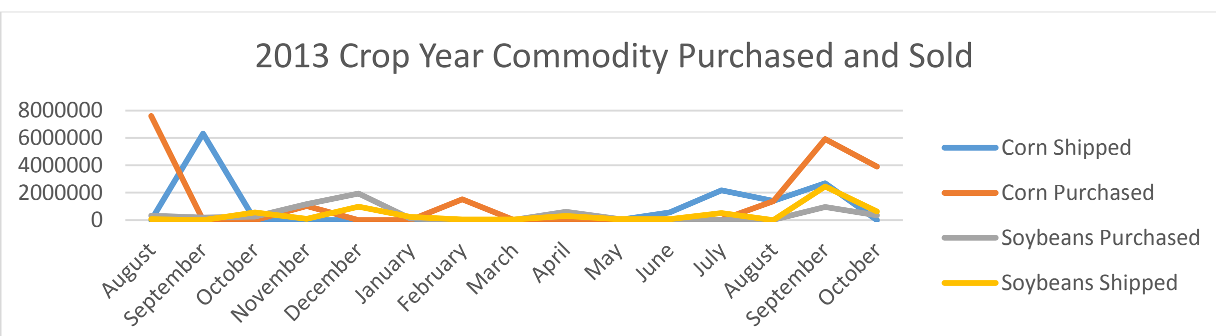


Figure 5.10: Crop Purchased and Sold 2013/14 Crop Year bushels/month

The model was adaptive to changes in stochastic variables and allowed for changes in the decision variables to maximize payoffs. It’s important to note, this change may not be realistic in terms of a grain trading company originally ordering 9 Primary shuttles, to then order 38. What this meant is the grain trading company changed its strategy to order more primary rail then needed to ship product as well as have excess to sell on the secondary market. The results are important for their interpretive value in strategy, where the 2013/14 crop year had large swings in the rail market that created an additional opportunity for a grain trading company to turn a payoff. This is significantly different then the base case where only 9 primary shuttles are ordered per month for 5 elevators.

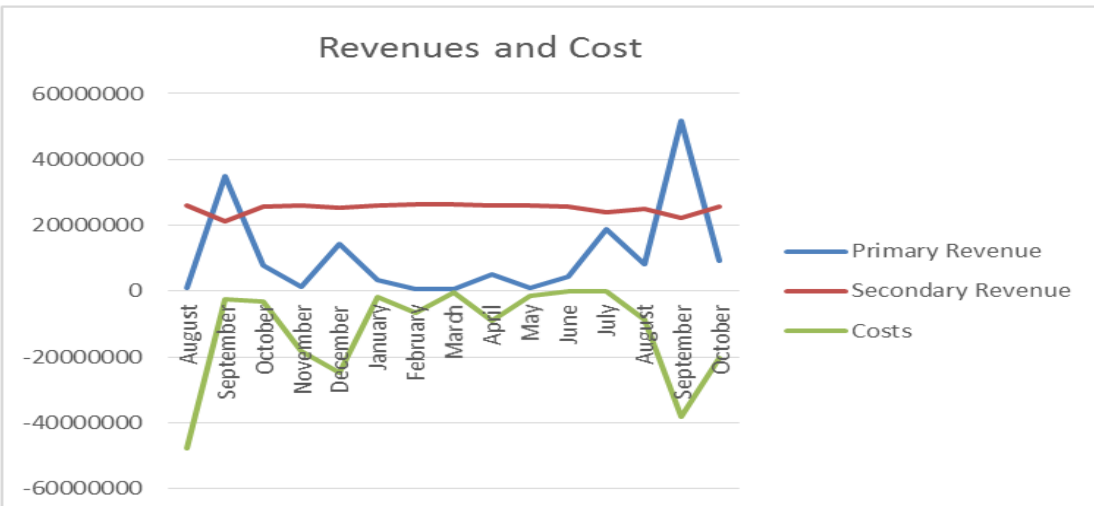


Figure 5.11: Revenues and Cost 2013/14 Crop Year

The reason behind this is the decrease in trip transit time, as well as the increase in secondary rail market values. These results are based on a grain trading company having knowledge of what stochastic variable values would have been in the 2013/14 crop year. Even with knowledge of projected variables, payoffs are very sporadic and movement of product to sell was so unpredictable that it paints a necessary picture of how a grain trading company; whom would have made decisions for the crop year 2013/14 in the base case, would be affected by the actual changes.

Comparing to Economic Theory of Profit Maximization

Profit maximization is a business utilizing its inputs to maximizing outputs. In this thesis, it is the purchasing grain commodities and rail cars in order to sell to destinations to maximize its profits. In the base case the majority of profits were gained by the sale of commodities through the use of cheaper rail. In contrast, the 2013/14 crop year brought a different strategy to maximize which included selling of the rail owned over selling the commodities outright. In either case the grain trading company exhibited a classic profit maximization of profits with two different strategies. Both situations had decisions made to maximize profits in the years run. This strengthens the understanding of profit maximization as we can see decisions being made to utilize inputs to maximize mean profits. Decisions made in each case can be changed in real life situations, but both cases provide a solution to a problem to be solved. Successful companies use these situations to better understand possible outcomes and prepare for real world externalities.

Summary

Nearly every variable between the base case and the 2013 -2014 differed in some way. What this in turn means is that a competitive grain trading company has strategies in place to reduce risk while still having outcomes lead to payoffs. A specific focus of this chapter was placed on the rail way markets and transit time. Both were shown to affect or how a strategy is run. The key to understanding how the problems arise for grain trading companies, is given with an understanding of how the rail markets affected decisions and payoffs.

In conclusion, a grain trading company made money in 2013 -2014 based on how much risk they wanted to assume. Although it wasn’t predicted, a company that relied on secondary market values to ship product would have not shipped nearly as much product as one who ordered more than enough primary rail cars. Each has its own disadvantage in certain years, but in the case a company that would have made money made the decision to purchase as many primary rail cars available to them. Neither strategy is an indefinite solution for a grain trading company, but was the correct strategy if the company wanted to maximize their payoffs in the 2013 – 2014 crop year.

CHAPTER 6. CONCLUSION

Review of Problem Statement

Logistics for a grain trading company is a risky variable in addition to changing prices and other market features. This was prevalent in the 2013 – 2014 crop year when logistic related variables took on highly volatile distributions. BNSF transit times decreased to averages that had not been expected and caused companies to divert from their original strategies. The scope of this thesis was written in regards to the rail market values in 2013 – 2014, as well as the transit time over the course of 12 months for the BNSF railway. Both played a major role in how the problem was developed.

Primary rail is sold by its representative railway at a price with no guarantees. What this means is the railway provides rail cars or shuttles for the term of the lease. If a shuttle is leased for one month, you are provided a 110 car shuttle and its turns per month, but the amount of turns are not guaranteed. In 2012 – 2013 this value was close to 3 trips per month, while in 2013 – 2014 it was closer to 2. When a grain trading company orders primary cars with expectations of 3 trips per month and in turn only gets 2, this creates a discrepancy in shipping capacity over the course of a month. If that company had contracted with farmers, it then must place this amount of crop in excess of shipping in storage or buy rail cars on the secondary market.

The secondary market also experienced volatility where 2012 – 2013 had a mean value of -50 which meant that companies would trade away there owned cars at $50/car under the tariff rate. This value took a turn in 2013 – 2014 where the mean value was roughly 1700 above tariff value. For a company that was forced to purchase secondary cars to meet shipping demand, this was an added cost. For a company that ordered more than enough primary COT's, this could have been an extra source of revenue.

The purpose of this thesis is to examine optimal strategies involved with rail logistics, and how those strategies change from year to year. Specifically when years' experience different distributions with the stochastic variables involved. The end goal of a grain trading company is to optimize resources to come to a profit maximizing point. This thesis focuses on these issues in an attempt to explain the losses that some companies may have experienced, and how some companies may have benefited. With the proper strategy, risks can be reduced and profits can still be gained. In some cases a strategy that was used to reduce risk, can also cause more loss. Because of this, the crop year 2013 – 2014 rail features are the primary research focus of this thesis.

Review of Process

This research was completed with the use of relevant data on basis values of corn and soybeans, futures values, rail primary and secondary values, transit time and farmer sales, as well as other random and nonrandom variables. The random variables in the model were stochastic and with a distribution that could be correlated to each other to return values that would move similar to how they would in the real world. These stochastic values were displayed in a format to explain how a grain trading company who owns 5 elevators would purchase and sell product to 3 separate destinations in order to maximize payoffs. This was done through the use of risk optimization through palisade (Palisade).

Risk optimization takes stochastic values for random variables, and simulates them a certain number of times to show changes in mean, maximum and minimum values of your target cell fluctuate with iterations of the stochastic variables. In the model, profits are maximizing the mean value of payoffs based on the stochastic variable values and decision variables. For the base case, the amount of crops to purchase and sell, and the amount of primary and secondary rail to buy and sell, are decision variables in the model. Risk optimizer selects values for these cells in order to come to a point of maximization.

Values used initially for the base case were the 2012 – 2013 crop year stochastic variables in the model. This case shows a normal year or base case, and derives the values used to make comparisons between sensitivities. Along with the base case, two other tests are run, which are a fixed and adaptive sensitivity. The fixed sensitivity shows how a company who chose’s the amount of primary rail to purchase before the beginning of the 2013 – 2014 crop year, would be affected by changes in stochastic variables. This test shows how a company would be impacted by making a long term decision without knowledge of stochastic variables distributions beforehand. The second sensitivity run is an adaptive case, where the values for the 2013 – 2014 crop were used in place of the base case values, and decision variables are made with knowledge of stochastic distributions

Model Definition and Theory

The model in this thesis is a Manufacturing Resource Planning MRP model run through the use of Risk Optimization. The MRP model optimizes the use of resources in order to maximize a payoff. This thesis uses rail cars and purchasing power as resources for the grain trading company. This section examines in review or revenues, costs and the theory behind why MRP was the best fit for this profit maximization case.

Revenues in the model are given in two separate ways; a primary and a secondary. Primary revenues are seen as the use of rail cars for shipment; the value of that shipped product, or the amount a rail car can be sold on the secondary market. The decision to either use or sell rail cars on the secondary market is a choice that is derived from the model. Secondary revenues are gained by selling excess rail cars that are not needed. This function allows a grain trading company to move rail cars off demurrage and sell them as a secondary source of revenue. These two functions involve selling rail cars, which is a key component of this thesis. It is also a major function in deriving revenues.

Costs in the model involve the purchasing of commodities for sale, Primary rail, secondary rail, fixed costs of fifty thousand a month, as well as other rail way costs including tariff costs. Specific focus is on the commodity and secondary rail costs. The table below gives the basis values for corn and beans at the elevator, basis value for corn at the gulf, bean basis at the PNW, secondary rail values for the base case 2012 and 2013 and the adaptive sensitivity run for the 2013 – 2014 crop year. Table 6.1 links this section to the major findings of this thesis. It also provides a base for concluding this thesis and provide future implications.

Table 6.1: Stochastic Changes from 2012/13 to 2013/14

Variable	*Units*	*2012 Crop Year*		*2013 Crop Year*	
		Mean	St Dev	Mean	St Dev
Corn Basis Elevator	Dollars/ Bushel	-8.12	39.90	-36.55	57.98
Beans Basis Elevator	Dollars/ Bushel	-27.18	31.84	-40.15	42.54
Corn Basis Gulf	Dollars/ Bushel	81.02	39.43	81.75	37.69
Beans Basis PNW	Dollars/ Bushel	127.22	24.23	143.71	33.33
Secondary Rail Value	Dollars/ car	-53	194	1755	1072

Table 6.1 shows that there were large swings in basis values at the elevator for both corn and beans, in addition in the basis value at the PNW for beans. Both of these can be argued that

rail transit time and cost impacted this value, which is discussed further in a separate section of this chapter. The largest swing in prices seen were the value of secondary rail car over the course of one year. This swing brought the value from a relatively small negative value or $-53/ car, to a large positive value of $1755/ car. This meant that if a grain trading company needed secondary cars to ship, they paid on average $1800 more than the previous year. This value is substantial as it can turn a profitable shipment of product, to a negative value. This value is a primary focus of this paper, and helps provide explanation of how situations arise for grain trading companies in the 2013 – 2014 crop year.

The theory involved is a profit maximization using an MRP model. Because this model does not include certain variable costs, profit is instead referred to as payoffs in this thesis. The reason this model is based on a profit maximization, is because the grain trading company is making decisions with its resources and how to allocate those resources in order to maximize its payoffs. An MRP model worked well in this case due to the fact that a grain trading company needed to allocate resources through scheduling over a year long period, in order to maximize its output (Selling crops and/or rail cars. The main goal of the grain trading company is to maximize payoffs and not maximize a utility or improve efficiencies. It is unbiased in choices that may portray a bad image, but instead one that is focused only on maximizing payoffs.

Major Findings

This section is broken into three parts that look at the major finding. The majority of this section reviews results found in chapter 5, but also begins to draw a close on this thesis. The first section reviews the changes in basis values at the elevator and destination markets. The second section reviews the primary and secondary rail car markets as well as trip transit time. The final section examines the strategies that were used for the base case and sensitivities.

Basis values for the model differed between the base case and the 2013 – 2014 crop year. 6.1 is the first step to understanding how revenue and cost structures changed between years. It can be seen below that the costs the elevator paid for both corn and soybeans dropped from the base case year to the 2013 – 2014 crop year. What this means is the price paid to the farmer decreased from one year to the next. There are reasonable explanations for this drop that could be linked to a massive crop yield that year, but also can be explained by the decrease in transit time for shuttle trains, and the increase in secondary rail cars. If an elevator is to stay competitive and still turn a profit in a high cost environment, it needs to evaluate what factors it can influence which would be the price it pays for a commodity. Many factors affect a grain trading company's payoffs that relate to both costs and revenues. But it is easy to see that the prices paid at the elevators were lower in the 2013 – 2014 crop year then they were in the base case. Destination basis also had a range of effects.

Corn values at the Gulf were not as volatile as the basis values at the elevator. There was however a change in the basis value at the PNW which showed an increase from year to year meaning the destination market paid more money to get soybeans moving. Table 6.2 shows the amount of crops purchased in the base case, fixed sensitivity and adaptive sensitivity done. Corn sold in the 2013 Crop year decreased over 89% while soybeans decreased 70%. These extreme decreases make more sense when evaluating how a grain trading company made money in the 2013 – 2014 crop year, but there was more of a decrease in corn because the values became more beneficial to ship more soybeans.

Table 6.2: Key Logistic Results of Base Case, Constrained and 2013/14 Crop Year Simulations

Decision Variable Description	Units	Base Case	Sensitivity S7 (Transit Time in 2013/14)	2013 Crop Year
Corn Sold	Bushels/ Year	85,561,214	85,561,214	9,057,643
Soybeans Sold	Bushels/ Year	9,915,188	9,915,188	2,921,521

Primary and secondary rail cars are a key driver in shipping product for a grain trading company. It is also a resource that needs to be planned accordingly to reduce risk as a grain trading company cannot just order rail cars at will. There are also variable factors that influence how the market works from year to year which include the values shown for primary rail on a rail ways auction, the secondary rail market value, and trip transit time. Table 6.3 below shows the key logistics variables between the base case, fixed and adaptive sensitivities. This comparison is important as it leads to the strategies discussed later. The logistics portion of this section displays links between the basis values at the elevator, and key logistics results, which defines strategy.

There are key differences from year to year that help us to explain the issues in the 2013/ 2014 crop year. S7 is a fixed sensitivity where the decision variables from the base case where held constant, what was changed is the distribution of trip transit time was changed to reflect the 2013/ 2014 crop year. The base case and S7 have the same primary rail purchased because S7 was a fixed sensitivity. Secondary rail cars purchased and sold was adaptive in all cases which is why the amount purchased and sold in the secondary market is different for each. In the base case, the grain trading company was able to satisfy shipping needs 84% of the time with primary rail ordered on a yearlong lease with only 16% of the time having to use secondary cars for shipment. This base case differed greatly from the other sensitivities. S7 was ran with base case values but with the distribution on transit time with the 2013 – 2014 crop year. In this case it can be seen that the grain trading company had to purchase over 50 more shuttles over the year in order to meet shipping demands, and only was able to satisfy shipping demands with primary rail 34% of the time. This dramatic change showed how a grain trading company that made long term decisions could have been impacted by externalities in the market. Specifically if these values are added to the rail values seen in the 2013 – 2014 crop year.

Table 6.3: Key Logistical Results between Base Case, S7 and 2013 Crop Year

Decision Variable Description	Units	Base Case	Sensitivity S7 (Transit Time in 2013/14)	2013 Crop Year
Primary Shuttles Bought	Shuttles/ Year long	9	9	38
Primary Rail shuttles Sold on Secondary Market	Shuttles/ Year	16	0	75
Secondary Cars Purchased	Shuttles/ Year	49	106	12
Percent of Time Inadequate Freight	Percentage/ Year	16%	66%	9%
Trip Transit Time	Turn times / month	2.9	2.2	2.2

The adaptive sensitivity or the 2013 – 2014 crop year model showed how a grain trading company would have changed its strategy in order to meet obligations in shipping and how to maximize its profits. Table 6.4 shows how strategies would have changed if the grain trading company had prior knowledge of the distributions from the 2013 – 2014 crop year. The section may not be real world applicable in how the strategy was executed, but gives an indication as to how a grain trading company would have altered their strategy given prior knowledge of stochastic variables. This is the major finding of this thesis.

In the base case, it can be seen in table 6.4 that the grain trading company used there rail cars for shipment of product from the origin to the destination market. That can be seen by the amount of crops sold over the year compared to the 2013 – 2014 crop year. It also is seen by the amount of times those primary cars are sold on the secondary market which was 16 times over the year. This is expected of an elevator, as we expect that they move the product to end user destinations. This analysis provides a solid base case and one that would be typical of a grain trading company.

Table 6.4: Comparison of 2012/13 and 2013/14 Crop Years

Variable	*Units*	*2012/13 Crop Year (Base Case)*	*2013/14 Crop Year*
Mean Payoffs	Dollars	$120,233,000	$202,510,930
St. Dev of Payoffs	Dollars	$5,582,266	$190,645,068
Primary Rail Ordered	Shuttles/ Year long Lease	9	38
Secondary Rail Ordered	Shuttles/ Year	49	0
Secondary Rail Sold	Shuttles/ Yea	16	75
Corn Sold	Bushels/ Year	85,561,214	9,057,643
Soybeans Sold	Bushels/ Yea	9,915,188	2,921,521
Percent of Time Inadequate Freight	Percentage of time primary could not ship	16%	9%

In contrast, the 2013 – 2014 crop year had different results and shows that a massive strategy change was made in order to maximize profits. The adaptive sensitivity for the 2013 –

2014 crop year showed that the grain trading company would turn the highest mean profits by selling rail cars on the secondary market instead of using them for shipment. Because of this, the amount of primary shuttles ordered increased from 9 to 38, with no rail cars purchased on the secondary market. Some crops were purchased and sold over the year, but a decrease in both commodities sold of 89% in corn and 70% in soybeans.

This change is drastic, and raises a red flag on the strategy accustomed to a grain trading company who owns elevators. This finding shows the value of trading rail in the secondary market, which also shows the value of the option to sell rail cars over using them for shipment. This change in strategy also defines why a grain trading company could have had outstanding gain, or extreme losses. If a strategy was to be long primary cars in the 2013 – 2014 crop year, you would either be able to satisfy your needs more effectively for shipment, or have excess after shipment for sale on the secondary market. While a company who is short cars and relies on secondary cars to meet shipping demands would have been subject to the volatility of the secondary rail market, while also not meeting shipping demands with primary rail owned. This strategy is also an extreme, and can be flipped in a market where it is more beneficial to be short cars when there is a surplus of rail available and for a cheap value.

The results are extreme and point to changing strategies between two years. The results show that a grain trading company would have earned a higher mean payoff if rail cars were sold instead of being used for shipment. Secondary rail sold increased from 16 to 75 between the two years which lead to a different source of primary revenue. It can also be seen that the secondary rail ordered between years decreased from 49 to 0. This meant that the grain trading company had enough primary rail ordered to meet shipping demands without being subject to the variability of the secondary market.

These results are not realistic for a real grain trading company. There are a few reasons which include that a grain trading company whom moves crops would ruin relationships with local farmers if crop is not purchased. Another would be the strategy of being long so many rail cars would have been unrealistic as well as the volatility of stochastic variables would be unpredictable. What the results show is a grain trading company would have benefited from being long rail cars in 2013/ 2014, but reasonably a long would have been around 15 primary shuttle cars and not 38.

Implications and Future Development

The implications of these results are that having the option of selling in the secondary market gives grain trading companies another source of reducing risk as well as a primary or secondary source of revenue. That option shows a value to grain trading companies as an arbitrage opportunity. If the correct strategy is chosen, the value has a large payoff. Results from the thesis would lead to further research in rail markets and trading opportunities related to rail markets.

This thesis can be developed further to show the payoff value of trading rail in the secondary market. An underlying goal of this thesis is to show that there are more ways for grain trading companies to make a profit through applying strategy and developing market intelligence in rail markets. The world is growing, and the demand for food is increasing, which means the logistical problems need to be addressed by both the rail way and the grain trading companies who use them. Both can succeed with proper strategies and reducing risk.

Summary

The results above shows is the occurrences of the 2013 – 2014 crop year where an externality on the market, but it was one where strategy in a market helped define how profits were made. The values of selling rail cars on the secondary market are shown through this thesis to have a large impact on payoffs. While some results may not correlate well to a real life implication, it does show how strategy changes affect profits. It also shows how the rail market can be a primary source of revenue if used in the correct way.

REFERENCES

Ballou, Ronald H. *Buisness Logistics Management*. New Jersey: Prentice-Hall, Inc., 1992.

Bensoussan, Alain, et al. "Computation of approximate optimal policies in a partially observed inventory model with rain checks." *Automatica* (2011): 1589-1604.

BNSF. *BNSF.com*. 03 08 2015. <http://www.bnsf.com/customers/how-can-i-ship/dedicated-train-service/#%23subtabs-2>.

DTN Prophet. *Commodity Market Trading* Data. Omaha: DTN ProphetX Energy and Commodities Sales, 3 August 2015. Price Ticker.

Economist, Office of the Chief. "Rail Service Challenges in the Upper Midwest: Implications for Agricultural Sectors – Preliminary Analysis of the 2013 – 2014 Situation1 ." 2015.

Fatka, J. "Rail Delays cause more than headaches." *Feedstuffs* 19 April 2014: 4 and 16.

Geunes, Joseph P, Ranga V Ramasesh and Jack C Hayya. "Adapting the newsvendor model for infinite-horizon inventory systems." *International Journal of Production Economics* (2001): 237-250.

Geunes, P. Joseph, V. Ranga Ramasesh and C. Jack Hayya. "Adapting the newsvendor model for infinite-horizon inventory systems." *International Journal of Production Economics* (2001): 237-250.

Gray, Dr. Richard. *Producer Recommendations on the Future of Canada's Transportation Act*. Saskatchewan, 2015.

Heckmann, Iris, Tina Comes and Stefan Nickel. "A Critical Review on Supply Chain Risk-Definition, Measure and Modeling." *Omega* (2015): 119-132.

Horvat, Liljana and Ludvik Bogataj. "A market game with characteristic function according to the MRP and input-output analysis model." *International Journal of Production Economics* (1999): 281-288.

—. "A market game with charectoristic function according to the MRP and input-output analsis model." *International Journal of Production Economics* (1999): 281-288.

Koh, S.C.I and S.M Saad. "MRP Controlled Manufacturing environment disturbed by uncertainty." *Robotics and computer Intergrated Manufacturing* (2003): 157-171.

Koh, S.C.L and S.M Saad. "MRP-controlled manufacturing environment disturbed by uncertainty." *Robotics and Computer integrated Manufacturing* (2003): 157-171.

LaChiusa, Chuck. *History of Buffalo*. August 2013. <http://www.buffaloah.com/h/dart/>.

Lagodimos, A.G. "Models for Evaluation the Performance of Serial and Assembly MRP Systems." *European Journal of Operational Research* (1995): 49-68.

Lorton, Sherry and Don White. *The Art of Grain Merchandising*. Champaign: Stipes Publishing Company, 2010.

Mangla, Sachin K, Pradeep Kumar and Mukesh K Barua. "Monte Carlo Simulation Based Approach to Manage Risks in Operational Networks in Green Supply Chain." *Procedia Engineering* (2014): 2186-2194.

National Agricultral Statistics Serice, USDA. *corn and soybean farmer sales by month*. 2011-2015. <http://quickstats.nass.usda.gov/?long_desc__LIKE=corn+sale&x=30&y=19#FE73CE38-48FD-33D5-96B2-3C330211EF05>.

Nooraie, S Vahid and Mahour M Parast. "A Multi-Objective Approach to Suppy Chain Risk Management: Integrating Visibility with Supply and Demand Risk." *International Journal of Production Economics* (2015): 192-200.

Palisade. "Risk Optimizer: Optimization with Simulation for Microsoft Excel." *Risk Optimizer*. Newfield: Palisade Corporation, 1998.

Pirrong, Craig. *NOT TOO BIG TO FAIL Systemic Risk, Regulation, and the Economics of Commodity Trading Firms*. Houston: Craig Pirrong, 2015.

Qi, Lian and Kangbok Lee. "Supply Chain Risk Mitigations with Expedited Shipping." *Omega* (2014): Article in Press.

Stowe, John D and Tie Su. "A Contingent-Claims Approach to the Inventory Stocking Decision." *Financial Management* (1997): 42-55.

Tempte. "PNW Shuttle rail values." 08 2015.

TradeWest Brokerage Co., 0. *Evening Market Recap*. Hillsboro, 2015.

United States Department of Agricultre, 0. "Grain Transportation Report." 25 December 2014. *USDA.* <Http://dx.doi.org/10.9752/ts056.12-25-2014>.

USDA. "Rail Service Challenges in the Upper Midwest: Implications for Agricultural Sectors – Preliminary Analysis of the 2013 – 2014 Situation1." 2015.

Wilson, William W, Bruce L Dahl and Donald C.E. Carlson. *Logistical Strategies and Risks in Canadian Grain Marketing*. Fargo: North Dakota State University, 1998.

Wilson, William W, Donald C.E. Carlson and Bruce L Dahl. *Logistics and Supply Chain Strategies in Grain Exporting*. Fargo: Agribusiness & Applied Economics Report No. 457, 2001.

Wilson, William W, Steven R Priewe and Bruce Dahl. "Forward Shipping Options for Grain by Rail: A Strategic Risk Analysis." 1998.