REAL OPTION ANALYSIS OF PRIMARY RAIL CONTRACTS IN GRAIN SHIPPING

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Real Option Analysis of Primary Rail Contracts in Grain Shipping

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ABSTRACT

Grain shipping for a country elevator involves many sources of risk and uncertainty. In response to these dynamic challenges faced by shippers, railroad carriers offer various types of forward contracting instruments and shuttle programs. Certain contracting instruments provide managerial flexibility by allowing shippers to sell excess railcars into a secondary market. The purpose of this study is to value this transferability as a European put option. A framework is developed around a material requirement planning schedule and real option analysis to represent the strategic decisions facing a primary shuttle contract owner. Monte Carlo simulation is incorporated with a stochastic binomial option pricing model to value the transfer option. A sensitivity analysis is then conducted to determine the impact of key input variables. This study provides insights about railcar ordering strategy, and the implications of transferable rail contracts for shippers and carriers.

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CHAPTER 1. INTRODUCTION

1.1. Overview

Increased volatility in the market for railcar demand has required grain shippers to pay more attention to their car ordering strategies. Their approach to ordering railcars can be the difference between efficient commodity movement through the supply chain, or piles of grain sitting on the ground outside with nowhere to go. This can be due to the shipper not having enough storage, not having enough cars ordered to meet their shipping demand, or the cars they have ordered being late due to bottlenecks. In response to these numerous risks, railroad companies offer various contracting instruments to grain shippers. These contracts differ from carrier to carrier, and change over time. Among these contract agreements are different terms and conditions, some of which provide shippers with managerial flexibility. The flexibility in this study refers to the options a shipper is provided with when they have excess railcars on hand. While traditional methods, such as net present value (NPV) analysis, provide tools to value the quantitative aspects of these contracts, valuing the qualitative components provide more of a challenge. One emerging capital budgeting method to value the flexibility embedded within investment decision making is real option analysis. This chapter highlights the logistical risks inherent in grain shipping, objectives of this study, procedures, and organization of the paper.

1.2. Problem Statement

Just as buyers and sellers of a commodity are exposed to price risk of the commodity itself, they are also exposed to logistical risk in each step of the supply chain (Wilson & Dahl 2011). The logistics process involves multiple steps, and each one is crucial to the overall goal or objective of the business. In many logistics systems, if any step in the process underperforms, the whole system itself is at risk of failing (Choi, Chiu, & Chan 2016). This is especially important in grain markets. as there are usually many steps involved between the initial producer, and the final consumer.

Take for example a soybean crush plant in China who has bought soybeans for delivery in a specified month. If these soybeans are coming from an exporter in the U.S., they would have been loaded on an ocean vessel at a port. Prior to this, the soybeans may have been sourced from an inland country elevator. If the railroad carrier that is hauling the grain from the elevator to the port experiences delays, the grain is late to the port. This in turn causes issues for the ocean vessel, since it must either wait for the grain, or move on without it. Either way, this forces the soybean crusher in China to either wait for the grain, whilst possibly delaying production, or source the soybeans from elsewhere, exposing them to the price risk of other markets.

In an industry as dynamic as grain merchandising, managers face many different decisions, and each of these decisions involves some level of risk. When it comes to ordering railcars, there are various sources of uncertainty that can affect returns to a shipper. Among many, three of the major sources risk stem from the fact that: 1) farmer deliveries (i.e. inventory levels) are unknown for certain, 2) prices of railcar service changes daily, and 3) railroad performance can fluctuate. The issue of rail performance has recently been at the forefront of grain shipping in the 2013/2014 marketing year when various factors caused large backlogs of grain, which is discussed later in this chapter.

1.2.1. Inventory Level Risk

The first issue, random inventory levels, stems from the fact that farmers do not always deliver grain according to a set schedule. Although elevators offer a variety of contracts to their producers that ensure grain delivery during a given timeframe, a large portion of farmer sales are the result of “cash” or “spot” deliveries. These sales occur when farmers decide that the current price posted by the elevator is sufficient for their needs, and sell grain on the "spot" by hauling it in and transferring ownership. Given the fact that farmers naturally sell more grain when prices are high yields the notion that elevators can control supply levels to some degree by raising or lowering their bids. Although this is true to some extent, elevators cannot directly dictate 100% of supply levels since the decision to sell in a spot sale is ultimately up to the farmer. Also, adding to the uncertainty is the fact that elevators do not exactly set the full price of grain. Rather, they set their "basis" value, which is premium or discount in relation to the futures market price of a commodity. The futures price, which is traded on a central exchange, typically serves as a regional or global benchmark price for a given month (Bernard, Khalaf, Kichian, & McMahon 2015). When elevators are in need of grain, they may increase their basis in order to attract farmer sales. However, a simultaneous decrease in futures prices may cause the posted cash price for the day to remain unchanged. This gives elevators even less control as to how much grain inventory they are able to purchase from farmers. Due to the fact that many railroad carriers offer yearlong contracts, this means that elevator mangers must make car ordering decisions for months or years in advance to ship inventory that they are unsure that they will have. Alternatively, if a shipper does not order enough cars, they may not be able to move grain in a timely manner and could be forced to halt farmer sales.

When farmers deliver grain, the elevator, who is exposed to cash price risk, can offset most of this risk by hedging in futures markets (Myers & Hanson 1996). The elevator is then exposed to basis risk. One of the only ways for an elevator to ensure supply levels and price is to issue forward contracts to producers, which specify the number of bushels, price, and time of delivery. These contracts are attractive to both parties since producers can mitigate price risk and they assure a supply of grain for the elevator (Mark, Brorsen, Anderson, & Small 2008).

Elevators also buy grain on "Delayed Price" contracts, which gives the elevator control of the grain, but allows the farmer to set the price later. Since a typical country elevator cannot forward contract 100% of farmer deliveries, they are almost always exposed to some degree of inventory risk.

1.2.2. Railroad Price Risk

The second major source of logistic uncertainty facing elevators is the fact that prices for rail service fluctuate monthly or daily (depending on the carrier and pricing mechanism). Rail rates are comprised of three main elements: tariff, primary auction price, and the secondary market rate. A shipper who forward contracts cars directly with the rail carrier pays the tariff and the primary auction price. Shippers who do not forward contract with the railroad, and instead utilize cars on an as-needed basis, pay the tariff and secondary market rate. Volatilities of tariff rates and primary auction rates are minimal, but secondary market rates fluctuate significantly.

The primary market allows the shipper to forward contract cars for a year at a stable price, but an elevator who has not contracted or locked in a forward price for rail service is exposed to potential rate changes every time they ship grain. In the BNSF pricing model, as well as most other major railroad carriers, shippers each pay a tariff rate that is posted for every origin and destination combination. This tariff rate is the base amount that the shipper pays to BNSF for rail service, which is meant to cover the cost of rail service, margin, and possibly a fuel service charge (bnsf.com). The fuel service charge is meant to be a variable part of the tariff that fluctuates with the price of fuel. Some carriers explicitly list this charge, and others build it into their tariff rate. This tariff rate is subject to change each month. This means that elevators may face a different shipping price each month if they are ordering cars on an as-needed basis. Given that there are no futures or derivative markets on railroad contracts for shippers to hedge in, the only way to mitigate price risk is to initiate some type of forward contract that explicitly lists the terms of quantity, time of placement, and price (Wilson & Dahl 2005).

The tariff rate only covers the cost to send trains to a destination. Reserving cars may add another cost. Each carrier has their own specific pricing mechanism, but in general, primary market shippers pay a premium over the tariff to reserve cars. Some carriers utilize auction allocation systems that award rail service to the highest bidder. However, this premium is usually minimal and does not vary too much.

If a shipper is buying rail service from an owner other than the railroad carrier, such as another elevator, the buyer pays a premium to the primary owner of rail service through a secondary market (TradeWest Brokerage Co.). This may also be a discount in relation to the tariff during times of excess car supply or low shipping demand. Although tariff rates do not change very often, or very drastically throughout the year, secondary market values (premiums or discounts in relation to tariff) can change daily. Figures 1.1 and 1.2 show secondary prices, and the difference in prices that a shipper who forward contracts in the primary market would pay (tariff) compared to one who utilizes secondary market cars. A variety of factors can affect these prices, including supply levels at elevators, demand for grain by buyers, demand of rail service from non-grain products, rail service disruptions, and others (Sparger & Prater 2013). Details on how each of these pricing mechanisms work is discussed in later in this chapter.

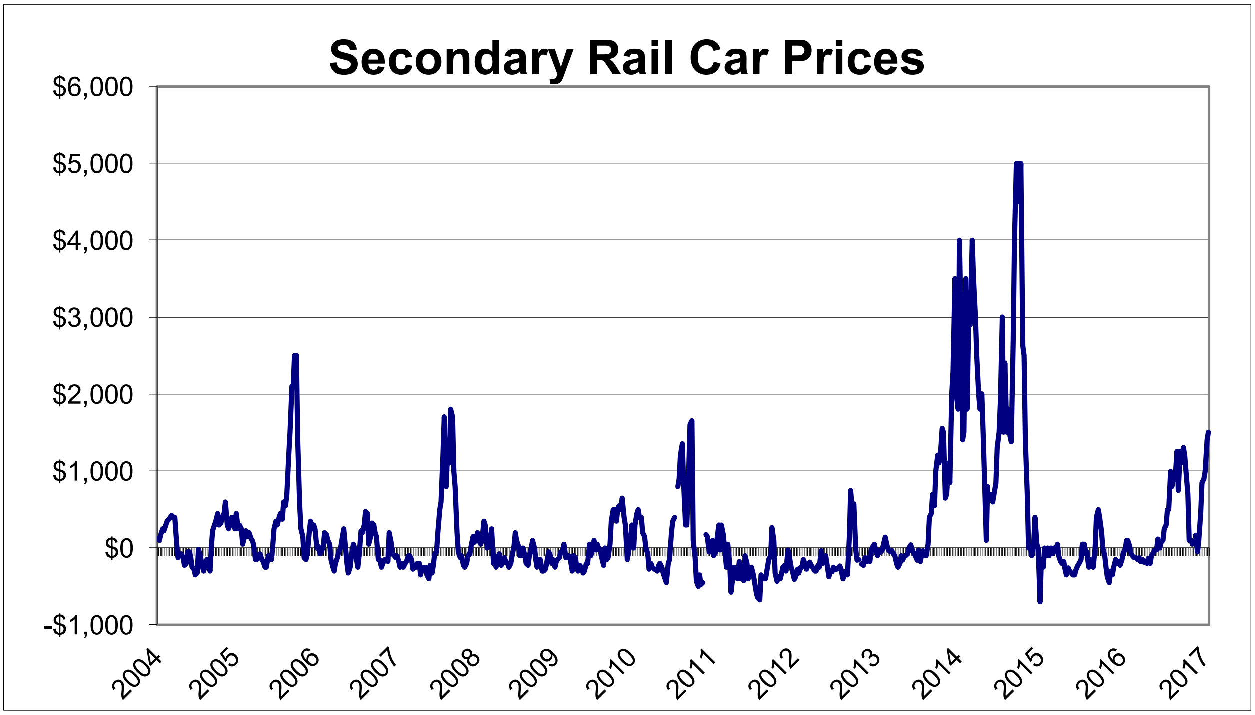

Figure 1.1. Secondary Railcar Prices (TradeWest Brokerage Co., compiled by Bruce Dahl)

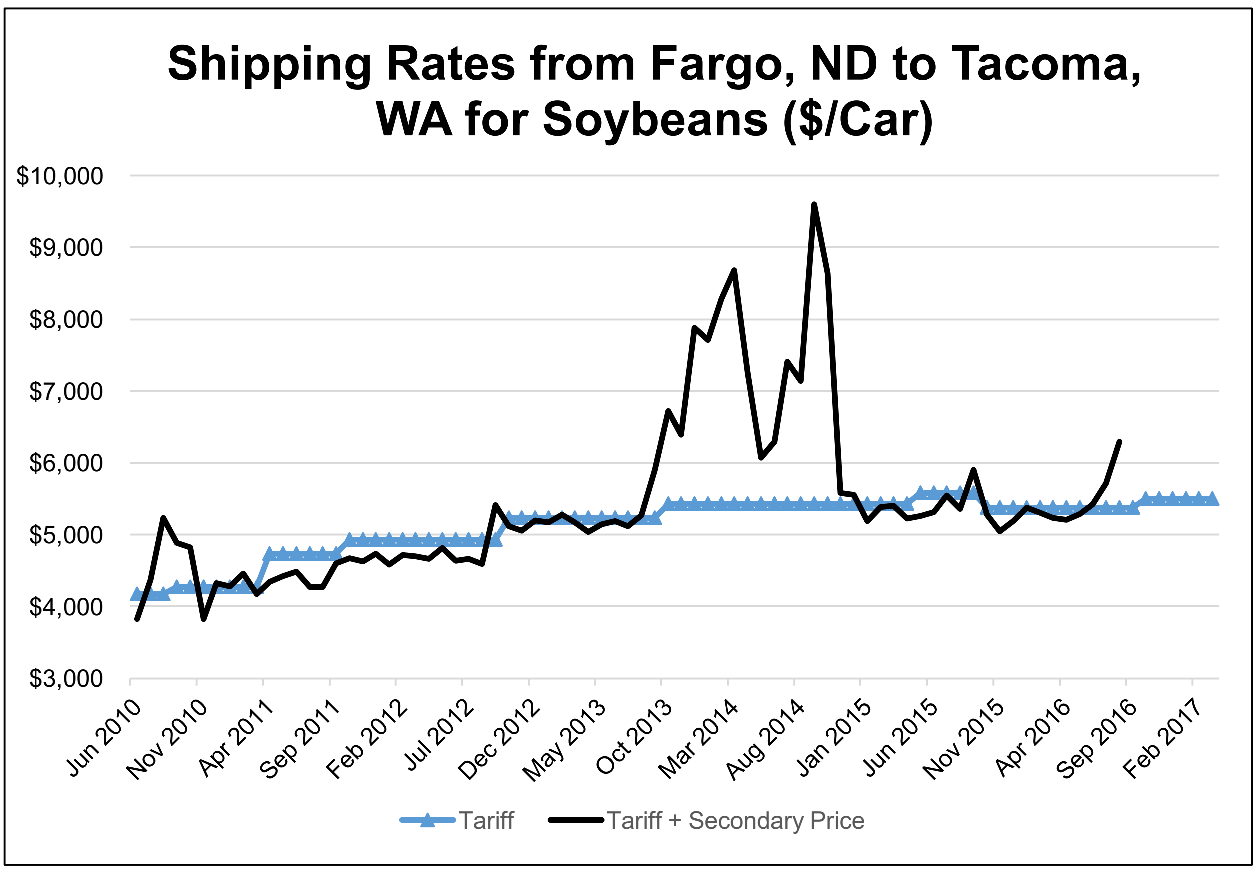

Figure 1.2. Historical Tariff Rates from Casselton to Tacoma (USDA-AMS GTR Report)

Rail markets and their volatility have large impacts on grain shippers who do not forward contract, and these impacts are sometimes carried through to the producers in the form of basis volatility (Wilson & Dahl 2011). If rail rates increase, this means that it is more expensive, or maybe not possible at all, for elevators to move grain. If elevators are not able to move inventory at an economically attractive rate, they would not be able to bid for farmers' grain as aggressively as they could if transportation was cheap. (Wilson & Dahl 2011).

Take for example in early October of 2016 when heavy rains and snowfall caused service disruptions in Montana. In a podcast to shippers, John Miller of BNSF explained that these storms caused rail tack switching mechanisms to malfunction and power outages to occur, which forced delays to some trains. In addition, BNSF crews and maintenance teams had difficulty getting to the affected areas due to white out conditions caused by the storms. Since Montana is a key shipping corridor to the Pacific Northwest, this caused a delay in service and secondary market prices shot up to $1,675 over tariff. By comparison, Union Pacific's cars, which were not affected by the storm, were trading at $100 under tariff during the same time. To put that into perspective, that is a 45 cent/bushel different in service prices that shippers under each carrier would have to pay, mainly due to adverse weather conditions (Jimmy Connor; R. J. O'Brien)

1.2.3. Railroad Performance Risk

A third major source of risk that grain shippers face when making logistic planning decisions is railroad performance risk. Many different studies have referenced this phenomena, using different terms such as efficiency, car performance, trips per month, and velocity, among others. Save for some minor nuances, these terms all refer to on-time rail performance (Wilson, Priewe, & Dahl 1998). Rail performance is important since it ensures efficient grain flows in a timely matter.

Say, for example, a shipper with a full elevator has scheduled a shuttle train to arrive in the first week of November. In anticipation of the shuttle freeing up some space in the elevator, the manager has forward contracted some grain from farmers to arrive during the second week of November. If the train happens to be late and miss the first-week delivery window, the elevator now has a capacity issue with the farmer expecting to bring in grain. If the train was scheduled to bring the grain to a port, this tardiness could cause issues further along down the supply chain with the ocean vessel. This is a simple example, but goes to show the importance of trains arriving at an elevator on time.

There are many reasons that railcar performance can fluctuate. It can be short-term factors, such as inclement weather, or more broad things like track congestion and large grain supplies. Tolliver, Bitzan, and Benson (2010) did a study on factors affecting railroad performance and concluded that length of haul, number of cars per train, and net tonnage per car all had positive influences on performance. Unsurprisingly, factors such as roadway congestion and railyard congestion were found to have negative impacts on performance. Also, the type of service provided had an impact on how efficient the trains were. Trains that were running as part of a forward contracted, dedicated service had better performance than cars that were for small units traveling short distances, or "way trains." Other qualitative effects that are hard to account for in a model were also said to be significant such as technological innovation, and institutional and labor factors.

There are many ways to measure railroad performance, depending on the type of service, and aspect of efficiency that is being analyzed. Some indicators that have been used include train speed, tonnage transported, or track congestion (Tolliver, Bitzan, and Benson 2010). The American Association of Railroads uses a measure called "revenue ton-miles per train-hour" that is a composite measure of train speed and revenue tonnage. While these methods are good indicators of railroad performance from a business standpoint, grain elevators are more concerned about performance in terms of on-time arrival of railcars, which is noted by the Surface Transportation Board (STB). Each week, all major U.S. carriers are required to submit a report to the STB detailing, among many other things, how many cars are late (outstanding orders) and the average number of days late for outstanding car orders. This metric details how many cars have been ordered for a specific delivery window and are currently late. This is important as it provides transparency to railroad efficiency measures (STB).

For dedicated-service trains, the most common metric used to indicate performance is "trips per month" (TPM) or velocity. The TPM metric is very important as it gives the owner of the contract an idea of how many cars they need to fill in a given month based on how many shuttle round trips are expected. Note that TPM is usually recorded as a decimal since it is an average across all dedicated service trains. This is also recorded and published in the STB report as well. TPM is an important variable that is discussed more later in this thesis.

Railroad performance is essential to grain shippers when planning their logistic needs. When shortages of shipping supply occur, basis levels collapse at origins and increases at destinations, meaning that farmers receive less for their grain while buyers must pay more. It is not necessarily always the fault of the railroad, and there is always debate upon who the burden lies when poor performance results in businesses and/or producers losing money.

1.2.4. 2013/2014 Situation

Recently, rail performance became a major issue that peaked during the 2013/2014 crop year when record supplies of grain, and increased demand for tanker cars to transport Bakken oil led to large bottlenecks in grain transportation. In a report from the Burlington Northern Santa Fe

(BNSF) railroad to the United States Transportation Board (STB) dated June 27, 2014, the largest railroad in North Dakota stated that they had 4,942 past due cars scheduled for grain shipment in the state, and the average length of tardiness on these cars was 32 days.

There has been an ongoing debate about who is responsible for these periods of backlogs in grain shipping. In a testimony to the United States Transportation Board during April of 2014, National Farmers Union President, Roger Johnson, stated that the consequences of these shortages were ultimately passed on to the farmer in the form of depressed basis levels. Basis is the difference between spot cash price and futures price for a commodity which the elevator sets to determine their bid to the farmer, based on many factors including supply and demand, and transportation costs. In addition to lower interior basis, bases levels increased at terminal and export markets since those shippers could not source grain and had to bid more aggressively. Johnson estimated that these shortages cost farmers $0.40-$1.00 per bushel for wheat, or $9,600 total per average farm. He argued that the STB needs to hold railroads responsible for these losses, require railroads to dedicate a portion of cars to grain, and ensure there is increased future investment in railroad infrastructure.

On the other side, railroad companies could argue that these are marketing issues, not transportation issues. During the fall of 2013, record oil prices were causing Bakken crude oil to flood the market, leading to major increases in demand for shipment along North Dakota's rail network. During the same time, futures prices for soybeans were inverted, meaning that it was more economical to sell grain rather than store it. Farmers were just coming off a large harvest and were eager to sell their crop, leading to excess supply situations at many elevators.

In the same June 2014 report from BNSF, it was evident that railroads were taking the matter seriously and ramping up investment in order to alleviate these backlogs in the future. The report stated that the carrier was planning the biggest capital investment year in history, which included 500 new locomotives, 5,000 new cars, and $3.2 billion in network investment.

1.3. Objectives

In response to the risks involved in grain shipping and the changing needs of elevators, certain carriers now offer “shuttle” contracts that allow the shipper to better match their shipping needs with their supply of railcars. Specifically, under a BNSF shuttle contract, the shipper can transfer or sell any unneeded cars into a secondary market. This provides the benefits of allocating cars to elevators who need them the most, and offers an additional source of revenue for the grain company. The goal of this study is to value this flexibility as a transfer option. The specific goals of this study are threefold:

1. Build a framework to value the transferability component of shuttle contracts as a European put option.
2. Calculate the base case result of the transfer option value.
3. Conduct a sensitivity analysis to determine the key factors impacting the value of the transfer option.

These objectives are meant to help grain shippers make better decisions regarding railcar ordering strategies. Effective logistics planning allows shippers to move grain more efficiently. When shippers buy and sell more product, farmers are offered more opportunities to sell their grain at competitive prices.

1.4. Procedures

Real option analysis is a way to value projects that allow for managerial flexibility after the initial investment has been made. Once grain companies have made the initial investment in a shuttle contract, they have the ability to sell individual trips if they either do not need the cars, or find it more profitable to sell railcars rather than ship grain. Among other factors, the amount of cars sold, and the price that they receive for them affect the value of this transferability. This option to transfer cars then has an impact on the initial value of the investment, since it would affect cash flows for the shipper. Since the owner has the right, but not the obligation to sell these railcars, this idea is similar to the concept of a put option.

The model is a stochastic binomial real option model, and is solved with Monte Carlo simulation. The core method used in this study is real option analysis, but there are some inputs for the option pricing solution that must be derived from other measures. The model consists of two main sections, or modules. Module 1 is a material requirement planning (MRP) schedule. This represents the grain inflows and outflows for a typical country elevator in the upper Midwest. The purpose is to project future demand for railcars, and the volatility of this demand. Based on elevator parameters, futures market prices, basis levels at the sale market, storage costs, and other factors, the module projects how many carloads of grain the shipper would require in each of the next 12 months. Demand for railcars is a key variable since it determines if the elevator would have excess cars to sell into the secondary market or not.

Module 2 is the option pricing model, and is based on various inputs, including those from the MRP schedule. The purpose is to calculate the transfer option value for each month, as well as other key outputs. Specifically, the module consists of 12 different stochastic binomial option pricing trees, each representing one month in the future. Using shipping demand as the underlying variable and supply of railcars as the strike value, the binomial lattices incorporate all inputs required to value a European put option. Whereas most real option models have a dollar value as the underlying variable, we incorporate shipping demand levels and a modified option payoff structure to better reflect the decision making process of a grain shipper.

Once the empirical model is defined, Monte Carlo analysis is implemented using @Risk, which is a Microsoft Excel add-in program. This simulates 10,000 repetitions of the model, based on stochastic parameters. The four stochastic variables include farmer deliveries, basis values, secondary rail market prices, and railcar velocity, which is a measure of performance. Monthly data for farmer deliveries, basis values, and secondary rail market prices extends from 2004 to 2016, and rail velocity data is from 2011 through 2016. @Risk provides stochastic, time-series projections of all variables for each of the next 12 months while taking into account trend and seasonality.

1.5. Organization

Chapter 2 of this thesis provides an overview of the rail contracting programs offered to grain shippers. It describes the evolution of these instruments, and highlights the key components relevant to this study. A summary of prior studies of grain shipping by railroad is then provided. Chapter 3 describes real option analysis and presents the theoretical model for the solution method. Real options are explained in a general sense, followed by types, examples, solution methods, and a description of how railcar shuttle contracts can be modeled as a transfer option. Chapter 3 concludes with a review of prior studies utilizing real option analysis. Chapter 4 describes the empirical model used to value to rail contracts as a transfer option. Both modules are presented in detail, along with descriptions of data and distributions of stochastic variables. Chapter 5 provides the results from a base case, and a sensitivity analysis of key input variables. Finally, Chapter 6 presents a summary of the study, including conclusions from results, implications, limitations, and suggestions for further research.

CHAPTER 2. RAIL SHIPPING IN GRAIN: BACKGROUND AND PRIOR STUDIES

2.1. Introduction

As with any agribusiness, proper logistics management is essential to ensuring timely movement of product along the supply chain. Whether the product being moved is the actual commodity that is being merchandized, or if it is an input for the operation, attention to forward planning can be the difference between efficient supply flows, or bottlenecks which can result in halts in operations. In the case of grain shipping, railroads move a commodity from the elevator to the next destination. The next destination may be a processor, or another merchandiser of grain, such as an exporter, who resells the grain into another market. It is important to distinguish between various users of grain, as they each play a different role in the grain supply chain.

- Country elevator: Grain facility located in rural areas near farmers. Their primary goal is to buy grain from farmers and resell to a different market for a higher price.
- Processing plant: An end user of grain which transforms the grain into another product, such as an ethanol plant, flour mill or soybean crusher who sells soybean meal and oil.
- Export terminal: A large grain storage facility located at or near a port. They buy grain from inland elevators and sell to foreign markets overseas.
- End user: Any firm who is the final consumer of grain, such as a cattle feedlot.

Grain does not always follow the same path through the supply chain. For example, a farmer who lives near a processing plant may sell their grain directly to the plant, rather than first selling to an elevator. Alternatively, a livestock owner may buy grain for feed directly from a farmer. The primary scope of this paper refers to country elevators buying from local farmers, and shipping to an export terminal via railroad, as shown in Figure 2.1. Specific markets are referred to in the description of data section.

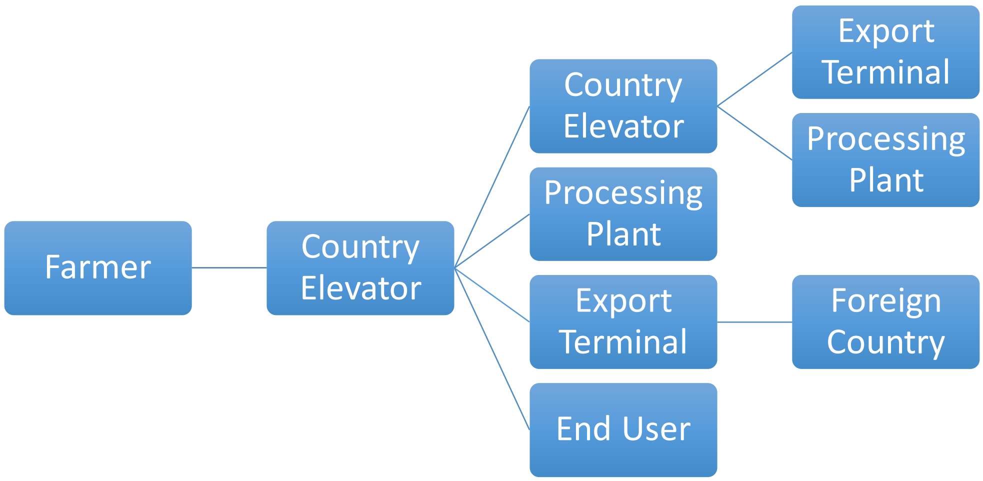

Figure 2.1. Typical Flow of Grain Through the Supply Chain

In order to ensure farmers are able to sell their grain when they want, and elevators are able to ship grain when needed, transportation is key to facilitating grain flow. If elevators were able to simply order railcars when they are needed and at a stable shipping price with guaranteed placement time, there would be no need for managers to plan their shipping needs in advance. However, this is clearly not the case. The fact that numerous factors impacting shipping demand are random, including basis, shipping costs, and car placement, requires shippers to strategically plan out their shipping demands based on forecasted levels of grain supply and demand.

Just as grain prices fluctuate, the cost of shipping changes daily. Not only are railcar prices uncertain, the probability that railcars are placed when needed by the elevator changes over time as well. Another source of uncertainty lies in the fact that elevators cannot predict the amount of grain that farmers deliver in a given day with 100% accuracy. This means that not only are shipping costs uncertain, but actual inventory levels are unknown to some degree as well. These factors, along with many other sources of risk, require elevator managers to carefully plan out their railcar ordering strategy.

In response, railroads typically offer an assortment of service mechanisms that give the shipper various degrees of managerial flexibility in the service. These service mechanisms may provide guarantees, such as offering guaranteed service for a longer timeframe at a locked-in rate, or flexibility, such as the option to sell any unused railcars that were previously contracted to the elevator. Understanding each of these various contracts and pricing mechanisms offered by railroads to shippers is essential for elevators in making future plans that best match their shipping needs.

This chapter aims to provide an overview of the development of railroad service mechanisms, and the key features of the current major railroad service options. Prior studies on topics related to railroad pricing mechanisms and supply chain management are then highlighted.

2.2. Evolution of Rail Pricing and Service Mechanisms

Although the federal government has regulated the railroad industry since 1887, it was not until the 1980s that policies were enacted that helped shape the rail market into that which we see today (Hanson, Baumel, & Schnell 1989). Prior to the 1980s, the primary mechanism for establishing rates was posted-price tariffs which were allocated on a first-come-first-served basis (Wilson & Dahl 2005). Under this mechanism, each origin/destination combination was assigned a tariff rate. During this timeframe, railroads were highly regulated by the government and tariffs rarely changed. With the first-come-first-served allocation mechanism, shippers applied for cars as needed, but there was no tool to ensure timely car placement. This created issues during periods of high shipping demand since cars were allocated to those that applied first, rather than those that valued service the most. Also, there were no mechanisms in place that forward contracted freight service.

These inefficient pricing mechanisms led to poor returns for railroad carriers, and forced some into bankruptcy. With the goal of improving flexibility in pricing, the government passed the Staggers Rail Act (SRA) in 1980. The SRA provided deregulation necessary for railroads to have more power in establishing rates as markets saw fit and utilized confidential contracts, which were the precursor to service guarantees (Hanson 1989 & Wilson 2005). These contracts allowed railroads to make forward service guarantees in various forms to grain shippers.

Without any cancellation penalties being imposed on these contracts, many elevators placed “phantom orders” just in case they would need grain in the future. By placing car orders in excess of their actual shipping needs, elevators had a better chance of receiving service since big orders were prioritized. The shippers could then cancel the unneeded cars and keep the ones they needed. Not surprisingly, these phantom orders led to an inefficient allocation of cars (Wilson & Dahl 2005).

This led to the Certificate of Transportation (COT) program created by BNSF (BN at the time) in 1988 which had some important features including forward contracting, auction allocation system, guaranteeing placement, and transferability (Wilson & Dahl 2005). The ability to transfer service to another shipper led to the secondary market that we see today (Wilson & Dahl 2011). Under the COT program, forward shipping guarantees were offered that provided bilateral penalties for each party upon default of agreed terms. Although BNSF was the first to adopt such a strategy, other major Class I railroads such as Canadian Pacific, Union Pacific, CSX, and others followed with similar auction-based, and car guarantee programs (Wilson, Priewe, & Dahl 1998).

Under the auction system, shippers placed bids to receive access to cars. In essence, the shippers were then bidding on or valuing the added benefits of the COT program, such as guaranteeing placement, forward pricing, and transferability, all of which are factors that reduce overall risk for the shipper. This also helped ensure efficient allocation during times of shipping surplus or shortage, since supply and demand factors would be reflected in the bids. Creating an auction-based system implied better economic efficiency, since cars were allocated to the shippers that valued them the most, rather than who applied first. Thus, the total shipping rate was then the tariff rate plus the premium that was bid. Although it is possible for a bidder to place a negative bid, i.e., a bid less than the tariff rate, the railroad has no incentive to accept such an offer as they are the primary service holder (Sparger & Prater 2013).

The other major component of the COT program is the transferability of these instruments. These instruments are not specific to a particular origin, destination, or shipper, which implies that the owner of these contracts can transfer the instrument to another shipper. If a given elevator owns a COT and does not need all of the cars that would be arriving in a given month, the contract gives them the ability to sell the trip to another shipper. This transferability component is what led to the creation of the secondary market. This concept lays the groundwork for this paper and is discussed in more detail later in the chapter.

The bilateral penalties were also important since shippers would now have to pay for cars that were ordered and then cancelled, which increased allocation efficiency. The cancellation penalties were originally paid out of pre-payment funds that were provided to the carrier by shipper upon winning the auction. Also, the instruments had provisions that required the railroad to pay a penalty when cars were not delivered to shipping origins on time. In the early 1990's, railroads started offering long-term shipping instruments (1-3 years). Under this system, grain companies owned cars that they would lease to the carrier and in exchange, receive a number of guaranteed loadings each month.

Since its inception in 1988, the COT program offered by BNSF has undergone many changes to the specific features and terms offered. However, the general idea of having forward contracted freight, auction mechanisms, bilateral penalties, and transferability is still commonly used in freight. Other railroad carriers have since offered similar programs including the Grain Car Allocation System (GCAS) offered by Union Pacific (Wilson & Dahl 2005). The general goals of each of these programs are to efficiently allocate cars among shippers and provide mechanisms for risk management.

2.3. Current Pricing and Service Mechanisms

In order to understand the optionality involved in rail markets, it is important to understand the current pricing mechanisms. Different pricing mechanisms involve different forms of optionality, depending on the type of contract offered. Whereas some contracts may offer guarantees of service for a period of time, others may offer price locks, or both. Various terms and conditions in each of these mechanisms provide alternative forms of managerial flexibility. Although specific mechanisms differ from carrier to carrier, there are some common characteristics. For example, most large carriers, including BNSF and Union Pacific, offer both short-term and long-term service contracts. The short-term contracts may only be for a small number of cars and one trip, whereas the long-term contracts provide a larger number of cars for service throughout the whole year at a specified price.

2.3.1. Primary vs. Secondary Markets in General

It is important to understand the difference between the primary and secondary market when discussing rail markets and their functionality. The primary market, although with some variation firm to firm, is the initial allocation of trains in which shippers bid for rights to utilize a specified number of cars for a certain time period forward. Carriers may allocate cars on a first-come, first-served basis, a lottery, or in an auction. The winners of each car offering are allocated contracts for service which specify elements such as forward order period, rate level (tariff), and number of cars per month (Wilson & Dahl 2005).

One of the important features of these contracts is their transferability, which is the foundation for the secondary market. This gives the owner of the contract the right to sell a number of cars during a given month to another shipper that is quoted as a premium or discount on the tariff rate. This is important to shippers due to the fact that there is large variability in shipping demand month-to-month due to intra-seasonal supply and demand levels (Wilson & Dahl 2011 & 2005). This variability creates problems if an elevator has a locked-in, constant supply of railcars to fill and ship out each month, since there would be months when you want to ship more or less than your allocation of cars allows. So, the primary owner of a contract may be able to sell one or more trips to another shipper, while still retaining the rights to that train afterwards. This mechanism, combined with the primary market, efficiently provides shippers railcar placement, rail rates, and the option to transfer these cars as a means to mitigate risk. Although the topic of the effects of auctions and secondary markets has been covered in many studies, there is limited research done on valuing these mechanisms, and even less so with real options methodology.

2.3.2. Mechanisms Relevant to This Study

Since there are seven Class 1 railroad carriers within the U.S. along with a number of small regional carriers, and each one has their own specific systems for car pricing and allocation, only one system is used in this model since it’d be impossible to include the elements from every carrier. The BNSF business model from shipping ag products is selected for a few reasons. First, they are the largest carrier of ag products, and therefore represent the largest share of individuals within the industry. Also, their allocation mechanisms facilitate a transparent secondary market, and the bids are therefore a good reflection of market conditions. Lastly, the elevators selected for this analysis are on BNSF rail lines. There are some terms and definitions regarding these mechanisms that should be specified. As listed in the BNSF 4090-A rulebook:

- "Monthly Grain Single: A COT order of one (1) covered hopper car, purchased for one (1) Shipping Period for one (1) month.
- Monthly Grain Unit: A COT order for twenty-four (24) covered hopper cars, purchased for one (1) Shipping Period for one (1) month.
- Yearlong Grain Single: A COT order of one (1) covered hopper car, purchased for one (1) Shipping Period per month for twelve (12) consecutive months as offered.
- Yearlong Grain Unit: A group of twenty-four (24) covered hopper cars, purchased for one (1) Shipping Period per month for twelve (12), twenty-four (24) or thirty -six (36) consecutive months as offered by BNSF.
- Shuttle: a full complement of covered hopper equipment (100-120 cars) with dedicated locomotives in dedicated service for a specific period of time, which moves from a single origin facility to a single destination facility."

BNSF currently offers three car ordering programs to their customers; lottery cars, Certificates of Transport (COTs) and the shuttle program. Table 2.1 lists the details of each of these programs, and the relevant terms are discussed further below. The secondary market mechanisms are also listed for comparison. Although BNSF allows its cars to be traded on the secondary market, they do not participate directly. All rules within the secondary market are privately negotiated between buyer and seller, and regulation and arbitration is provided by the National Grain and Feed Association.

Table 2.1. BNSF Car Ordering Programs (bnsf.com)

Feature	Non COT Units and Singles (Lottery Cars)	Certificate of Transport (COTS)	Pulse COTs	Shuttle Program	Secondary Market
Pricing	-Tariff Lottery program Single car: <15 cars Units: 24-54 cars -General Tariff program -No prepayment	-Auction system. Can be for Singles, Units, or Destination Efficiency Trains (110 cars) -Prepayment of $200/car plus premium, as a performance bond. $200 is then subtracted from total freight bill	-Price is tariff only. -No prepayment	-Weekly auctions, tariff can change each month. Winner pays bid to BNSF, rarely below tariff	-Buyers and sellers post bids/asks through a third party broker. Bid/ask can be positive or negative. Effective tariff is the rate at time of shipment
Allocation through time	-Single trip commitments	-Can be either monthly (one shipment) or 12 or more monthly consecutive commitments. Priority given to bids of longer duration	-BNSF publishes daily offers for single car, one-time trips in a specified future delivery period	-Usually yearlong commitments	-Daily bid/ask sheets published and distributed by broker. Service is usually for one trip only
Allocation to Shippers	-Lotteries held each of the first 3 weeks of each month	-Weekly auctions: -Monday – DET's -Tuesday–Monthly Units, -Wed. –Yearlong Units, -Thursday – Monthly Singles, Yearlong Singles	-First come, first served basis	-Weekly auctions each Wednesday – variable depending on market conditions	-Buyer (seller) indicates acceptance of offer (bid) through broker.
Window for Delivery	-Three 10-day periods of each month in the future	-Three 10-day periods/month in the future	-Three 10-day periods of each month in the future	-First placement is a 10-day period of the given month, after which placement is dictated by velocity	-Can be any period, usually 10-15 day window

Table. 2.1. BNSF Car Ordering Programs (bnsf.com) (continued)

Feature	**Non COT Units and Singles (Lottery Cars)**	**Certificate of Transport (COTS)**	**Pulse COTs**	**Shuttle Program**	**Secondary Market**
Specification of Want Date	-Roughly 30 days after lottery, -Customer specifies window -BNSF decides specific date	-Up to 30 days prior to shipping period. Request any date within shipping period	-Up to 30 days prior to shipping period. Request any date within shipping period.	-First shuttle order must be placed at least 10 days in advance of startup period	-Indicated at time of bid/offer
Cancellation	-$100/car unless order remains unfilled by end of placement period -General tariff cars cancelled 30 days after last day of placement period	-$200/car/trip ($160 cancellation + $40 pre-pay forfeiture) for Yearlong Grain Units and Yearlong Grain Singles	-$250/car if cancelled between car order placement and last day of shipping period -$200/car for cars that are not given a specified want date prior to shipping period	-$200/car per shipment period -If a shuttle is cancelled, all remaining trips on the shuttle train are cancelled	-Negotiable between primary owner and buyer
Transfer Among Shippers	-No	-Through secondary market	-Yes, but not organized by BNSF. Shippers may arrange transfers among themselves	-Through secondary market	-Resell in secondary market
Transfer. Among Origins	-Yes, upon BNSF approval	- N/A	- N/A	-Yes, but $1,000 per train per trip IF specified after train leaves prior destination	-No
Loading Incentive	-No	-Available for DET if four unit trains combined but no loading incentive	-No	-Origin Efficiency Payment -Release <15 hours: $100/car -Release <10 hours: $150/car	-Yes, same as primary owner. OEP payment goes to the loading facility

Table 2.1. BNSF Car Ordering Programs (bnsf.com) (continued)

Feature	**Non COT Units and Singles (Lottery Cars)**	**Certificate of Transport (COTS)**	**Pulse COTs**	**Shuttle Program**	**Secondary Market**
Demurrage	-$75/car/day after 24 hours, debit/credit system	-$75/car/day for singles after 24 hours $600/hour/train for units after 24 hours	-Standard demurrage, $75/day after 24 hours	-After 24 hours, $600/hour/train After 48 hours, $1,000/hour/train	-Standard demurrage
Guaranteed?	-None	-If order placed more than 10 days prior to start date. If placed 1-9 days before, cars are honored but not guaranteed placement. -If guaranteed cars are 15 days late after want date, BNSF pays max. $200/car to shipper (Non-Delivery Payment, cars still honored), or shipper can cancel.	-If order placed more than 10 days prior to start date. If placed 1-9 days before, cars are honored but not guaranteed placement. -If guaranteed cars are 15 days late after want date, BNSF pays max. $200/car to shipper (Non-Delivery Payment, cars still honored), or shipper can cancel.	-No, but if < 5 trips/month per 61-day period, shipper can cancel trip for free at BNSF discretion	-Yes. If disputes or late cars cannot be settled between parties, NGFA handles arbitration
Contract Specs.	-Date and time -Name of party -Name of person receiving request -Kind and size of cars wanted -Number of cars wanted -Date wanted -Commodity to be loaded -Destination and route	-Car number(s) -Origin -Consignor -Destination -Consignee -Route -Commodity -Other terms	-Car number(s) -Origin -Consignor -Destination -Consignee -Route -Commodity -Other terms	-Car number(s) -Origin -Consignor -Destination -Consignee -Route -Commodity -Other terms	-Date of contract -Quantity -Kind of grade of grain -Price or pricing method -Type of inspection -Type of weights -Applicable trade rules -Transportation specs -Payment terms -Other terms

2.3.3. BNSF Shuttle Program

Car ordering programs that are specifically used for this analysis are the shuttle program and secondary car markets. The reason for this is that shuttles, and shuttles bought and sold through the secondary market now represent a majority of all ag commodity railroad traffic (industry source). Therefore, by evaluating these markets, the model best represents current market conditions and strategies used by industry participants. It should also be noted that these programs change on a year-to-year basis, but the main concepts usually remain the same. Throughout the marketing year, BNSF is in constant communication with grain handlers in regards to upgrades and tweaks that can be made to the programs in order to ensure that the contract mechanisms are mutually beneficial for the carrier and the needs of the shippers. The programs evaluated in this study are current as of November, 2016.

Although the exact definition of a train shuttle varies from carrier to carrier, the idea behind the BNSF program is that a shipper bids on 100-120 car service that is forward contracted at a locked in rate. When BNSF holds an auction for a certain number of cars, shippers place bids that are interpreted as premiums to secure cars. This premium does not include the tariff rate that is paid each time a shipment is made. For example, if a shipper places a winning bid of $20,000, they make a one-time payment to BNSF of the full $20,000. The actual per-trip shipping costs (tariff) are paid at the time of shipment. The exact schedule of auctions is not set, and fluctuates based on BNSF's inventory of railcars and the demand in the market. The duration of these contracts is usually one year. This means that shippers must forecast their estimated shipping demand for the upcoming year and bid accordingly. An advantage that the shuttle program offers is a locked in shipping rate. The owner of the shuttle contract has the option to lock in either the tariff rate at the time of bidding, or the rate during the first shipment.

As briefly mentioned earlier, although the shuttle program reduces price risk for owners, there remains quantity risk. In the shuttle program, the train is meant to be in constant use, running from origin to destination repetitively. Rather than BNSF specifying that the shuttle owner gets a certain amount of trips per month, the quantity depends on railroad performance, or velocity. When railroad traffic is low, and everything is running smoothly, a shuttle owner may have to fill four trains in a given month. When performance is weakened due to factors such as heavy traffic or inclement weather, a shuttle may only make two trips in a month. This is a very important point when it comes to a logistic manager planning out freight needs. Not only do they have to estimate how many cars they need, they have to estimate how many cars they will receive based on railroad performance, and is therefore a random, or stochastic variable in their logistic planning models. Historical performance of BNSF shuttles is shown in Figure 2.2.

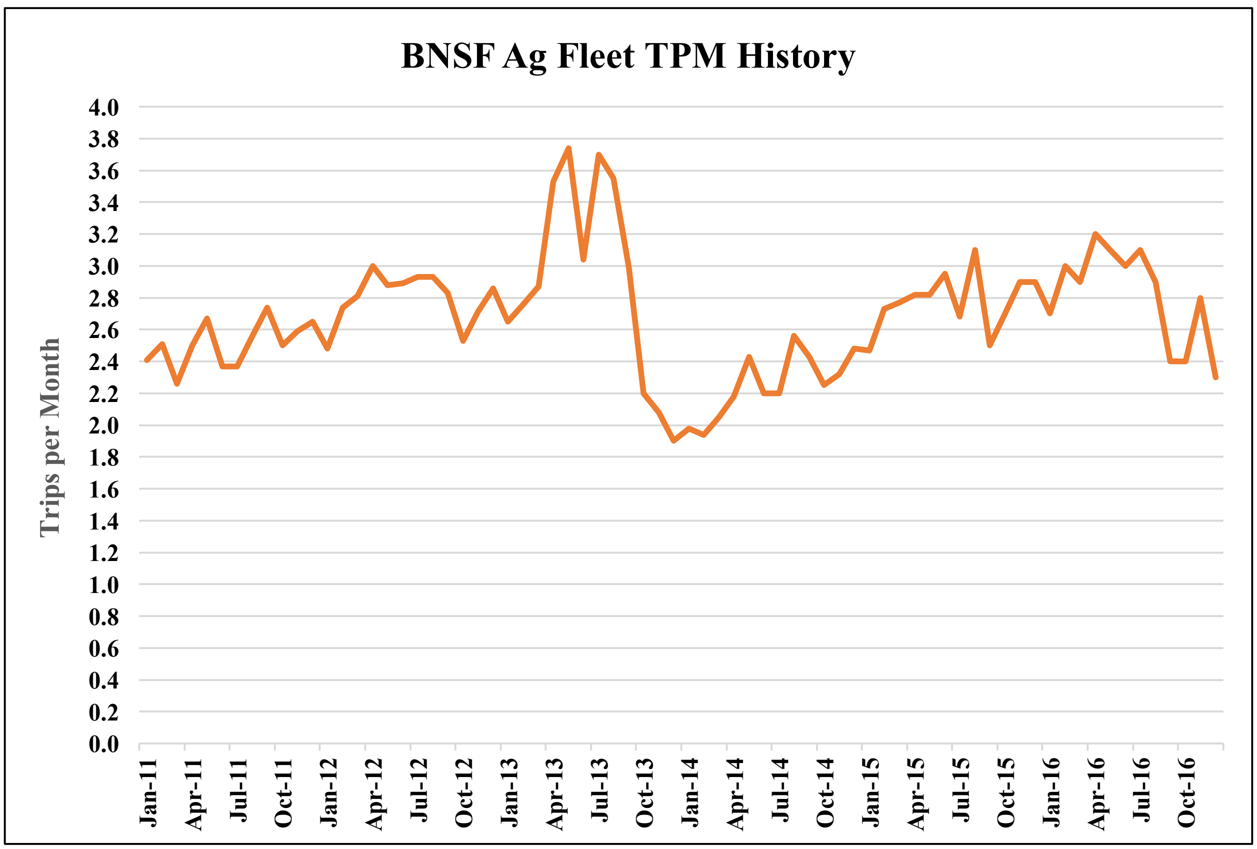

Figure 2.2. BNSF Historical Performance (bnsf.com)

Another very important aspect of the shuttle program, and the key component of this study, is the transferability of the service. This can also be interpreted as an option given to the owner when they do not need the train. If a shuttle contract owner finds that they do not need all of the cars coming to them in a given month, they essentially have three options. They can either cancel the cars for $200/car/remaining trip, sell them into the secondary market, or source grain in order to use the cars, in what we refer to as a "forced" shipment. There is also the option of letting the cars sit idle, but this incurs significant demurrage costs, and is not considered a viable alternative for this study. Since it is not possible to cancel just one or two trips, or essentially pause the shuttle, timing plays a large role in deciding whether to cancel cars or sell into the secondary market (industry source). If secondary market values are trading at a discount, or negative rate, the shuttle owner who does not need all of the cars must decide whether to pay the cancellation fees and forfeit the rest of the trips, or to sell the cars for a loss and retain ownership. If there are still many months left on the shuttle contract, the owner may be willing to sell cars at a large loss (less than -$200/car) in the short term in order to retain ownership in hopes that shipping demand and/or secondary market prices rally in the distant months. If there is only one month left on the shuttle, or only a couple of trips, there is no incentive for the owner to sell the remaining trips for less than $200 below tariff, when they can just cancel them for $200/car/remaining trip. The cancellation economics behind a shuttle contract are very dynamic and involve many variables. The only time a shuttle owner may cancel a single trip, is if they receive less than five trips in 61-day period, but this is at the discretion of BNSF and does not happen very often.

Since the main point of the shuttle program is to efficiently allocate railcars and move grain, BNSF wants cars to be moving rather than sitting in a rail yard or at an elevator. In order to encourage this, BNSF began charging demurrage, and offering Origin Efficiency Payments (OEP). Demurrage is a penalty that elevators must pay to BNSF if cars sit on their tracks for more than 24 hours. If cars are released under 15 hours, the elevator receives an OEP of $100/car, and this value increase to $150 if released in 10 hours or less.

2.3.4. Secondary Market

Although the secondary market is similar in some ways to the primary market, there are some key differences that managers must take into account. Instead of an auction-based car allocation system, a bid-offer system is used (Crabb, John). These bids and offers are published either through a third party broker, such as TradeWest, or directly from the shuttle owner (e.g., CHS, ADM, etc.). Since each elevator can only ship with certain carriers, there is a separate secondary market for each carrier that allows such a program. These offers are published daily and come in a variety of forms. All bids and offers are quoted as a premium or discount in relation to tariff. For example, if an elevator bought secondary cars for $100/car/trip, they must pay $100/car/trip to the seller, and the tariff rate to BNSF. Bids and offers are usually for one trip only, but can be for multiple forward trips as well, usually out to a year. For example, the offer could specify two trains per month for the next five months at a certain price. The bid or offer also lists a specific window for delivery. These windows are usually ten days, and are either first, second, or third period of each month. If it lists a fifteen-day period, it is for either the first or last half of the month. If a buyer of secondary market service decides that they do not need the cars, they can either resell in the secondary market, or cancel for a fee. The secondary buyer usually does not have free reign over the cars, though, and resale and cancellation must be negotiated with the seller. Similar to the primary market, secondary buyers can be either charged demurrage, or receive OEP. Payment under these programs would be from (to) the secondary buyer to (from) BNSF. Figure 2.3 shows part of the bid/offer sheet that TradeWest Brokerage Co. sends out each day. It is showing that, at the time, there are shippers looking to buy cars for $115/car, and sell cars for $145 for shipment anytime in January.

* UP 100 CAR BE SHUTTLES - TRACK, BASIS GRP 3 *			BNSF 110 CAR SHUTTLES	
	SHUTTLES-GRP 3		DLVRD PNW XPORT	
	UP 110 BE/BC BID ~ *PAPER* ~ ASK -2 CTS for 100 car origin		BNSF 110 SHUTTLES(SE) ~ *PAPER* ~ BID (BNSF) ASK	
**** BIDS AND OFFERS THROUGH MAR ARE BASIS THE CHC UNLESS NOTED BY SYMBOL ****				
INTRANSIT SPOT	- -	- -	- -	- -
THIS WEEK NEXT WEEK	- -	- -	- -	- -
JAN/17	-	-20-	115	145
BY FEB 15	-25(MAINLINE NE)	-20-	-	-

Figure 2.3. Bid/Offer Sheet for Secondary Market (Courtesy of TradeWest Brokerage Co.)

One of the important and relevant aspects of the secondary market is the fact that car placement within the specified time window is guaranteed by the seller. This a big difference from the primary market, where this guarantee does not exist. If a secondary seller is unable to get cars to the secondary buyer's location within the window listed in the contract, the seller is considered in breach of contract. Under this situation, the buyer has the option to either accept the late cars and resume business as usual, or require that they receive cars from another source. The buyer could either buy cars elsewhere and force the original secondary seller to pay any price differentials, or have the seller furnish cars from another train that they control. Either way, the solution to late cars is usually negotiated between the buyer and seller. If a resolution cannot be reached, the case is handled by the NGFA.

2.4. Central Freight Desk System

The separation between primary and secondary markets is not always black and white as far as the terminology. While a few small grain companies do buy shuttle contracts, a majority of the current shuttle contracts are owned by a few of the largest shippers (industry source from ADM). Rather than each individual elevator buying shuttles from BNSF, a grain company who owns many elevators buys a large pool of shuttles that is managed from central freight desk. A shuttle train almost never sticks with one elevator, but rather sticks with one grain company or operator and trips are allocated between elevators as needed. As long as the train is notified before it reaches a destination, the next origin can be any location at the choice of the contract owner.

The freight desk, who controls and manages all of the shuttles that a grain company owns, works with country elevators, both owned and not-owned, to sell shuttle trains for either single-trip or multiple-trip commitments. Due to this "freight desk" system, the line between primary and secondary markets is not always clear. Some freight managers consider the primary market as strictly transactions between them and BNSF (industry source from CHS). Some freight managers who work with a regular book of country elevators (some owned by the company and some not) consider transactions between them and the country elevators as primary market transactions. If the freight manager sells a train to a non-regular customer, they may consider this to be a secondary market transaction. The country elevator that buys the train usually has the option to either resell or cancel the trip. However, this is at the discretion of the freight desk operator.

According to at least one large U.S. grain company, a freight manager typically sells their shuttles to elevators for $25-$50/car/trip over the premium that they paid BNSF for the cars. The freight desk operator is assuming all risk and liability in regards to the cars being placed on time. In situations where cars are not able to be placed on time, the freight operator and country elevator are in communication to determine the solution, and a resolution is usually achieved before arbitration from the NGFA is required. Whereas, if the elevator were to buy cars straight from BNSF, they would be at risk of late car placement.

Although the exact definitions of primary and secondary markets are not standardized in practice, in the interest of clarity we must establish some language for this study. The primary market strictly refers to transactions between BNSF and the owner of the shuttle contract. Secondary market transactions refer to sales between either: 1) freight desk operators and any customer (country elevator), or 2) country elevators and another country elevator. Further clarity is provided as needed. A visual of this freight desk system is represented in Figure 2.4. It should be noted that the figure is purely hypothetical, and does not represent the business of any specific company.

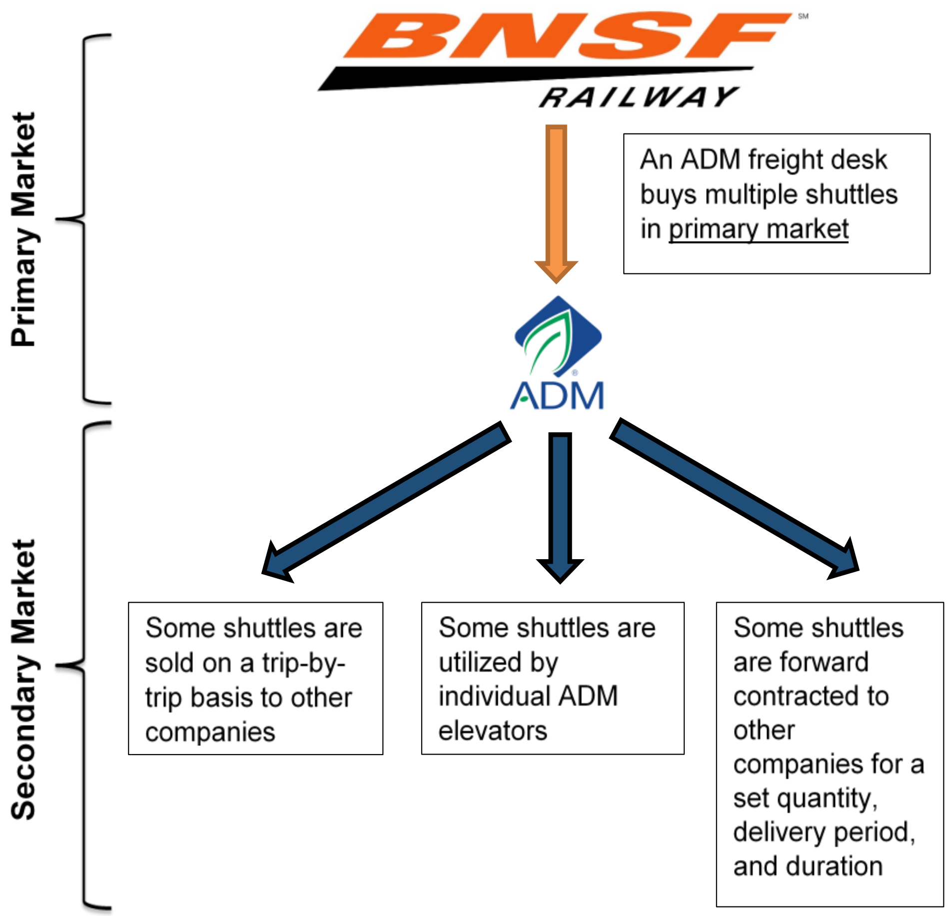

Figure 2.4. Freight Desk System Flowchart

2.5. Previous Studies on Rail Pricing Mechanisms

The last section of this chapter reviews the current literature on rail shipping in grain markets. The specific subjects reviewed are the impacts of rail rates on basis, railcar allocation mechanism design & pricing, and rail pricing and logistical supply chain management.

2.5.1. Impact of Rail Rates on Grain Shippers and Producers

Many different researchers have studied the history and effects that the rail policy changes of the 1980s had on the grain market. Before railroads became deregulated, Martin (1979) argued that the rail rate structure of the time was based on "value of service," rather than "cost of service." This structure was concluded to operate to the disadvantage of society. Hanson, Baumel, and Schnell (1989) argued that it was excessively tight government regulation during that first century that led to the bankruptcy of many large railroads. These regulations made it difficult for railroads to have the flexibility needed to adapt to various changing market demand conditions and the freedom to drop business units that were not performing, which led to widespread failure. Vachal, Bitzan, VanWechal, and Vinje (2006) also studied the effects of rail deregulation and found that both grain shippers and producers benefit from the decreased rail rates. However, producers in areas with more inter and intra-modal competition benefit more than those in less competitive areas. They summed up the importance of shipping prices to farmers with the statement, "Rail rates are a key determinant in grain market viability and producer profitability in these rail dominated markets." The market structure of the railroad industry and its impact on rates has also been studied. Winston, Maheshri, & Dennis (2011) found that the impact of the mergers of large railroad companies have no long-run impact on grain transportation prices and consumer welfare.

A number of studies have been conducted with the goal of examining the causal relationship between rail prices and basis levels/prices to producers. Wilson & Dahl (2011) found that basis has become more volatile over time, and is impacted by factors such as shipping costs, ocean rate spreads, export sales, railroad performance, and others. Their results further validated some previous findings about increases in basis volatility and the importance of export sales' effect on basis. On the other hand, their results found performance in rail car shipments to be less of a determining factor in basis whereas other studies found the impact to be much greater.

Rail service disruptions caused by increased traffic from competing commodities, such as oil, have been reported to have impacts on elevator prices, and have been a popular research topic. Villegas (2016) concluded that oil traffic, among other factors, is a determinant of wheat basis, and that this relationship is stronger in upper Midwest states, like North Dakota. The latest major example of this phenomena in the Upper Midwest was during the 2013-2014 marketing year when increased rail demand from oil and coal led to disruptions in grain shipping. Unable to move their inventory, shippers were forced to bid less aggressively for grain. This led to multiple studies on the topic to quantify the impact this had on producers. A study done by Frayne Olson (2014) for Sen. Heidi Heitkamp estimated that rail disruptions caused an aggregate loss to farmers statewide of $66.6 million, or a little bit over $2,000 per farm. This study did not necessarily analyze a direct relation between railroad price, performance, and basis. Rather it assumed that basis would be the same as an analogue year, and then made derivations. In a report for the Minnesota Department of Agriculture, Usset (2014) used similar methods to estimate the impact of the 2013-2014 rail disruptions on Minnesota producers. Comparing 2014 to years with similar grain supply/demand levels, he estimated that farmers lost 40 cents/bushel on soybeans, 30 cents on corn, and 41 cents on hard red spring wheat. Another study by the Agricultural Marketing Service of the USDA (2015) estimated the losses to be three percent of all farm cash receipts, but acknowledged the difficulty of pinpointing the exact cause of these losses. In another resulting study for the American Farm Bureau Federation, Kub (2015), further reviewed the 2013/2014 situation, but also argued that increasing infrastructure of truck, rail, barge, or pipeline transportation would reduce congestion of grain flow.

2.5.2. Railcar Allocation Mechanism Design & Pricing

After the Staggers Rail Act, researchers have conducted studies on the specific contract mechanisms offered by carriers, and how they impact car ordering strategies by shippers. In their findings, Hanson et al. (1989) concluded that these guarantee contracts that were "origin" contracts (contracts between grain shippers and railroads) had a large impact on local wheat bids to farmers and "destination" contracts (contracts between non-elevator grain buyers and railroads) had large impacts on corn and soybean bids. One limitation of their model was that it assumed the grain bought from farmers was immediately resold to another user, which does not account for storage decisions. In a similar study, Hanson, Baumhover, & Baumel (1990) found that transportation factors such as contract terms, mileage allowances, and mode all have significant impacts on handling margins for grain elevators.

Similar to Hanson (1989), Wilson & Dahl (2005) analyzed the impacts that guaranteeing mechanisms have on the grain industry. Much of the previous studies had concluded that auctions are effective in car allocation. Although the authors agreed with this, they were among the first to point out some problems with the system and what the market did to overcome them. They highlighted the fact that each shipper has unique costs facing them and therefore each employs different bidding strategies, and also the importance that informational advantages have in competition between elevators of the same region.

The main study that provides framework for this analysis is that of a master's thesis by Lee (1999). While the specific model structure and parameters differ from those in this study, the Lee analysis was the first to incorporate real option analysis into valuing rail contracts for grain shippers. At the time, BNSF offered a contract that had three main components: 1) it allowed for transferability of cars into the secondary market, 2) a better probability of cars showing up on time relative to the general service contracts, and 3) required a deposit of $300/car. The Lee model calculated the summation of payoffs from these three components, and interpreted the result as the total contract value. Real option analysis was utilized to value the transferability component. The only component of these contracts that is still present in today's shuttle contracts is the transferability, which is interpreted as an option value and is the focus of this study. Lee found this transferability to be worth $3.21 per car, and that volatility of shipping demand and secondary market prices had a large, positive impact on this option value.

Our study incorporates more modernized modelling techniques, and more extensive data sources in order to account for differences in rail contract structure, and provide refined results with fewer assumptions. For example, the Lee model uses farmer deliveries as a proxy for monthly shipping demand. Rather, this model includes a simulated rail shipping demand schedule derived from farmer deliveries, returns to storage, and other key variables. Another key difference is that the payoff structure of the Lee model allows for the possibility of a negative value of the transferability, or a negative option value. Since the theory on option pricing does not typically allow for negative values, this problem is addressed and accounted for in our model. Also, whereas the Lee model results are interpreted as the total contract value, the results of this model are interpreted as just one component of the total contract value.

Wilson, Priewe, and Dahl (1998) conducted a comprehensive strategic analysis of various car ordering strategies for a grain shipper based on non-guaranteed, short-term, and long-term guaranteed service. Results indicated that, at the time, strategies using short-term car guarantees provided for larger payoffs, but also more risk exposure. They also concluded that variability in farmer grain deliveries has a significant impact on the shipper's bottom line. These results are important to note, since they demonstrate that contracts that offer a long-term car guarantee help reduce risk for an elevator, and therefore may have more value than a short-term contract.

2.5.3. Rail Pricing and Logistical Supply Chain Management

Other studies on railroad logistics have focused on how the prices, mechanisms, and strategies implemented by shippers affect the grain supply chain. Wilson, Carlson, and Dahl (2004) corroborated other studies by demonstrating that shippers who utilize forward freight are provided with better service reliability, and that managers need to take rail performance into account when making car ordering decisions. According to the study, "Results from these simulations demonstrate that demurrage costs can be reduced by adopting the anticipatory strategy. In fact, ordering cars naively and ignoring railroad performance, results in higher costs. Hyland, Mahmassani, and Mjahed (2016) conducted a study to demonstrate the effects that switching from conventional rail service to shuttle have on travel time, cost, and capacity of railroads. One unique part of their model is that it included negative impacts incurred to upstream supply chain participants due to shuttle implementation. These include longer trucking distances between farms and elevators, and longer storage times at elevators, both stemming from the fact that shuttle programs help give rise to elevator consolidation. Results indicated that shuttle service transports grain faster, cheaper, and increases rail capacity compared to conventional service. However, one of the assumptions, among many others, is that both shuttle and conventional railcars show up to the elevator as soon as it accumulates enough grain to fill a train. This ignores the facts that rail performance differs between shuttle and non-shuttle programs, and that elevators frequently store grain for at least some period of time. A similar study by Ndembe (2015) also found that increased use of shuttle trains in North Dakota, along with intermodal competition, lead to reductions in rail rates.

Studies have also analyzed the relationship of demand for rail shipment with various explanatory variables. Babcock & Gayle (2014) used a two-region spatial equilibrium model to find that crop production and barge rates have a positive impact demand for rail shipment, while rail prices have a negative relationship with rail demand. In a similar study on rail demand, Prater, et al. (2013) analyzed the decrease in the share of grain and oilseed harvest being moved by rail. They found that increased ethanol production, biodiesel production, and concentration of animal feeding are three of the most significant explanatory variables.

In study comparing spatial differences in rail rates, Babcock, McKamey, and Gayle (2014) compared wheat rates per ton-mile in states with inter-modal competition (Kansas) to those in captive markets (North Dakota and Montana). Results indicated that North Dakota has the highest rail rates for wheat, whereas there is little difference between rates in Kansas and Montana.

2.6. Summary

In conclusion, this chapter provides an overview of the current shipping mechanisms available, and the prior studies done on grain shipping. There are many different sources of risk facing grain shippers, and each provides a unique challenge. Of these, certain sources of risk are easier to mitigate than others. Grain prices can be mostly hedged with futures, and grain quantity can be partially mitigated with the use of forward contracts. Risk in rail shipment of grain is more difficult to manage since there is no derivative market for hedging. Users of primary shuttle instruments can lock in shipping rates, but the quantity of rail cars received is subject to rail performance. Users of secondary rail shuttles are guaranteed placement within a window of time, but they are subject to price risk every time they make a purchase, unless they negotiate a forward contract with the seller.

The current rail shipping mechanisms available to elevators each offer unique flexibility, or optionality. This optionality is essential considering the dynamic nature of grain shipping. The main option available to a user of primary cars, and the focus of this study, is the ability to transfer, or sell cars into the secondary market. This transferability comes into consideration when a shipper either cannot fill all of the cars coming to them, or finds that it is more profitable to sell rail cars rather than sell grain. In order to plan logistic needs, shippers must evaluate the various mechanisms available to them. Since some rail contracts offer this transferability and some do not, a shipper must know how much of a premium to pay for a contract that includes this option versus one that does not.

While there have been many studies done on rail shipping in grain, the majority of the existing literature analyzes relationships between factors such as rail prices, rail demand, basis levels, and regulation policy. Little has been done on topics of shipping strategy or valuation of alternative contracts available to shippers, or to value individual options imbedded within these contracts. This model builds on the framework of the 1999 Lee study, but has key differences as previously referred to. Other than that of Lee, no other study in this field of grain shipping has utilized real option analysis.

CHAPTER 3. REAL OPTION ANALYSIS: BACKGROUND AND PRIOR STUDIES

3.1. Introduction

Virtually all investment decisions, whether it is to develop an oil reserve or buy an input for business operations such as railcars, involve risk and uncertainty. Traditional methods of capital budgeting and valuation, such as net present value (NPV), work well in evaluating the quantitative aspects of investments. However, there are many qualitative or strategic components of an investment that require more creative methodologies to accurately value, such as certain types of managerial flexibility, and this flexibility has value (Trigeorgis 1996). Real Option Analysis (ROA) is a relatively new and evolving capital budgeting technique which aims to quantify some of these qualitative characteristics of investments.

It is important to distinguish when the real option approach is necessary. In general, it comes down to the level of uncertainty and flexibility involved with a decision. If there is little uncertainty and little flexibility involved with a decision, traditional budgeting methods are more appropriate (Amram and Kulatilaka 1999). Given the dynamic and complex nature of grain logistics, ROA is an appropriate technique to evaluate railcar ordering and mechanisms. There are many sources of uncertainty in railcar demand, and the decision to buy railcars and sell excess railcars is contingent on the amount of shipping demand we have. This chapter provides an overview of ROA in general, the specifics of the type of option used in this study, and a summary of prior studies that have implemented ROA.

3.2. Real Option Analysis Overview

Over the past thirty years or so, ROA has developed as an alternative financial method to evaluate capital expenditures and investments. According to Dixit and Pindyck (1994), investments involve both quantitative features such as costs, prices, and dividends, and qualitative features such as irreversibility, uncertainty, and timing. Irreversibility refers to the fact that once an investment is undertaken, at least part of the initial outlay is a sunk cost and is unrecoverable should the investor change their mind later on. Uncertainty is an important factor that affects the future rewards of an investment. In nearly all investments, expected cash flows are affected by many different factors, and the slightest change can be the difference between positive and negative return on capital. Timing of an investment is also important as it helps to better gauge the potential outcomes. If an investor is able to postpone an investment in order to get more information about the future, they can reduce some (but usually not all) of the uncertainty. The interaction of these qualitative characteristics play an integral role in determining investment outcome, but are overlooked in traditional capital budgeting models (Dixit and Pindyck 1994).

3.2.1. ROA vs. NPV

Real option analysis is a fairly new topic that has been gaining in popularity as a way to evaluate a project or asset's inherent value while taking into account variability that arises throughout its lifespan. It is comparable to NPV and discounted-cash-flow (DCF) methods in regards that they are both valuation tools (Turvey 2001). However, the NPV approach has some implicit assumptions that make it a more rigid tool and weaken its connection between theory and application. For one, it assumes that investments have a "now or never" proposition. That is, an investment must either be taken today based on current market expectations, or never at all. In reality, literature has shown that the ability to delay an investment can have a substantial impact on the overall result (Dixit and Pindyck 1994). Another assumption of the NPV approach is that cash flows are static and known beforehand with some degree of certainty (Trigeorgis 1996). This presumption about not only static cash flows, but a static operating strategy (committing to investment until the end of its expected useful life), implies that the value calculated through NPV analysis can only be generated if all expectations about costs, sales, prices, demand, etc. are correct.

Amram and Kulatilaka (1999) point out that in order to compensate for the static nature of traditional investment forecasts, managers may provide a range of forecasts. Even if the outcomes under these various forecasts are known, the decision to invest or not is still subjective in nature. The authors also discuss managerial flexibility. As an investment takes course, mangers are usually presented with opportunities to possibly expand, contract, or shut down a project, among other alternatives. The contingency nature of these investment decisions shows that they are not static, but rather dependent on outcomes from prior events. Traditional methods of budgeting fail to take into account this managerial flexibility and the impact that it may have on the overall return.

Real option analysis takes into account uncertainty, flexibility, and irreversibility of the decisions that are made throughout a project's lifespan, which is not accounted for in NPV since NPV assumes static cash flows. Alizadah and Nomikos (2009) pointed out that ROA becomes more important as the uncertainty in project increases since volatility is not taken into account for using traditional NPV. Due to this fact, the actual value of a project is often understated using NPV since there are options, either hidden or not realized, embedded within a given deal. NPV fails to quantify the uncertainty, flexibility, and irreversibility that these additional options provide (Turvey 2001).

3.2.2. Real Options vs. Financial Options

In the most simplified terms, real option analysis is essentially taking financial option pricing methodology and applying it to a "real" asset. In financial derivative markets, a call option is the right to purchase the underlying asset, and a put option is the right to sell. The owner of a call option has the right, but not the obligation to purchase the underlying asset at a specified price called the strike price. In return for the option, the owner pays a premium to the seller. In contrast, the owner of a put option has the right, but not the obligation to sell an asset at a given strike price, and similarly pays a premium to the seller of the option in order to obtain this right. With traditional financial options, the underlying asset that is being bought or sold upon exercise is either a stock on a company or a futures contract.

ROA uses same principle and applies it to physical assets. Instead of the option allowing an owner to purchase, say, a corn futures contract, the option may allow the owner to explore a tract of land for gold. If the soil test results are favorable, the owner of the option could exercise their right to buy or lease the land. For example, a quarter of farmland for sale may also be embedded with the chance to rent more of the seller's land in the future (option to expand). This would be treated as a call option, since it involves the right, but not the obligation to make further investment down the road. If you make the investment, you are exercising the option, in which case the strike price is the cost of renting the additional land (Dixit 1989).

Current option pricing theory states there are five factors that affect financial option value; underlying stock price, strike or exercise price, time to expiration, volatility, and interest rates. As shown in Table 3.1, these five factors can be applied to investments, and be used to price an option on buying or selling the underlying asset or investment.

Table 3.1. Financial Options vs. Real Options (Trigeorgis 1996)

Option on a Stock	**Real Option on Investment**
Current value of stock	Gross PV of expected cash flows
Exercise price	Investment cost
Time to expiration	Time until opportunity disappears
Stock value uncertainty	Project value uncertainty
Riskless interest rate	Riskless interest rate

3.3. Types and Examples of Real Options

Given the vast scope of investment opportunities, there are many different types of flexibility that may be available to a potential investor. Each investment has unique characteristics, and therefore may incorporate different types of optionality. The following describes some common types of real options and examples of where they can be applied.

- Growth options – Whenever early investment in a project may lead to the potential for a future investment, this can be thought of as a growth option. The key here is that in order to undertake the future investment, the decision maker must first take part in the initial investment. Based on the success of the initial cash outlay, the investor has a better idea if it is optimal to undertake the future investment. Common applications include R&D, and strategic acquisitions. An example would be if an investor is considering purchasing a pharmaceutical company that is developing a drug which, if approved, would take 5 years to generate cash flow. Hence, the probability of the drug getting FDA approval may impact the value of the pharmaceutical company today (Trigeorgis 1996).

- Deferment option – If an investor holds the rights to defer investment until market conditions potentially improve in the future, this adds value to the overall investment and can be viewed as an option (Trigeorgis 1996). This is also referred to as a postponement option, or a wait-and-see option (Winston, 2008). An example would be a company who owns a lease to a tract of undrilled land with oil reserves, but current oil prices make the investment to drill not worthwhile. Or, a farmer with grain storage who has the opportunity to hold his inventory until prices are more favorable in the future.
- Licensing option – This is common in industries that require patents and intensive R&D. In many licensing agreements, the developer of a patent may sell the technology to a marketer. An initial payment may be followed by additional payments that are contingent on the success of selling the product which requires the patent. From Winston (2008): "Suppose that during any year in which profit from a drug exceeds $50 million, we pay 20% of all returns to the developer of the drug. What is the fair price for such a licensing agreement?"
- Option to sell/transfer/abandon – If an investment has been made, but market conditions change over time, management may be able to abandon the investment and sell the assets at current market value. The resale value has an impact on the initial value of the investment, since a higher resale value adds insurance to the asset. This is common in capital-intensive industries such as airlines and railroads (Trigeorgis 1996). For example, anyone who has ever bought car insurance has essentially purchased a real option. In the event of a bad car accident, the value of the vehicle drops to the salvage value. However, with insurance, you have the option to essentially sell the car for the amount that it was covered for minus any deductible, synonymous to a put option. The premium one pays for car insurance each month can be thought of as a premium on a put option.

- Switching option – Whenever a manager has flexibility in regards to the output mix of an operation, or the inputs needed to produce an output, this adds value to the operation. If input prices are volatile, the ability to switch between inputs allows the manager to make cost-effective decisions (Trigeorgis 1996). Consider a farmer who lives near many elevators vs. one that only lives near one elevator. The famer with more markets to sell to can switch where they deliver their grain based on who is offering the best prices. Similarly, a farmer who can grow multiple different crops has the ability to change year-to-year output based on which is the most profitable.

In addition to these, there are numerous other option types that may be present in any given investment. There are also cases when multiple options are available in an investment. These situations are referred to as compound, or sequential options. These situations require more complex analysis since if the options interact with each other, their joint value may differ from the sum of their separate values (Trigeorgis 1996). Also, similar to financial options, real options can be classified as American or European. American options can be exercised at any time before expiration during the life of the option, whereas a European option can only be exercised at expiration (Winston 2008).

3.4. General Methods of Calculating Real Option Values

As there are many different types of real options, there are many different methods to calculate option values. Each method or approach provides different ways to calculate a solution for an option. The type of approach used depends on scope of the problem, and the various flexible and uncertain components of the decision. This section gives a brief overview of the solution methods described by Amram and Kulatilaka (1999), and the solution techniques available under each method. The proceeding section then provides a more in-depth look at the methods used in this study.

Amram and Kulatilaka (1999) present three general option solution methods: partial differential equations (PDE), dynamic programming, and Monte Carlo simulation. "The PDE solves a partial differential equation that equates the change in option value with the change in the value of the tracking portfolio." This approach is an easy and fast way to solve option values, but cannot be used in situations with many sources of uncertainty or contingency decisions. There are three different ways to calculate option values with the PDE approach: analytical solutions, analytical approximations, and numerical solutions. The most widely used PDE method to provide an analytical solution is the Black-Scholes model. The Black-Scholes model is popular for its simplicity and risk-neutral approach. Only five inputs are needed for the Black-Scholes model: current value of the underlying asset, cost of investment, risk-free rate of return, time to expiration, and volatility of the underlying asset. However, due to the complex nature of rail shipping and contingency nature of decisions, it is not appropriate for the scope of this study.

The idea behind dynamic programming is to take potential outcomes of an investment decision while incorporating optimal future decision strategy, and discounting the values back to the present. The most common solution technique using dynamic programming is the binomial option approach. The binomial approach assumes that the underlying variable being analyzed can move up or down in each period of time based on volatility and probability measures. Based on the state of the underlying variable at each period, a decision is made based on numerical rules in a backward recursive fashion. Dynamic programming is an attractive method for its ability to handle complex decision structures, and offers transparency into sources of option value based on intermediate values. As this study utilizes this approach, it is discussed in more detail later.

The Monte Carlo simulation method uses stochastic processes to estimate thousands of possible outcomes of an underlying variable. It simulates outcomes of each variable based on input parameters and takes “draws” from a distribution of possible returns. Based on the outcome of the underlying variable, an optimal decision is made and the payoff from the decision is discounted back to the present time. After thousands of draws or “iterations”, the average of the outcomes is used to determine the option value. Simulation is useful since it can be utilized with other solving techniques, and can handle complicated decision rules. Since most options require forward projections, simulation accounts for the fact that forecasted values rarely reflect reality to a high degree.

3.5. Methods Relevant to this Study

This section explains the theory behind the methods that are specifically used in this study, and links real option theory to the application of railcar shipping. The first part demonstrates how the transferability component of a primary rail instrument can be modeled as a put option. The next section explains the theory behind the solution method, which is the binomial option pricing model. Then, a generic example is provided of a European real option solution using the binomial pricing method.

3.5.1. Railcars as a Transfer Option

As a primary shuttle contract owner, one of the key components of the instrument is the ability to transfer service into the secondary market to another shipper who is willing to pay for the cars. In a given shipping period, if the owner of the shuttle contract finds that it is suboptimal to utilize all of the railcars coming to them, they can sell the excess cars. Another way to say this is that they have the option to abandon the cars for a salvage value. Note that it is not the contract itself that is sold into the secondary market, but rather individual trips. Given the temporary nature of the sale of assets, the term “transfer” is used for clarity rather than “abandon,” but the underlying principles are the same. The only difference is that a typical abandonment option assumes that once the sale of assets is made, the investment is over. Alternatively, with the transferability of railcars, the owner can sell an individual trip and retain ownership of the contract for future shipments. This means that each individual shipping period can be modeled as a separate option. For simplicity, this study assumes a shipping period is one month. Specifically, since a put option gives the owner the right, but not the obligation, to sell an underlying asset, an abandonment or transfer option can be modeled as a put option (Winston 2008, Alizadeh and Nomikos 2009).

In a financial put option, the underlying variable that determines the intrinsic value of the option is the futures price. If the futures price drops below the strike price, the option is now “in the money” since it has intrinsic value. The owner can then exercise their right to take a short position at the strike price and receive the difference between the futures price and strike price. If the futures price is above the strike price, the option to sell at the strike price has no value and the owner’s loss is limited to the premium paid for the option. The same idea applies to rail contracts. Instead of the underlying variable being a futures contract, the main determinant of the option value is the level of shipping demand. If shipping demand drops below the shipping supply, i.e. the amount of rail cars coming to the shipper, then the shipper has excess rail cars to use up. Therefore, shipping supply is comparable to a strike or exercise price since it is the level of shipping that triggers an excess or shortage of cars. Without the transferability, the shipper would be forced to either use the cars anyways, or cancel the contract and pay a steep penalty.

Therefore, the more excess cars the shipper has, the more the transferability is worth. This is analogous to saying that the transfer option has value, or is "in the money." Whenever shipping demand exceeds shipping supply, the option to transfer cars has no value since there are no excess cars to sell. The shipper then has to either buy in cars from the secondary market to cover the car shortage, or forgo shipping the grain. The shipper is then out only the extra money, if any, that they paid to have the transferability option, which is the focal point of this study. If a shipper has the hypothetical choice between a contract with and without the transferability component, it is important to know how much of a premium they should be willing to pay for the transferability. Figure 3.1 demonstrates the relationship between regular put options and the transferability of railcars.

Figure 3.1. Relationship of Put Options and Railcar Transferability

3.5.2. StochasticBinomial Option Pricing Model

The binomial option pricing model (BOPM), first proposed by Cox, Ross, and Rubinstein (1979), is a popular method for pricing both financial options and real options. It assumes that the life of an option, *t,* can be broken down into equal discrete time periods, Δt, and the path of the asset value follows a binomial process. During each discrete time period, the underlying asset can either increase or decrease by an up factor, *u* (*u* > 1), or down factor, *d* (*d* < 1). *u* and *d* are held constant throughout the length of the option. Starting with the base value of the asset, and ending with the expiration of the option, the asset branches out into a tree that represents a series of up or down movements based on the asset volatility, σ, and risk-free interest rate, *r*. The probability of an up movement is defined as *p,* and therefore the probability of a down movement is (1-*p*).

The binomial pricing method is popular for its flexibility in a wide range of uses. It is useful in real option analysis for its ability to incorporate changing volatility, contingent decisions, and easy calculations. Further, the only information needed is the current asset value, volatility, and the risk-free interest rate. It also is based on the risk-neutral approach, which implies that the return of any asset should be the risk-free rate of interest in a risk-neutral world.

Once the current asset value, volatility, and risk-free interest rate are known, the first step to create a binomial pricing tree is to estimate the parameters for *u, d,* and *p*, which are:

$$\mathrm{u} = e^{\sigma * \sqrt{(\Delta \mathrm{t})}} \tag{3.1}$$

$$\mathrm{d} = \frac{1}{u} \tag{3.2}$$

$$\mathrm{p} = \frac{[e^{(r * \Delta \mathrm{t})} - \mathrm{d}]}{(\mathrm{u} - \mathrm{d})} \tag{3.3}$$

Starting with the initial asset value, the first branch of the tree is constructed as in Figure 3.2 below.

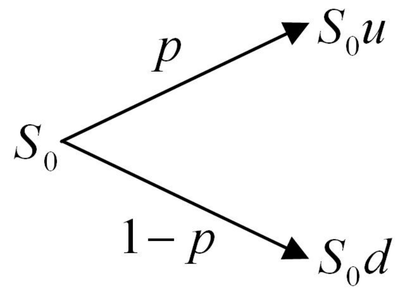

Figure 3.2. Generic One-Branch Lattice Tree

This process is repeated until all branches are calculated, and at the end there is a set of possible outcomes, similar to Figure 3.3 below. The number of branches depends on the length of the option and Δt. For example, if the time interval is one month on an option that expires in one year, there are twelve branches. The time interval depends on user preference and there is no set number required, but more branches provide for more robust results.

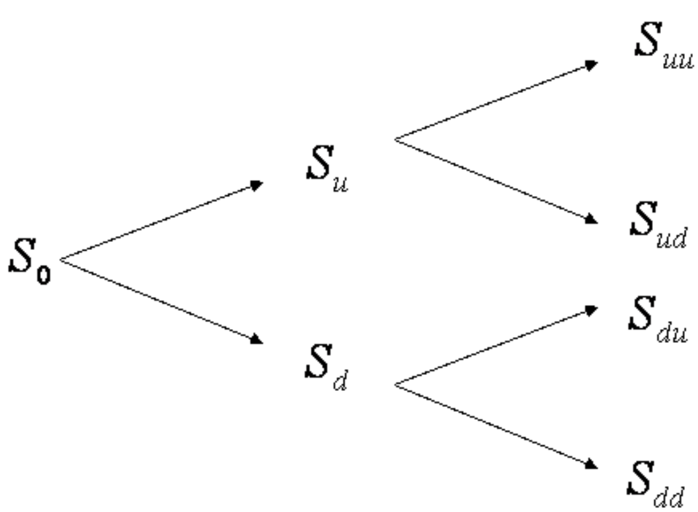

Figure 3.3. Generic Extended Lattice Tree

The next step is to calculate the payoff of the option at each node at expiration. The payoff for a put and call option are as follows:

$$V_N Put = \max(X - S_N, 0) \tag{3.4}$$

$$V_N Call = \max(S_N - X, 0) \tag{3.5}$$

where V_N is the value at each expiry node, X is the strike price of the option, and S_N is the price of the underlying asset at expiration.

The final step is to discount the payoffs back to the present by a method of backward induction. The payoff is calculated starting with the penultimate node and continued backwards in a sequential manner. European option values at each node are calculated as:

$$V_n = e^{-r*\Delta t}(p * V_u + (1-p) * V_d) \tag{3.6}$$

where V_n is the option value at each node, and V_u and V_d are the option values of up and down movements at $n+1$. This process is repeated until the first initial node is derived, and this value is the final option value.

The payoff for an American option is slightly different, since the value at each node must be compared to the possibility of early exercise, but is not used in this study.

3.6. Real Option Analysis in Prior Studies

3.6.1. Early Real Option Studies

Although financial option pricing has been studied extensively since the 1970s, it was not until a decade or so later that real option theory started gaining popularity. McDonald and Siegel (1985) demonstrate how option pricing theory can be applied to a firm that has the option to shut down production if variable production costs exceed revenues. Pindyck (1988) points out that the timing of an investment can be thought of as an option. Before an investment is made, a manager has the option to wait or defer the investment to any point in the future. Therefore, when investment is made, they are exercising the option to wait. Pindyck argues that this is an essential component in investments with industry-specific capital since the project is most likely irreversible.

Dixit (1989) was also one of the first to study real options as they apply to investment decisions. He made the connection between the decisions that firms face under uncertainty and options in that there is a certain “trigger price” where firms should enter a deal, which is similar to a call option. Dixit argues that the cost of an investment is similar to a strike price, and making the investment is analogous to exercising a call option. He also recognizes that, in some situations, exercising can lead to additional options, such as abandoning the investment in the future, which leads to a compound option, and requires deeper analysis. Kemna (1993) provides an early collection of case studies on real options in the petroleum industry.

3.6.2. Real Option Analysis in Agriculture

Real options have been applied to many different areas of agriculture and have a virtually unlimited number of possibilities. In an early study, Flood (1990) demonstrates how real option pricing can be applied to the federal deposit insurance system. By setting a price floor, insurance acts like a put option, and this model shows how option valuation can estimate the net value of the government’s fund, or determine a theoretical insurance premium for banks. Similarly, Dahl, Wilson, and Gustafson (1995) use real option pricing to estimate the value of credit guarantees offered to various importing countries. This credit guarantee is similar to insurance, and can be modeled as a put option. Results show that Canadian guarantee programs have the lowest implicit value, while French guarantees have the highest value. In another real option study on support programs, Tirupattur, Hauser, and Boyle (1997) use real option analysis to compare the governmental cost of corn support programs to the value obtained by corn producers. This study also discusses the relationship between support programs and put options.

Real options are also a popular methodology in ag biotechnology. Turvey (2001) applies a variety of options to a Mycogen case study done in 1998. It shows that an agribusiness firm specializing biotechnology, when facing investment decisions, may be facing more than one type of option and that they be connected with each other, i.e. learning options can lead to options to expand. Building on the Turvey study, Churchill (2016) provides a comprehensive framework for valuing real options embedded within ag biotech license agreements, and identifies eight different real options that are commonly used in current contracts. In a study on genetically modified wheat development, Shakya, Wilson, and Dahl (2012) use real options to conclude that potential GM wheat development is the most profitable in the Prairie Gateway and northern Great Plans regions in the United States. In a more recent study, Wynn (2017) uses real options to conclude that developing drought tolerant canola is profitable in certain regions.

It has been shown that real options are not only better at predicting future profitability, but also managerial behavior of farmers. A study by Isik and Yang (2004) uses real options to explain farmer behavior in participation in the Conservation Reserve Program. Results show that uncertainty and irreversibility of the CRP negatively affect participation since there is an option value embedded in this choice, which is unrealized by the payments. More recently Ihli et. al. (2013) show that ROA predicts farmer investment behavior better than traditional NPV analysis. Onel and Goodwin (2014) analyze the long-term movement of labor away from the agricultural sector using real options. They argue that when someone migrates away from farm-labor, they are taking into account more than just a positive wage differential. Rather, potential migrants face irreversibility, uncertainty, and adjustment costs which create a threshold, which must surpass the option value of waiting before they change their labor sector.

In a study on the California water market, Tomkins and Weber (2010) demonstrate that a bilateral option contracting model for temporary transfer rights of water would capture gains from trade that go unrealized in permanent transfers. Other areas of agriculture that real option analysis has been applied to include land conversion costs (Miao, Hennessy, and Feng 2014), and organic farming (Tzouramani et al. 2009).

3.6.3. Real Option Analysis in Shipping

In more recent years, real option analysis has been gaining popularity in not only capital budgeting, but also in shipping and transportation markets. Most of the existing literature involving real options and shipping analyze ocean transportation. Alizadah and Nomikos (2009) provide a comprehensive review on derivatives and real options in shipping. The authors cover the ocean shipping derivative market, and real option methodology. Examples are provided for options to abandon, expand, contract, lay-up, switch, delay investment, and others as they relate to ocean freight. Siqin, Bin, and Jinhai (2013) use the Dixit real option model to determine when ocean container companies should enter and exit the market based on timing of investment and trigger prices. Results show that price is a crucial factor, and that it is different for each type of freight. In a similar study, Balliauw also uses real option analysis to determine entry and exit points for an ocean shipper by taking into account cyclical markets, investment costs, redeployment values, and operational costs. Rau and Spinler (2016) also utilize a real option model to determine optimal vessel capacity within the container industry under oligopolistic competition. Among other results, they show that competitive intensity, number of players, volatility, fuel-efficiency, lead time, and cost all affect the optimal capacity.

3.7. Conclusion

Due to the static nature of traditional financial valuation methods, such as NPV, real option analysis has emerged as a popular form of capital budgeting. ROA is popular for its ability to account for managerial flexibility that may be embedded within an investment decision, as well as uncertainty of outcomes. Although the complexity of ROA application keeps many managers hesitant about implementing it, once the model is specified the calculations are rather simple. There are numerous different types of real options, and various scenarios where it is applicable.

This chapter demonstrates how primary shuttle contracts can be modeled as a real option. Specifically, the transferability of these contracts can be valued as a put option, since it gives the owner the right to sell unneeded cars into the secondary market. The preferred method for solving this type of option is a binomial lattice tree.

Although extensive research has been done on both rail markets and real option analysis, limited studies have combined the topics to examine the value of options embedded in rail contracts. Wilson, Priewe, and Dahl (1998) analyze the strategic performance of various options available to grain shippers who utilize railroads, but do not attempt to value the embedded real options that the strategies contain, which is the aim of this paper. As previously mentioned, Lee (1999) uses real option analysis to value the rail contracts available at the time. This included a transferability component, as well as the marginal increase in value that guaranteed rail mechanisms provide. Most of the existing literature on real options in transportation has involved various aspects of ocean shipping.

CHAPTER 4. EMPIRICAL MODEL FOR THE TRANSFER OPTION

4.1. Introduction

Given the fact that certain railroad contracting mechanisms allow the shipper to sell excess or unneeded cars into a secondary market, this added flexibility creates value and can be modeled as a transfer option. Since a transfer option gives the owner the right, but not the obligation to sell the unneeded cars, this is synonymous to a put option (Winston 2008, Alizadeh and Nomikos 2009). The premium on this put option is interpreted as the marginal difference that a shipper should pay for a contract with this flexibility versus one that does not. The previous chapters explained the background of these rail mechanisms and real option analysis methodology. This chapter presents the empirical model for calculating the value of this transfer option. An overview of the model is outlined with the basic structure and input parameters. Derivations of each model component are then shown, followed by the data sources and distributions of stochastic variables.

4.2. Basic Model Overview

The model represents a typical North Dakota grain shipper who utilizes primary shuttle contracts. The model represents a one-elevator shipper, but can be easily adapted for a larger grain company with multiple locations. Since the derivations are similar for any number of elevators, only one is used for purposes of simplicity and clarity. The elevator is a soybean shipper who buys grain from local farmers using a combination of forward contracts and spot deliveries, and then resells to exports markets in the Pacific Northwest (PNW) based on a strategic shipping schedule. The model represents one year of business to match the current length of shuttle contracts offered by BNSF (*bnsf.com*). The timeframe coincides with the soybean marketing year, which runs from September through the following August.

There are five main components for any option model. Table 4.1 builds on Table 3.1 and presents the relationship between components of financial options, real options in general, and the transfer option for railcars.

Table 4.1. Five Components of Transfer Option

Component	**Financial Options**	**Real Options**	**Transfer Option**
Underlying Variable:	Current value of stock	Gross present value of expected cash flows	Shipping demand
Strike Value:	Exercise price	Investment cost	Shipping supply
Time to Maturity:	Time to expiration	Time until opportunity disappears	Time until railcars are utilized
Volatility:	Stock price uncertainty	Project value uncertainty	Volatility of shipping demand
Risk-Free Rate:	Riskless interest rate	Riskless interest rate	Riskless interest rate

There are two main components to the overall model. Module 1 is a Material Requirement Planning (MRP) schedule, and Module 2 consists of the stochastic binomial option pricing trees. In general, an MRP model is used to estimate how much of an input would be required in the future to meet a production schedule. The MRP model represents the business operations for the grain shipper. Based on projected farmer sales, grain prices, and inventory levels, the MRP schedule estimates how much shipping demand the elevator has for each of the next 12 months forward, and therefore how many rail cars are required. Specifically, shipping demand represents how much grain the elevator sells based on returns from storage, and capacity constraints. Shipping supply then refers to the number of railcars that are received based on railroad performance, measured in trips per month. In the base case, we assume the elevator implements a strategy in which they bid for enough shuttles to cover as close to 100% of the forecasted shipping demand as possible. However, due to fluctuations in railroad performance, the exact number of cars received each month fluctuates. This variability in both shipping demand and supply causes either a shortage or surplus of railcars each month. During months when shipping supply exceeds shipping demand, the transfer option now potentially has value since the shipper may decide to sell the extra cars into the secondary market. During months when shipping demand exceeds supply, there would be a shortage of railcars and require the elevator to source additional transportation, in which case the transferability has no value. After shipping demand levels are derived for each month forward, the volatility of shipping demand can be derived, and these two components are used in option pricing module.

Module 2 consists primarily of twelve different stochastic binomial option pricing trees. As previously mentioned, a shipper with excess railcars can sell the rights to individual trip, but retain ownership of the remainder of the contract. Therefore, each individual trip could be modeled as a separate option. For simplicity, we assume the elevator makes shipping decisions on a monthly basis, which is why there are twelve option trees. Also, we assume that the elevator makes the decision to utilize or sell the monthly railcar supply during the month in which they are delivered. For example, the option on cars arriving four months from now would not be decided upon until that time when the inventory levels are known with higher confidence. This implies that the transferability is a European option, since it is not exercised until expiration (Lee 1999). The alternative would be an American option, which can be exercised at any time prior to expiration. However, modelling the transferability as an American option would add much more complexity to the MRP schedule and require additional assumptions. Option values for each month are presented for the base case, but the average of all monthly values is sufficient to represent the overall option value. Figure 4.1 shows the general flow of the modules and option parameters. Once all option input parameters are specified, Monte Carlo simulation is implemented using the Microsoft Excel add-in program, @Risk.

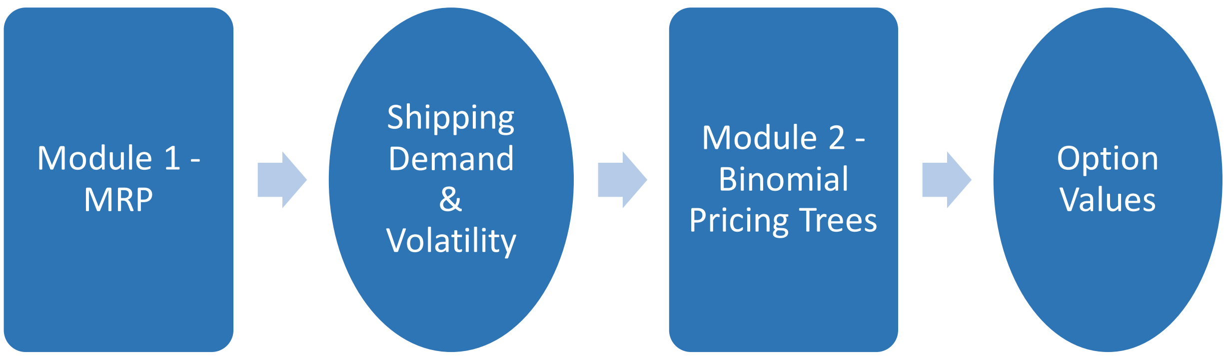

Figure 4.1. Module Flow

4.3. Detailed Elements of Model

The following section presents the formulas for calculating each part of the model. The formulas are in sequential order, starting with elements of the MRP schedule and derivations for shipping demand and volatility are presented. Then, inputs for the stochastic binomial option trees are defined, as well as the basic solution process.

4.3.1. MRP Module Details

The first step for the MRP is to determine the annual amount of grain handled by the elevator, which is how much volume or throughput of grain the shipper buys and sells during the year. Measured in bushels, this is defined as:

$$h_a = \omega * \gamma \quad (4.1)$$

where h_a is the amount handled, ω is the elevator capacity, and γ is the turnover ratio. The monthly grain handle is then derived based on historical data of farmer deliveries, defined as the percentage of marketing year sales for each month as follows:

$$h_i = h_a * \widehat{s_i} \tag{4.2}$$

where $\widehat{s_i}$ is the percentage of total marketing year sales that farmers make in each month, i, where i=1,…,12.

Farmer sales are a combination of spot deliveries, and forward contracted grain. The percent of sales that are forward contracted are known with certainty each year based on strategic planning by the elevator. The more forward contracted sales there are, the less volatile farmer deliveries are each month. The "∧" symbol represents a stochastic variable.

Once farmer deliveries are estimated for each month, the next step is to determine how long to store the grain. The first step is to derive the cash prices at the destination market in the PNW, defined as:

$$c_i = f_i + \widehat{b_i} \tag{4.3}$$

where f_i is the futures price, and $\widehat{b_i}$ is the basis at the PNW. As a profit maximizing grain company, the shipper hedges in the month that provides the largest return to storage. Return to storage are composed of revenue from storage, and the costs of storage. Revenue from storage is essentially the gain in cash price that the shipper would receive from storing and selling the grain in a deferred month rather than today. Revenue, cost, and return to storage can be defined as:

$$\delta_{i,j} = c_j - c_i \tag{4.4}$$

$$k_{i,j} = \phi * (i - j) + \frac{r}{12} * c_i * (i - j) \tag{4.5}$$

$$\theta_{i,j} = \delta_{i,j} - k_{i,j} \tag{4.6}$$

where $\delta_{i,j}$ is the revenue from storing from receiving month, i, until shipping month, j, where j=1,…,24. $k_{i,j}$ is the cost of storage, ϕ is the physical cost of storage/bushel/month, r is the interest rate, and $\theta_{i,j}$ is the return to storage. Therefore, the overall return to storage for grain received each month, i, is as follows:

$$\pi_{store,i} = \max(\theta_{i,j}) \ \forall \ i \tag{4.7}$$

Whenever $i = j$, revenue and cost of storage are zero, since shipment is being made in the same month as it was received. Also, we hold that the maximum length of storage is one year from the receiving date. Therefore:

$$j - i \leq 12 \tag{4.8}$$

Once these calculations are derived for each month, we now have a preliminary shipping demand schedule. Since farmer deliveries and PNW basis values are stochastic, this demand schedule is different for each Monte Carlo iteration. Inventory levels for each month are calculated as follows:

$$\mathrm{I}_i = I_{i-1} + h_i - s_{d,i} \tag{4.9}$$

where I_i is the ending inventory for each month, and $s_{d,i}$ is the initial shipping demand for each month. Before a final shipping demand schedule is derived, adjustments are made according to the following constraints:

1. Storage capacity - Whenever $\mathrm{I}_i > \omega$, storage has been exceeded, so additional grain must be shipped.
2. Shipping capacity – Denoted by S_c, the elevator can only ship a certain number of trainloads in each month. The logic behind this constraint is that if there is a given month where shipping demand is very large, it likely large for other regional grain shippers as well, and cars are then more difficult to secure. According to at least one elevator

manager, the rule of thumb is that this quantity is equal to four times the number of shuttle contracts owned, denoted here by Q. Therefore, $S_c = 4Q$. Q is derived in a later section of the model.

3. Rounding/integers – Since shuttles typically arrive in units of 110 cars, the elevator only ships grain if it can fill up all 110. Any grain leftover from rounding is carried over until the next month. Under certain situations, this can cause the inventory to exceed storage capacity. However, in this situation only, the grain is carried over anyways by allowing for ground storage.

An example of part of the MRP schedule is shown in Table 4.2. Therefore, the final shipping demand for each month becomes:

$$S_{d,i} = s_{d,i} + adjustments \quad (4.10)$$

Table 4.2. Shipping Demand Schedule Example

Shipping Demand							**Ending Inventory**	
Month	Int'l Ship Demand	Int'l Ending Inventory	Adj. for Cap.	Total Ship Demand	Cars	**Train Loads**	Long/short bu. from Rounding	Adj. Ending Inventory
Sep	2,713,238	-	-	2,713,238	729	**6**	256,058	256,058
Oct	6,002,228	-	-	6,002,228	1,612	**8**	2,725,988	2,725,988
Nov	6,125,226	-	-	6,125,226	1,645	**8**	2,848,986	2,848,986
Dec	-	5,436,804	436,804	436,804	117	**1**	27,274	5,027,274
Jan	-	9,056,244	4,056,244	4,056,244	1,090	**8**	780,004	5,780,004
Feb	-	8,776,550	3,776,550	3,776,550	1,014	**8**	500,310	5,500,310
Mar	-	8,227,968	3,227,968	3,227,968	867	**7**	361,258	5,361,258
April	5,986,258	-	-	5,986,258	1,608	**8**	2,710,018	2,710,018
May	4,909,392	-	-	4,909,392	1,319	**8**	1,633,152	1,633,152
June	3,222,675	-	-	3,222,675	866	**7**	355,965	355,965
July	1,945,629	-	-	1,945,629	523	**4**	307,509	307,509
Aug	932,509	-	-	932,509	250	**2**	113,449	113,449

Once the shipping demand schedule is estimated, shipping demand volatility is derived for each month, denoted as σ_i. Following the method of Winston (2008), there are two steps to calculating volatility for a real option as follows:

$$\rho_i = Ln\left(\frac{S_{d,i}}{S_{d,i-1}}\right) \tag{4.11}$$

$$\sigma_i = stdev(\rho_1, \ldots, \rho_i) \tag{4.12}$$

where ρ_i, is simply a ratio variable. For example, the volatility for the six-month option is a function of the shipping demand in the previous six months. In the first month, September, $S_{d,i-1}$ is assumed to equal the average of the other 11 months, and is held static.

The last input needed before proceeding to the binomial trees is monthly shipping supply, $S_{s,i}$. This represents how many railcars the shipper receives in each month, based on the number of shuttle contracts owned, Q, and railroad performance/velocity, $\hat{v}_i$. Recall from earlier that the shipper attempts to buy enough shuttle contracts to cover as close to 100% of shipping demand as possible. This is a strategic planning variable, and is adjusted in the sensitivity analysis. Therefore, the number of shuttle contracts the elevator buys can then be defined as follows:

$$Q = \frac{100\% * h_a}{(C_{cap} * 110 * 12 * v_e)} \tag{4.13}$$

where v_e is the expected velocity, which is different and independent of monthly velocity, and Q is rounded to the nearest whole number. Expected velocity is important since a shipper who anticipates a high velocity orders fewer shuttles since they expect to get the same supply with less cars, and vice versa. C_{cap} and 12 represent how many bushels can fit in a railcar, and the number of months in a shuttle contract, respectively. Monthly shipping supply is then defined as:

$$S_{s,i} = Q * \hat{v}_i \tag{4.14}$$

4.3.2. Stochastic Binomial Option Pricing Module Details

The underlying variable, and starting point for the lattice trees is monthly shipping demand. Whereas most real option studies designate project value as the underlying variable, measured in dollars, we use shipping demand, measured in railcars, for a few key reasons. Another way to think of the underlying variable in a real option model is the variable that contingent decisions are based upon, and in most studies, project value drives decision making. If project value changes, certain decisions are made. However, for a grain shipper, the decision to sell excess railcars depends on the level of shipping demand, rather than the value of the cars in the secondary market. If the underlying variable in this model were to be secondary rail market prices, it would imply that the elevator would be willing to forgo shipping grain if it was more profitable to sell railcars. While this is true to some extent, the primary revenue source for a grain company is the buying and selling of grain. A typical country elevator would not shut down operations just because it was more profitable to sell all of their shipping capacity in one month. Since the main goal of an elevator is to profit from grain sales, shipping demand is the variable that drives contingent decisions. Essentially, the primary goal of the elevator in this model is to sell grain at a profit, and any extra cars can be sold as a secondary source of revenue.

Once returns to storage, shipping demand, volatility, and shipping supply are defined, the other inputs for the lattice can be derived. The “up” factor, “down” factor, and risk neutral probability are calculated from equations (3.1), (3.2), and (3.3). Table 4.3 shows an example of the input derivations for the January option, which is the fifth option month.

Table 4.3. January Option Inputs

Parameter	**Derivation**	**Value**
Underlying Variable	$S_{d,i}$	880
Strike or Exercise Value	$S_{s,i}$	550
Interest Rate	r	2.5%
Volatility	σ_i	88%
Time Until Expiration	t	5 months
Length of Branches	Δt	1 month
Up Factor	$e^{\sigma_i * \sqrt{(\Delta t)}}$	1.29
Down Factor	$\frac{1}{u}$	0.78
Probability of Up Move	$p = \frac{[e^{(r*\Delta t)} - d]}{(u - d)}$	0.44
Probability of Down Move	$1 - p$	0.56

The lattice for each binomial pricing tree can then be constructed to represent possible paths that shipping demand can follow. The ending nodes are then possible values for the January shipping demand level based on upward and downward movements. Each ending node for shipping demand is either greater or less than the exercise or strike value, which is shipping supply. Based on whether there is an excess number of railcars at each node, option values can be calculated.

If there is a shortage, the shipper would have to buy in cars and the transferability would have no value. However, if there is an excess of railcars, this does not necessarily mean that the transfer option has value. This would only be the case if selling excess railcars was the only choice available to the shipper. This would not conceptually be a “real option” since the shipper is being forced to sell the cars. Another problem arises from the fact that secondary car prices are sometimes negative, which means that the shipper would be losing money by exercising the option. This implies the possibility of negative option values, which does not corroborate with option theory.

In reality, the shipper has other possibilities and requires deeper analysis to calculate the value of the transferability. The option payoff equation (3.3) must be modified for the transfer option. We identify three viable alternatives available to a shipper with excess cars: sell cars into the secondary market, cancel the cars for a penalty, or find a use for the cars and “force” a shipment of grain. There is also the possibility of letting the cars sit unused, but the extreme demurrage costs the shipper would incur makes this an unviable alternative. The forced shipment choice requires the light assumption that a shipper is able to source any additional grain necessary to fill the remaining cars. The transfer option then only has value if selling the cars into the secondary market is the most profitable among the three alternatives. When selling cars is the most profitable choice, we can say that the option is “in the money” (ITM), and if cancellation or forcing a grain shipment is the most profitable, the option is “out of the money” (OTM). Figure 4.2 illustrates the alternatives available to the shipper at each ending node.

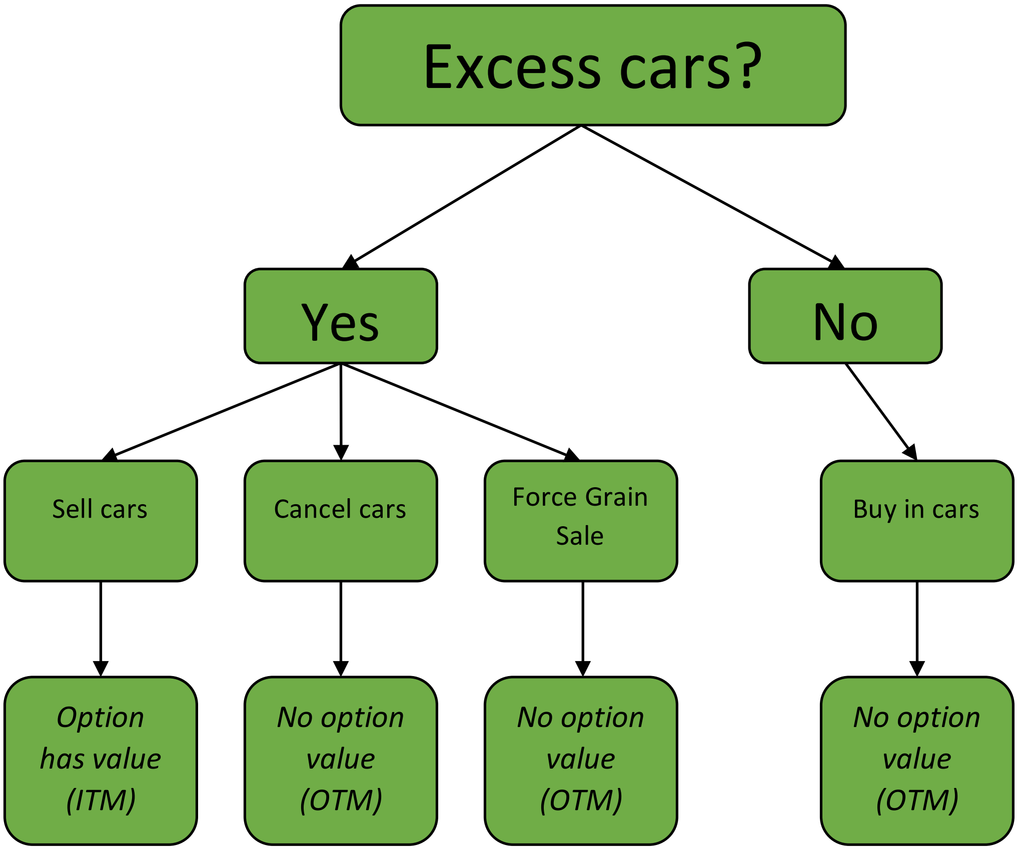

Figure 4.2. Railcar Choice Alternatives

Since the shipper only sells excess railcars into the secondary market if it is the most profitable among the three alternatives, a payoff for each choice must be derived. These three payoffs are defined on a per car basis as follows:

$$\pi_{sellcars,i} = \widehat{\alpha_i} \tag{4.15}$$

$$\pi_{cancel,i} = -200 * 3 * (13 - i) \tag{4.16}$$

$$\pi_{force,i} = -\pi_{store,i} * C_{cap} \tag{4.17}$$

where $\widehat{\alpha_i}$ is the secondary rail market price. In [4.16], 13 is used assuming that cars are cancelled at the beginning of the option month. The payoff for selling cars into the secondary market is simply the prevailing market price. The cost of cancelling a BNSF shuttle is $200/car/remaining trip. BNSF assumes three trips per month, so the cost of cancellation depends solely on the number of months left in the contract. A shipper who cancels cars early in the contract pays significantly more than one who cancels with only a month or two left. The payoff of forcing a grain shipment is the opportunity cost of storing the grain. In months where storage is profitable, forcing a shipment is a cost for the elevator, but in months where it is more profitable to ship grain, the cost is zero.

If selling cars into the secondary market is the highest payoff, then the actual net value of transferring the cars is not just the secondary price, but the marginal increase in payoffs between selling cars and the next best alternative, defined as:

$$\pi_{net,i} = \max\left[\pi_{sellcars,i} - (\max(\pi_{cancel,i}, \pi_{force,i})), 0\right] \tag{4.18}$$

Therefore, to derive the transfer value at each end node, we modify equation (3.3) to the following:

$$\pi_{transfer,i,n} = \max\left[S_{s,i} - S_{d,i,n}, 0\right] * \pi_{net,i} \tag{4.19}$$

where n is each end node. We then utilize equation (3.5) to discount the end node option values back to the present to get the monthly option values in total dollar amount. For interpretations, the total dollar figure is divided by the number of cars so that the option value is in dollars/car/trip. To keep the denominator consistent across months, expected velocity is utilized rather than monthly velocity. Figure 4.3 shows a fully developed example for the January option, for one Monte Carlo iteration. The option values for each month are then averaged to reflect the overall option value.

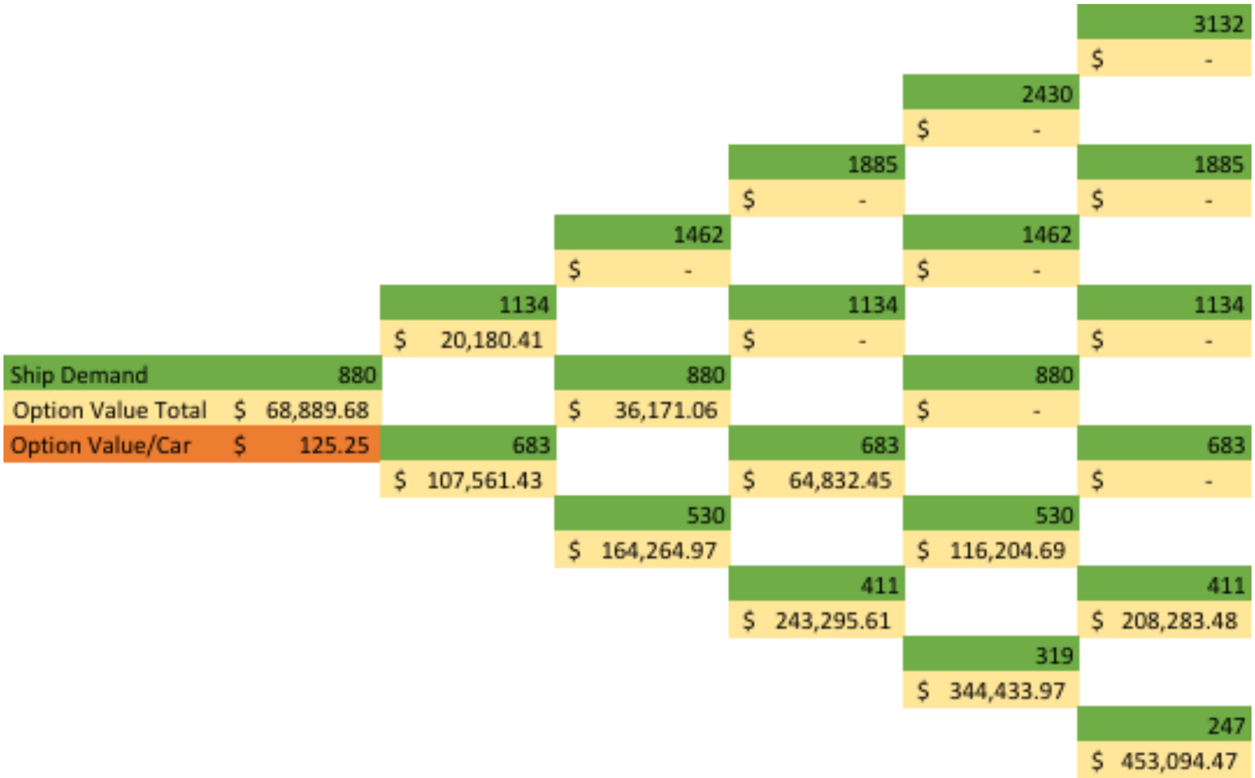

Figure 4.3. January Transfer Option

4.4. Model Setup

Tables 4.4 and 4.5 demonstrate the model setup. The base case inputs show the key fixed parameters that are used in the model. Futures prices reflect the forward price curve for soybeans. This variable is left static to isolate the effects of the spreads on shipping decisions and option values. Table 4.6 shows the variables on which a sensitivity analysis is conducted. These variables were selected based on their impact on key outputs, and to show how different management strategies effect the outcomes. Relevant output variables for the base case and sensitivity analysis are then presented in Table 4.7.

Table 4.4. Base Case Inputs

Parameter	**Value**
Interest	2.5%
Elevator Storage Capacity	5,000,000 bu.
Elevator Turnover Ratio	6
Handling Cost	$0.12/bushel/month
Shuttle Size	110 cars
Shipping Capacity	8 trains/month
Railcar Capacity	3,723 Bushels
Car Ordering Strategy	100% of forecasted grain handle
Percent Forward Contracted	25%
Expected Velocity (TPM)	2.5
Shuttle Contracts Owned	2
Shuttle Contract Length	1 year

Table 4.5. Futures Prices

Contract Month	**Price**
September	9.59
November	9.44
January	9.47
March	9.5
May	9.53
July	9.55
August	9.52
September	9.34
November	9.2
January	9.22
March	9.23
May	9.25
July	9.27
August	9.24

Table 4.6. Inputs for Sensitivity Analysis

Variable	**Category**	**Change**
Secondary Rail Prices	Stochastic	Base case mean ± \$300, \$600
Rail Velocity	Stochastic	2, 2.5, 3.0, 3.5
Shipping Demand Volatility	Derived	Base case mean ± 25%, 50%
Futures Spread	Derived	-\$0.15, -\$0.05, \$0.00, \$0.05, \$0.15
Car Ordering Strategy	Strategic	60%, 80%, 100%, 120%, 140%

Table 4.7. Outputs to Evaluate

Base Case	**Sensitivities**
Option Values	Option Values
Shipping Demand	Shipping Demand (for some)
Shipping Demand Volatility	Shipping Demand Volatility (for some)

4.5. Data Sources and Distributions

This section provides a description of data and sources. Also, distributions of stochastic variables are presented.

4.5.1. Description of Data and Sources

Since the model requires monthly projections, all historical data is either collected in monthly format, or converted to monthly. PNW soybean basis, and secondary rail market values were provided by TradeWest Brokerage Co., and assembled by Bruce Dahl. Weekly data from September of 2004 to August of 2016 were converted into monthly values by taking the average of the weekly values. Of the 668 data points for PNW basis, 80 missing values were supplemented by the Thomson Reuters Eikon database, using the symbol "SYB-TERM-PORT." Analysis was conducted to ensure complementarity between the two datasets. Monthly data for farmer deliveries for soybeans in North Dakota was retrieved from the USDA-NASS database, also ranging from September of 2004 to August of 2016. This data represents the percentage of crop year sales that farmers made each month within a given area. Data on railcar velocity in trips per month was retrieved from bnsf.com from January of 2011 through August of 2016. Railcar capacity was also from bnsf.com. Futures prices for soybeans reflect the forward curve on September 1st, 2016 and were retrieved from Data Transmission Network (DTN) ProphetX. Elevator information, such as turnover ratio, handling cost, shipping capacity, and expected velocity, was based on discussions with managers and shipping controllers, including Levi Hall of Beach Coop. Grain Company, Dan Mostad of Berthold Farmers Elevator, Kirk Gerhardt of ADM, and David Pope of CHS.

4.5.2. Stochastic Distributions

The four stochastic, or random variables in the model are PNW basis, farmer sales percentage, secondary rail market prices, and rail velocity. Since the variables are projected for each of the next 12 months, time series distributions are estimated rather than a probability density function. @Risk has a tool that fits the data automatically while considering stationarity, trend, seasonality, and correlations. The possible time series distributions include 11 variations of autoregressive, moving average, Brownian motion, and both regular and generalized autoregressive conditional heteroscedasticity models. @Risk makes the proper transformations, fits the data to each distribution, and ranks the fit based on Akaike Information Criteria (AIC). Once the data is fitted to each distribution, formulas for forward projection functions are provided. Tables 4.8 and 4.9, and Figures 4.4 - 4.7 show information about the best fitted distribution for each variable, correlations, and sample paths. In the distribution figures, the historical line represents the historical data entered into @Risk. The sample path shows an example of the projected values for one iteration, and the gray areas show the confidence intervals of the sample path.

Table 4.8. Stochastic Variable Information (@Risk)

Variable:	**PNW Basis**	**Farmer Sales %**	**Secondary Rail Prices**	**Velocity**
Distribution:	Autoregressive-moving average	Autoregressive conditional heteroscedasticity	Brownian motion	Autoregressive
Function:	{RiskARMA11(0.0012,0.19,0.60,0.83,0.18,0.21)}	{RiskARCH1(8.35,8.8548,0.39,8.3)}	{RiskBMMR(232.3,557.34,0.26,912.5)}	{RiskAR1(2.74,0.22,0.73,2.5)}
#1 AIC Score:	-58.68	763.55	2186.77	-18.72
Transformations:	Trend	Seasonality	None	Seasonality

Table 4.9. Correlation Matrix (@Risk)

	PNW Basis	**Farmer Sales %**	**Secondary Rail Prices**	**Velocity**
PNW Basis	1.000			
Farmer Sales %	-0.120	1.000		
Secondary Rail Prices	0.014	0.084	1.000	
Velocity	0.011	-0.030	-0.212	1.000

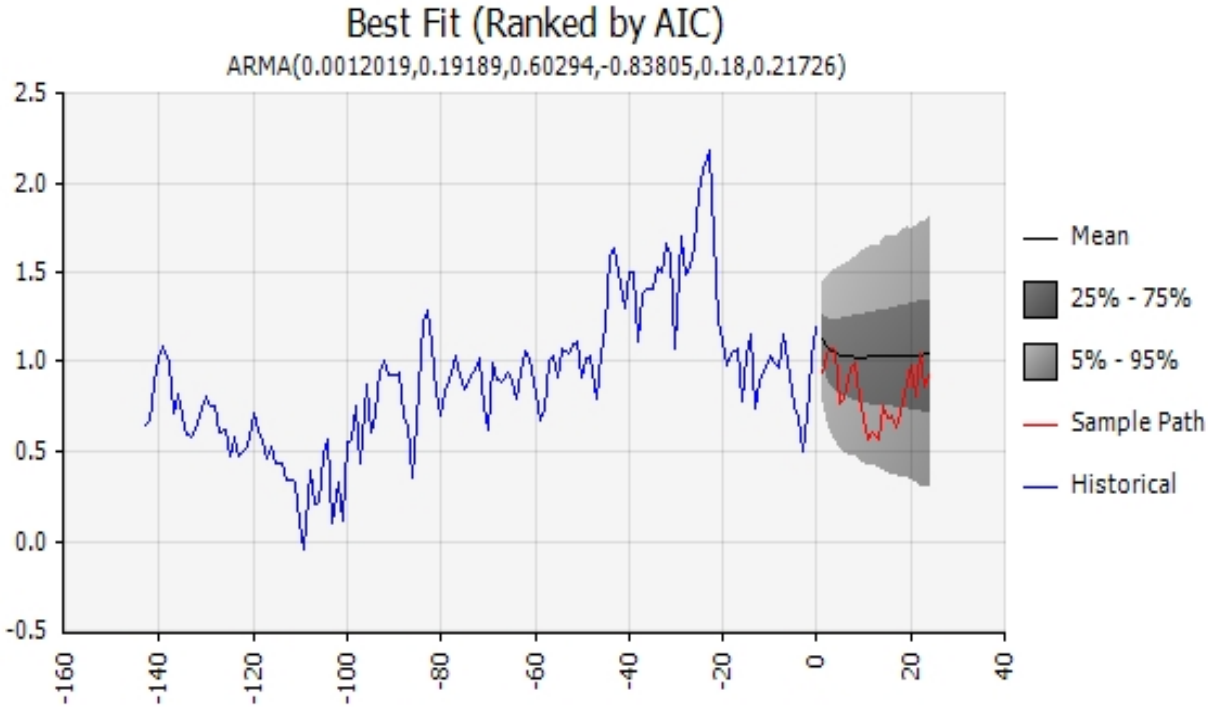

Figure 4.4. PNW Basis Sample Path (@Risk)

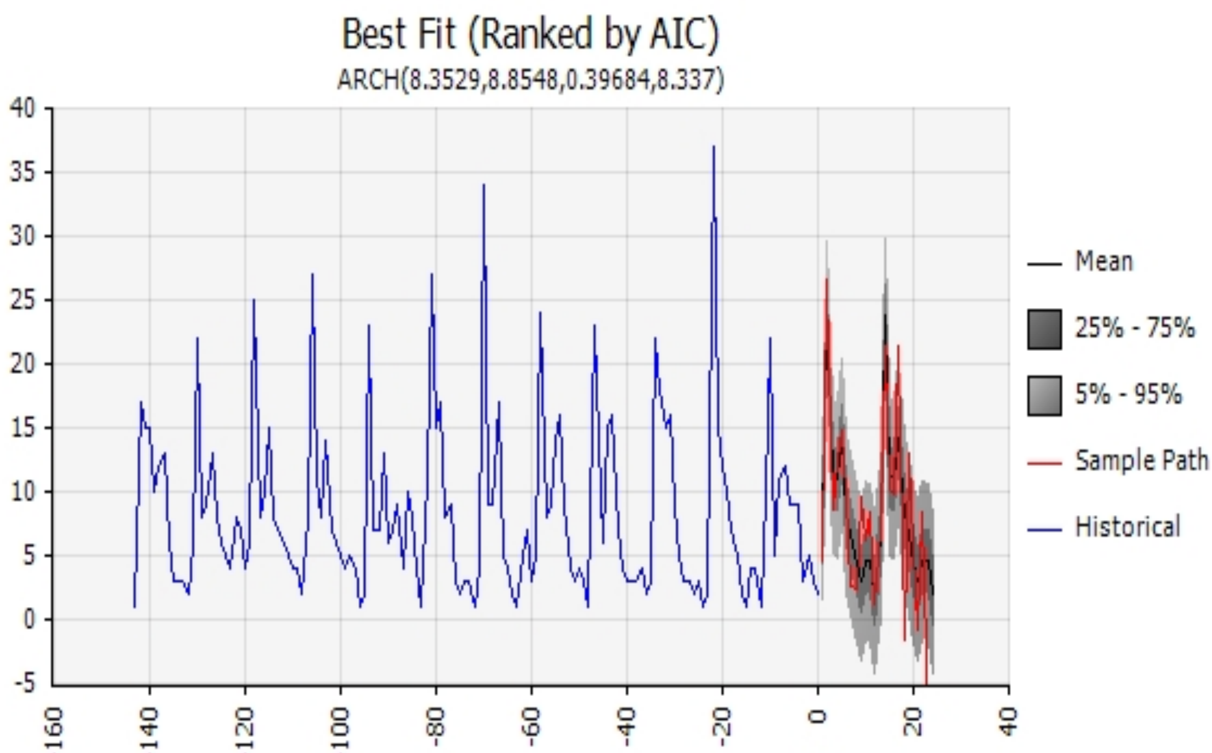

Figure 4.5. Farmer Sales Percent Sample Path (@Risk)

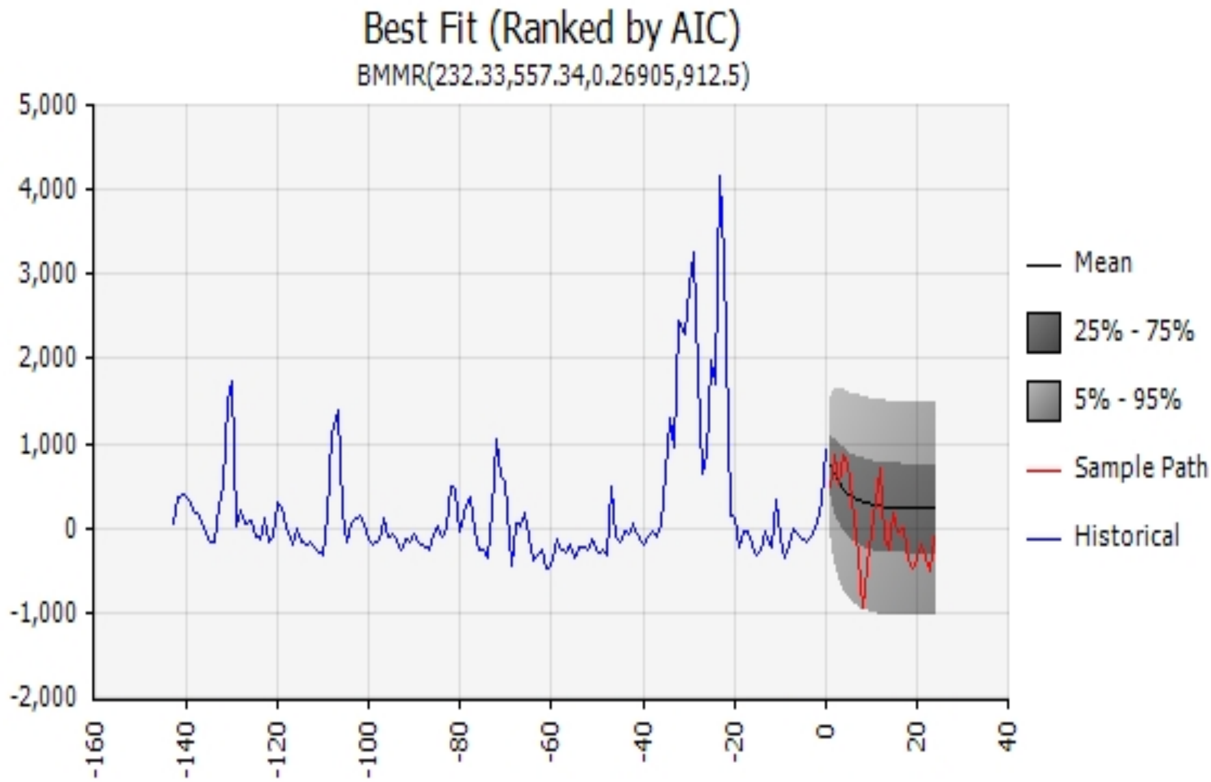

Figure 4.6. Secondary Rail Market Sample Path (@Risk)

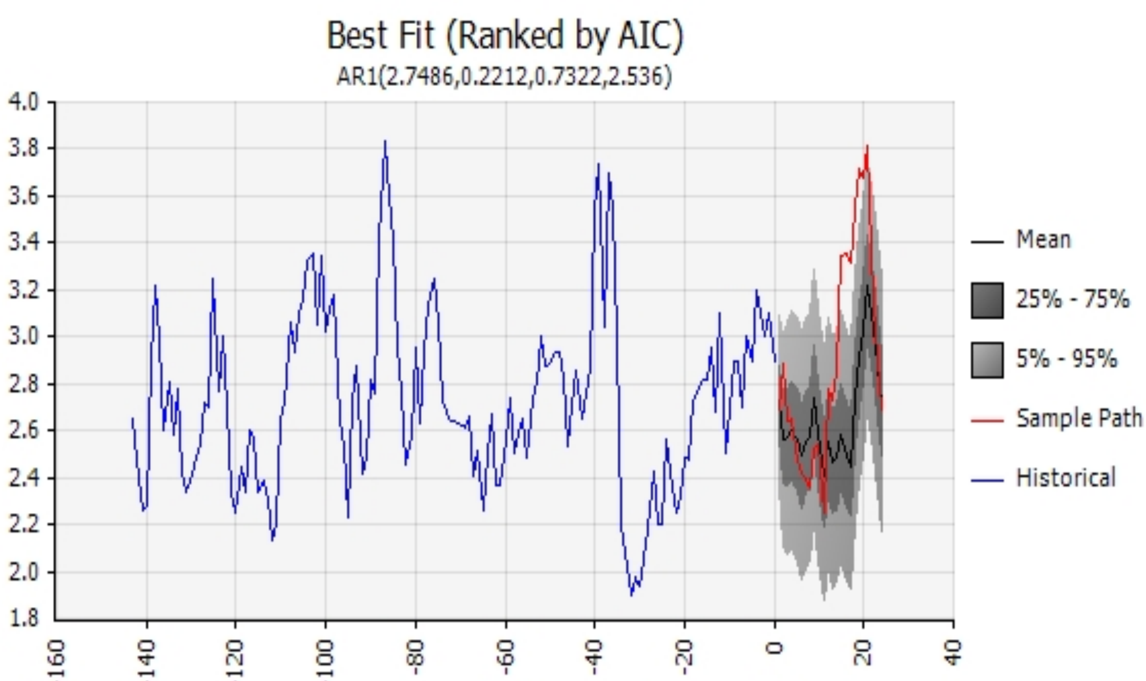

Figure 4.7. Velocity Sample Path (@Risk)

4.6. Summary

This chapter summarizes how primary rail contracts can be modeled as a real option, and shows the empirical model, stochastic and fixed inputs, and data sources. Specifically, the contracts are modeled as a transfer option, which is similar to a European put option. Also, the scope of the model, underlying assumptions and constrains are presented, along with the logic behind them. It also shows the variables on which a sensitivity analysis is conducted, along with the outputs to be evaluated. Module 1 is the MRP model, which derives a forward shipping schedule in order to estimate parameters for the real option model. After shipping demand, supply, and volatility are derived, they are inserted into Module 2, which is the set of stochastic binomial option pricing trees.

CHAPTER 5. RESULTS

5.1. Introduction

Due to the many dynamic variables in grain shipping, logistics management is becoming more and more paramount. To help mitigate some of the risks involved, railroad carriers offer contract mechanisms that provide various forms of flexibility to shippers. One of the components in some shuttle contracts is the ability to transfer or sell previously contracted cars into a secondary market. In order to efficiently bid for railcars with this added flexibility, it is important for the shipper to know how much value this transferability has within the contract.

Previous chapters explained the risks and options facing a grain shipper, real option methodology, and how transferability can be modeled as a put option, where shipping demand is the underlying variable and shipping supply is the strike price. An empirical model is then defined for a North Dakota grain shipper utilizing primary rail instruments with this added flexibility. An MRP schedule is defined to project shipping needs throughout the life of the shuttle contract, and the transfer value is derived using stochastic binomial option pricing trees. Monthly data for PNW basis values, farmer sales, secondary market values, and railcar velocity are used to create time-series stochastic variables. Data for PNW basis, farmer sales, and secondary market values are from 2004 through 2016, and railcar velocity is from 2011 through 2016.

For the transfer option to have value, two things need to happen; the shipper must have excess railcars, and selling these excess cars into the secondary market must have the highest payoff among the three alternatives. The alternatives under an excess car situation include selling cars in the secondary market, cancelling the contract, or utilizing the cars, which may require the shipper to source additional grain. When these two conditions are met, the transfer option can be said to be “in the money” versus “out of the money.”

This chapter first presents the base case that estimates the value of this transfer option. Simulation results for key inputs including monthly shipping demand, and shipping demand volatility are also described. The base case represents an elevator that utilizes primary market shuttles with a 5,000,000-bushel storage capacity, which they turnover six times per year. In order to ship close to 100% of their annual handle each year, two shuttle contracts are purchased. It is assumed that that they can ship up to eight trainloads each month. Also, 25% of the total grain handled each year is forward contracted. Each train the elevator receives is a full 110-car unit, and the elevator only utilizes the cars if they can fill all 110. Base case inputs and distributions for stochastic variables are also defined in Chapter 4.

A sensitivity analysis is run on certain stochastic and strategic input variables to analyze their effect on relevant outputs, and interpretations are provided. The unique scenario in 2013/2014 is also analyzed to see how it would impact these values if similar conditions were to occur again. The results are then summarized in a conclusion.

5.2. Base Case Results

Monte Carlo simulation is implemented using @Risk to simulate 10,000 iterations. The mean values from the simulated outputs are used for discussion. The transfer option for each month is presented, and the average of the monthly values represents the overall option value for a primary shuttle instrument. These option values are quoted in dollars/car/trip, meaning that the overall effect on bidding strategy depends on how many cars the shipper needs, and their expectation about velocity. Further, per car, per trip values are used since they are directly comparable to secondary rail market prices. Results are presented in Table 5.1.

Table 5.1. Base Case Results

	Option Values	Ship Demand (Cars)	Ship Demand Volatility	Secondary Market Prices	Velocity
September	$246	466	40%	$742	2.73
October	$164	724	59%	$619	2.56
November	$143	742	72%	$541	2.56
December	$134	766	75%	$467	2.60
January	$106	802	74%	$417	2.56
February	$108	783	73%	$377	2.48
March	$159	722	74%	$344	2.55
April	$203	671	77%	$322	2.57
May	$297	577	81%	$294	2.74
June	$261	583	86%	$284	2.59
July	$215	576	89%	$276	2.41
August	$184	544	90%	$256	2.55
Average	**$185**	**663**	**76%**	**$412**	**2.57**

Base case results show that the average value of the option is $185. This implies that, of the total contract value, $185 of it is derived from the transfer value. In situations where the contract costs less than $185, this implies an extra value is provided by the carrier to the shipper. The option is worth the least in January at $106, and the most in May at $297. The average shipping demand volatility is 76%. Volatility is higher in deferred months since there is more variability in predicting what shipping demand would be ten months from now, rather than in one month.

In iterations where the option value is very high, the inputs causing this appear to be high secondary market prices, low shipping demand, and high shipping demand volatility. For example, in the iteration with the maximum option value of $947, the secondary market price input percentile was 94%, meaning that it was one of the highest draws for that input. The percentiles for shipping demand, and shipping demand volatility during the maximum option value iteration are 2%, and 98%, respectively.

Figure 5.1 shows the average option value distribution over all months. The horizontal axis shows the option values, and the vertical axis values are the probabilities of each value occurring. There is a wide range of possible values, since there are many dynamics that affect the optimal shipping decisions. The confidence interval shows that there is a 95% chance that the option value is less than $461. The distribution is skewed and truncated at zero. For shippers, this implies that large option values are possible, but the transferability is usually towards the left-hand side of the distribution. For carriers, this implies that $185 is the minimum that they should receive for offering the shuttle contract, since the transferability alone is worth $185. Zero is the lowest possible value, since if the option has negative value, it would imply that selling cars would not be the best alternative available to the shipper and a different choice should be made in regards to their excess railcars.

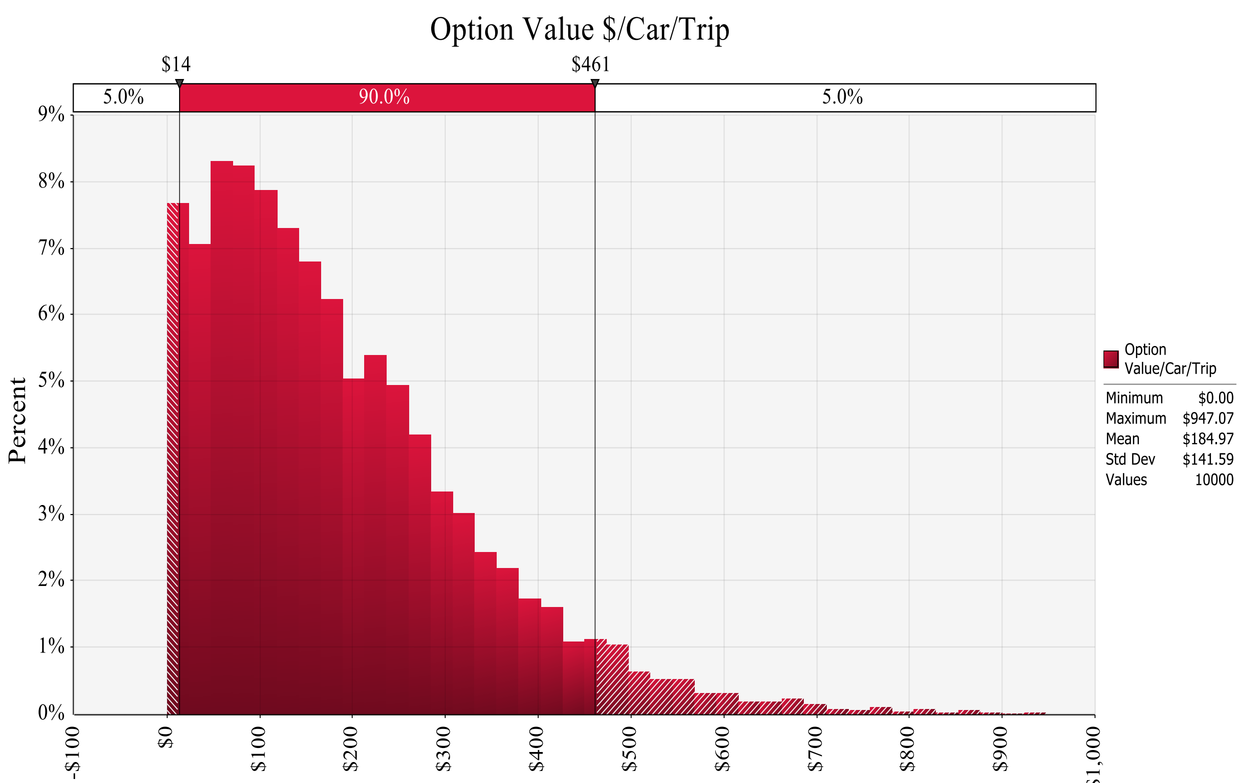

Figure 5.1. Base Case Distribution of Results (@Risk)

While there are many factors that affect the option value, the seasonality in month to month changes is partially explained by shipping demand levels. The lowest monthly option value, January, is the month with the highest shipping demand, and the highest option value occurs in the month with one of the lower levels of shipping demand. This relationship between transfer value and shipping demand is shown in Figure 5.2. The negative correlation between option value and shipping demand makes sense intuitively, since months with higher demand would provide fewer excess cars to transfer into the secondary market, and vice versa.

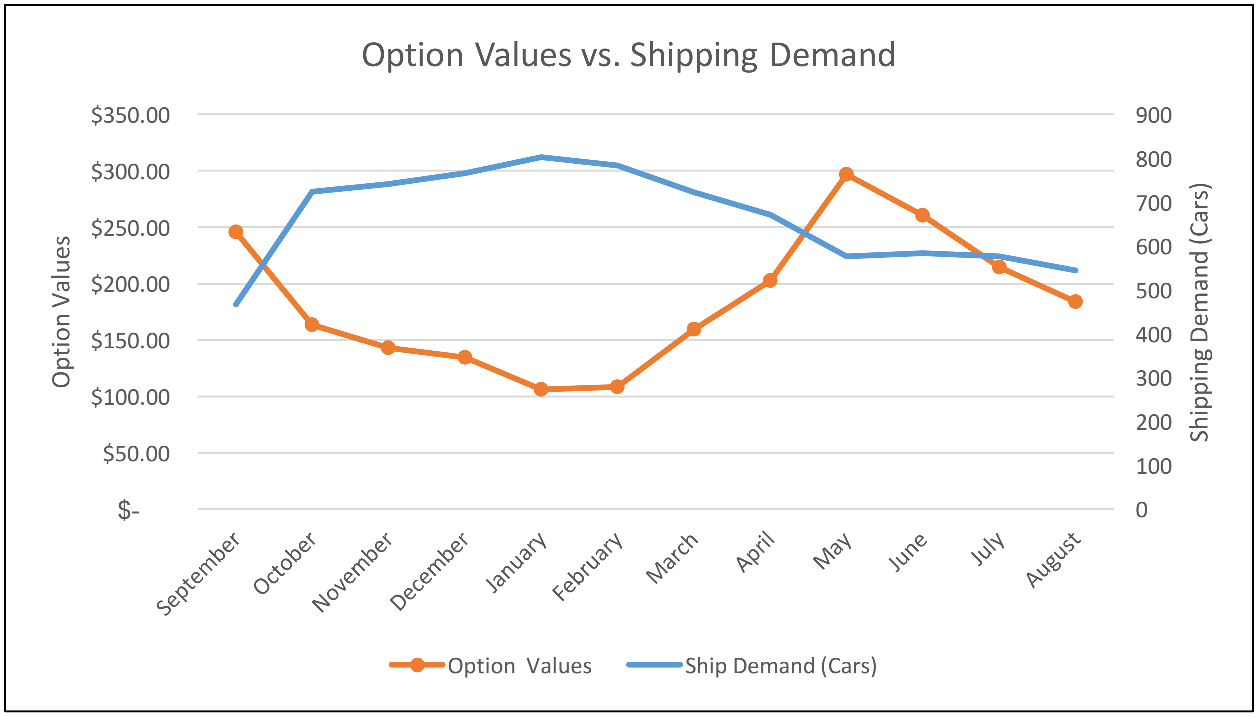

Figure 5.2. Option Values and Shipping Demand

Another input that affects the seasonality of the option value is velocity. In months where the railroad performance is stronger, there is more supply of railcars in the market. If the elevator receives more cars in certain months, there is a greater chance of having excess cars available for sale into the secondary market. The relationship between option price seasonality and velocity is shown in Figure 5.3. One explanation for the seasonality in velocity is the export schedule for major U.S. commodities. The main export season for grain is late fall and winter, which is when the lowest railroad performance occurs. High export levels mean that there is relatively more rail tack congestion from elevators attempting to get grain to the port.

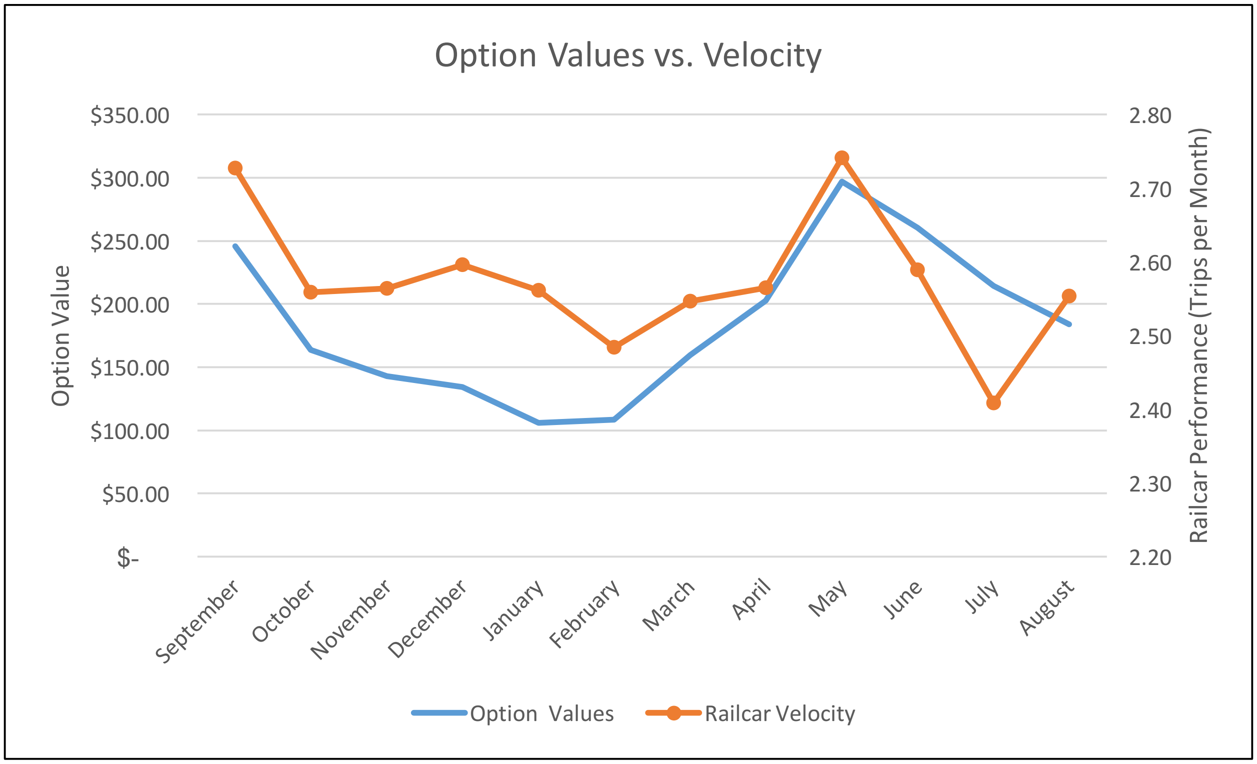

Figure 5.3. Option Values and Railcar Velocity

Figures 5.4 and 5.5 show that, based on correlation coefficients and tornado graphs, secondary market prices have the largest overall impact on the transfer value, since it is the price the shipper receives for selling excess cars. Volatility also has a large, positive impact on option values, which corroborates with option pricing theory. As discussed previously, shipping demand levels have a negative relationship with option values. This is a direct relationship, since lower shipping demand would produce more excess cars, which increases the value of the transfer option. Velocity has a positive impact on the transfer option value, but is much weaker compared to the other inputs. This can be explained by the fact that velocity is just one part of shipping supply. The other component of shipping supply is how many shuttle contracts the elevator owns. Since velocity is the only stochastic part of shipping supply, its impact on the transfer option is much less than shipping demand, since demand is more variable.

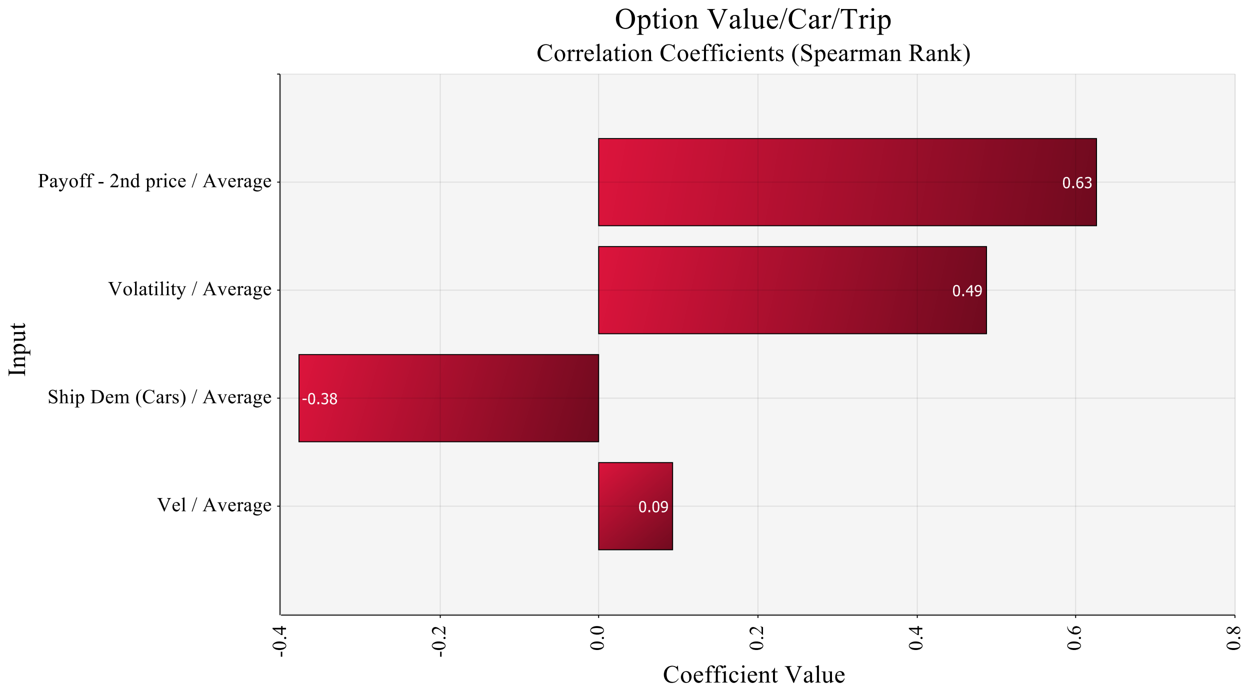

Figure 5.4. Correlations of Key Inputs with Option Value (@Risk)

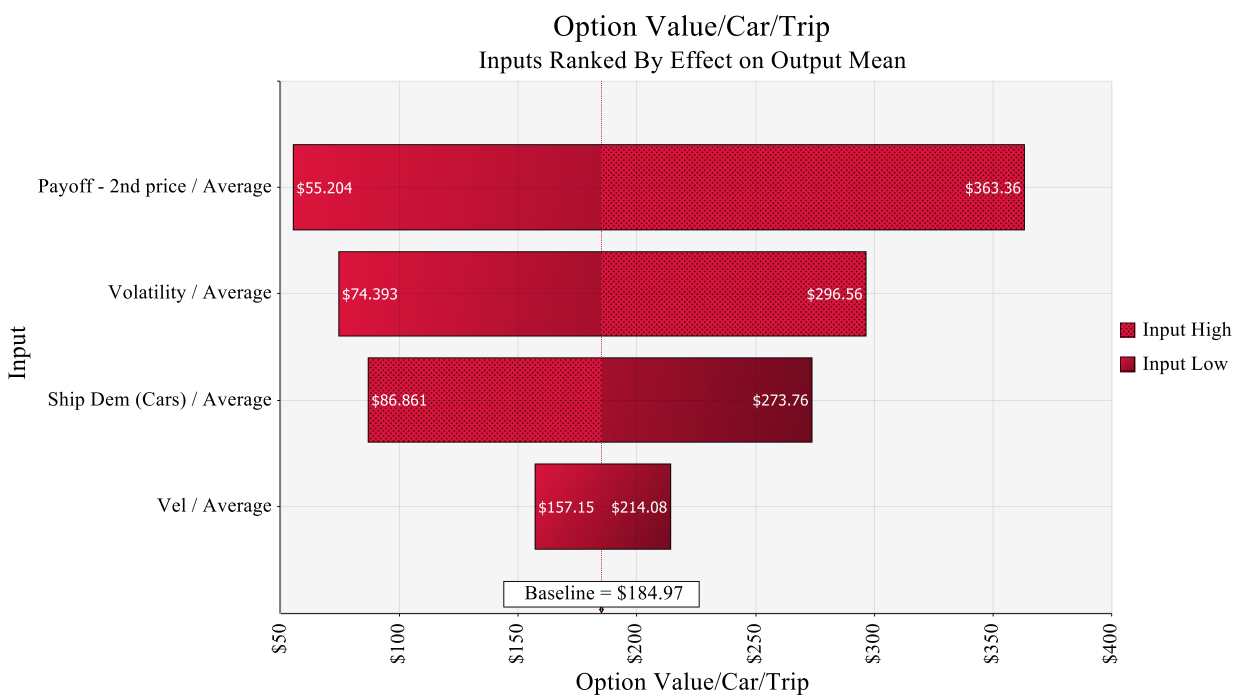

Figure 5.5. Impact of Key Inputs on Option Value (@Risk)

Under excess car situations, the shipper has three choices: sell, cancel, or utilize the cars. One interesting statistic is the likelihood of each choice providing the best payoff. Nearly every time, the optimal strategy with excess cars is to either sell them into the secondary market, or utilize them with a "forced" shipment, which is when the shipper sells grain regardless of the profitability. Cancelling the contract was the optimal choice for any month in only three out of 10,000 iterations. This is shown in Figure 5.6.

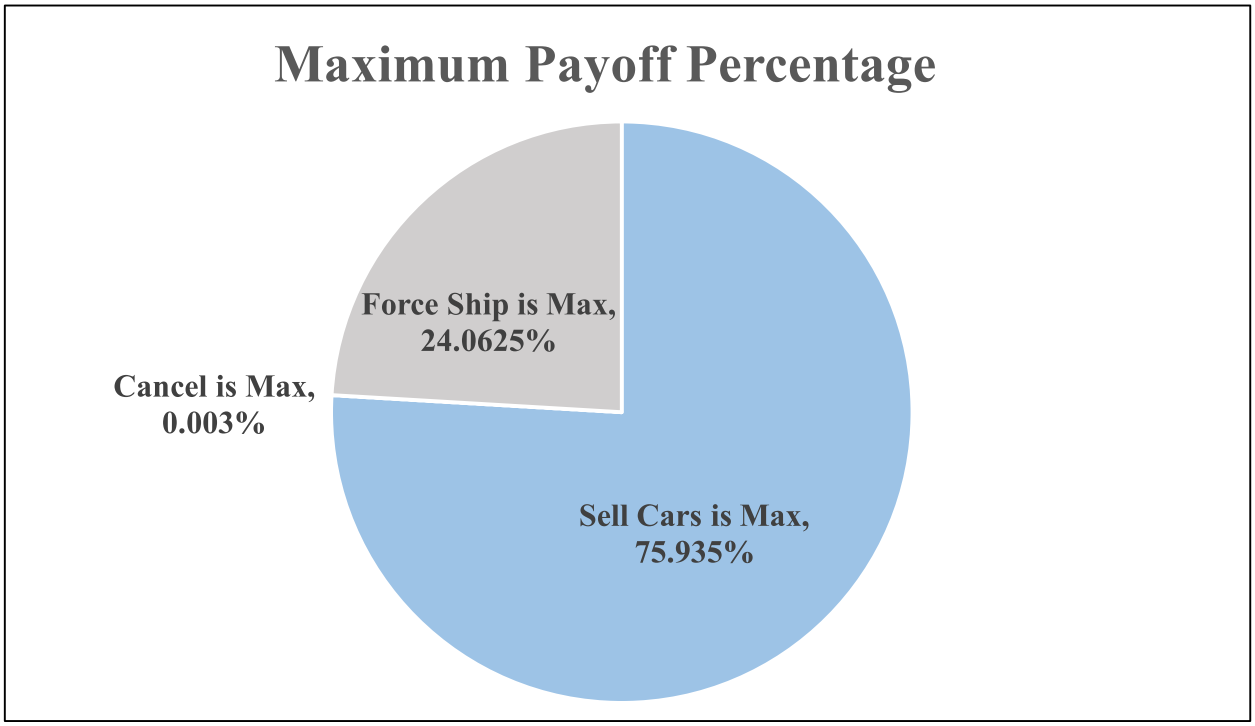

Figure 5.6. Maximum Payoff Percentage

5.3. Sensitivity Analysis on Stochastic Variables

In grain shipping, there are many different dynamic variables that impact grain flow and profitability. Therefore, there are also key variables that impact the transfer option value. Due to the random, or stochastic, nature of these variables, it is difficult to estimate what the actual outcome would be, even with Monte Carlo simulation. One useful method is to conduct sensitivity analysis to demonstrate how changes in the underlying stochastic variables impact the transferability.

While nearly every input in the model affects the option value to some degree, four key stochastic variables are identified: secondary market prices, shipping demand volatility, velocity, and inter-month spreads of futures prices. Although volatility is a derived variable, it changes with each iteration and is a main component of option pricing. While the spreads in futures prices are held constant throughout the simulation, they affect storage decisions, which affect shipping demand levels. The sensitivity analysis is conducted by only changing one variable at a time relative to the base case, using the "simtable" function in @Risk. Each possible variation of the target input is considered one simulation. In order to single out differences in outputs based only on the selected input, the settings in @Risk are defined such that each simulation uses the same seed generator. The situation in 2013/2014 is also recreated to demonstrate how a similar scenario would impact the transfer option.

5.3.1. Sensitivity – Secondary Market Prices

The first sensitivity is conducted on secondary rail market prices. These are important since it determines the price that the shipper would receive if they sell their excess cars. As shown in Figure 5.4 above, they are highly correlated with the transfer option value. The mean secondary price for the base case was $411. For the sensitivity analysis, prices start at -$200 and increase in $300 increments up to $1,000. Table 5.2 shows the resulting transfer option values from the four simulations and compares them to the base case scenario.

As expected from the correlation results, the secondary market prices demonstrate a positive relationship with the transfer option values. When prices are held constant at -$200, the option value is $39, and increases steadily to $329 as prices increases to $1,000. This shows that expectations about secondary market prices are important to a shipper when considering car ordering decisions. A shipper who expects lower prices to prevail should be more conservative about the number of shuttle contracts they own, and vice versa.

Table 5.2. Sensitivity - Secondary Rail Market Prices

Month/ Secondary Price	**-$200**	**$100**	**$411 (Base)**	**$700**	**$1,000**
September	$13	$55	$246	$236	$327
October	$40	$81	$164	$178	$227
November	$36	$74	$143	$168	$216
December	$32	$68	$134	$167	$216
January	$26	$55	$106	$138	$179
February	$28	$59	$108	$149	$194
March	$47	$94	$159	$222	$286
April	$57	$119	$203	$289	$375
May	$85	$176	$297	$434	$562
June	$64	$142	$261	$385	$506
July	$36	$99	$215	$323	$435
August	$0	$43	$184	$300	$428
Average	**$39**	**$89**	**$185**	**$249**	**$329**

5.3.2. Sensitivity – Shipping Demand Volatility

Volatility is one of the main components that affect any option value. Volatility represents the variability in month-to-month shipping demand. It is derived by taking the standard deviation of natural log ratios of monthly shipping demand. Shipping demand is derived from the material requirement planning schedule, which includes numerous variables including farmer sales, PNW basis values, storage costs, etc. Option pricing theory states a positive relationship between volatility and option values for both puts and calls. Therefore, since level of shipping demand is the underlying variable in the transfer option, sensitivity on volatility is conducted to provide insights for different types of shippers, as well as demonstrate robustness of the binomial option pricing model. The base case resulted in an average volatility of 76%, meaning that the actual shipping demand is expected to deviate within 76% of the projected shipping demand. Four different sensitivity simulations are run by holding shipping demand volatility constant, starting with 25% and increasing to 125%. Resulting option values are presented in Table 5.3.

Table 5.3. Sensitivity - Shipping Demand Volatility

Month/ Volatility	**25%**	**50%**	**77% (Base)**	**100%**	**125%**
September	$246	$246	$246	$257	$266
October	$142	$144	$164	$172	$196
November	$111	$117	$143	$158	$186
December	$88	$98	$134	$154	$190
January	$53	$66	$106	$131	$170
February	$57	$72	$108	$138	$179
March	$104	$124	$159	$196	$236
April	$149	$168	$203	$235	$273
May	$240	$261	$297	$324	$358
June	$197	$218	$261	$281	$314
July	$152	$170	$215	$229	$260
August	$112	$133	$184	$195	$227
Average	**$138**	**$151**	**$185**	**$206**	**$238**

As expected, shipping demand volatility has a positive impact on option values. Starting at 25%, the option value is $138, and increases steadily to $238 as volatility increases to 125%. The impact of shipping demand volatility has implications for different types of shippers. A country elevator may have higher volatility since a majority of sales are from farmer spot deliveries. An export terminal may have lower volatility due to strong seasonal patterns and market power. Shipping demand volatility also affects the variability in option outcomes in a positive manner, as shown in Figure 5.7. As volatility in shipping demand increases, the number of excess cars each month becomes more variable, which makes the option value more uncertain. When shipping demand volatility is only 25%, the standard deviation of the option value is $106, and when shipping demand is 125%, the standard deviation increases to $151. This means that when shipping demand volatility is low, the option value is lower, but less uncertain.

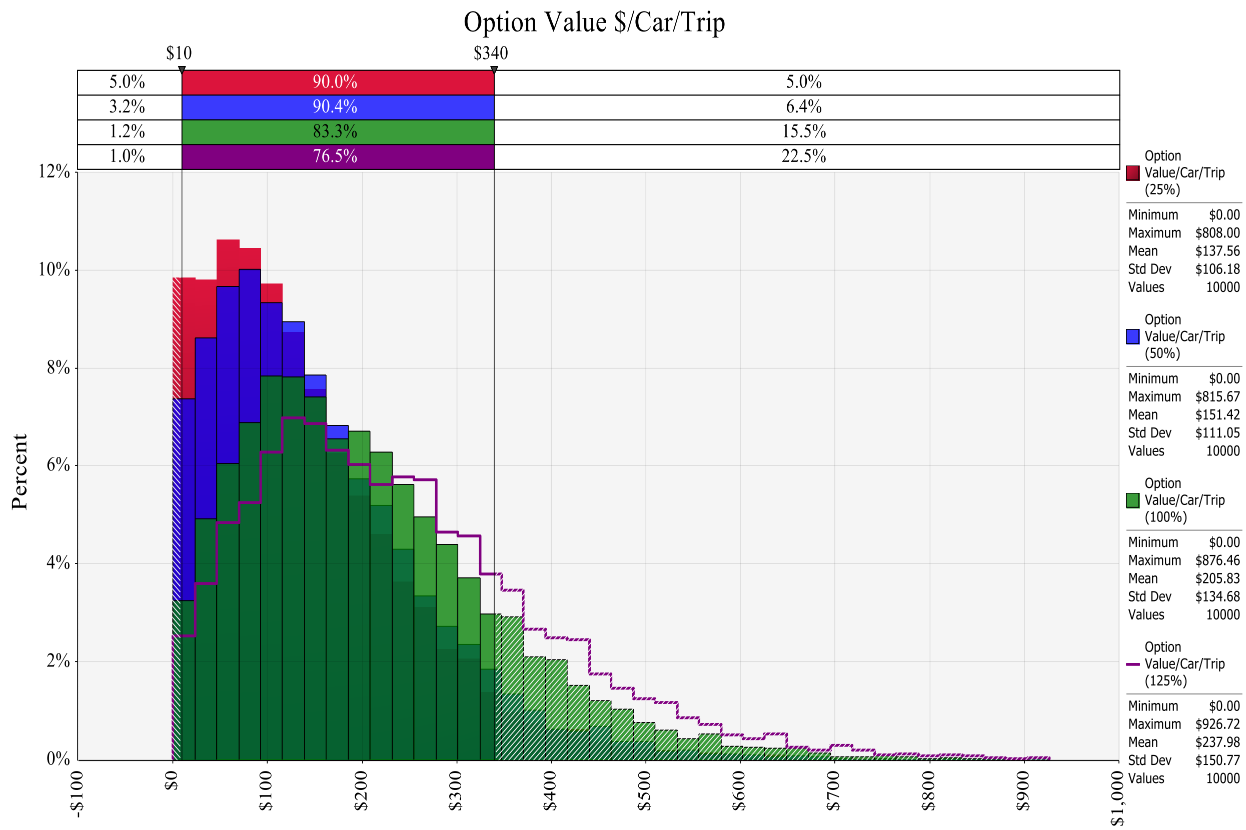

Figure 5.7. Shipping Demand Volatility & Option Values (@Risk)

5.3.3. Sensitivity - Rail Velocity

Rail velocity, measured in trips per month (TPM), is an underlying stochastic variable that determines shipping supply, or how many cars the elevator receives each month. During months with strong railroad performance, i.e. larger TPM, the shipper receives more cars to fill, and vice versa. Rail performance can be influenced by factors such as weather, track congestion, etc. Shipping supply is important since it represents the trigger point at which the elevator either has an excess or shortage of cars, which is interpreted as the strike or exercise price in the option model. Performance changes every month and through time. The distribution of railroad performance, measured in trips per month, is shown in Figure 5.8. The base case resulted in a mean velocity of 2.58 over all months. For the sensitivity analysis, velocity is held constant at 2.0 TPM and increases to 3.5. Resulting option values are presented in Table 5.4.

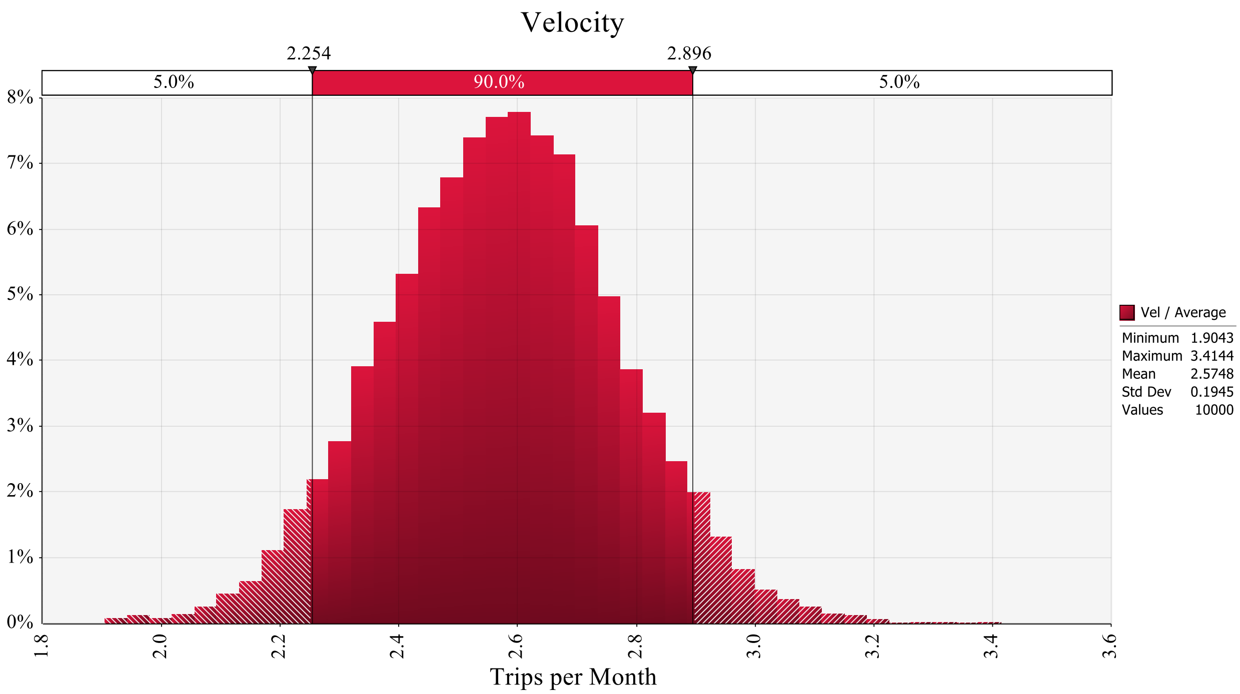

Figure 5.8. Velocity Distribution - All Months (@Risk)

Table 5.4. Sensitivity - Rail Velocity

Month/ Velocity	**2**	**2.5**	**2.58 (Base)**	**3**	**3.5**
September	$117	$198	$246	$308	$438
October	$102	$158	$164	$223	$297
November	$91	$136	$143	$197	$273
December	$81	$125	$134	$180	$245
January	$63	$100	$106	$150	$219
February	$68	$110	$108	$164	$229
March	$103	$156	$159	$219	$298
April	$135	$195	$203	$266	$345
May	$191	$263	$297	$341	$430
June	$181	$250	$261	$328	$410
July	$165	$230	$215	$301	$380
August	$123	$181	$184	$244	$311
Average	**$118**	**$175**	**$185**	**$243**	**$323**

Results show that velocity has a positive impact on option values. With the low-end velocity of 2.0, the option value is $118, and increases to $323 as performance increases. This result is expected, since higher velocity, and therefore higher shipping supply, means that there is a better chance that the elevator would have excess cars that can be sold into the secondary market. The relationship between velocity and option value is non-linear, and is slightly exponential, as shown in Figure 5.9 with the spread between simulation results increasing from $57 to $80. This is an important result as it shows the significance of projecting railcar velocity when making car-ordering decisions. Shippers who expect strong performance would not need to buy as many shuttle contracts as one who predicts weaker performance. However, they may consider keeping up order quantities since there is greater option value under this circumstance.

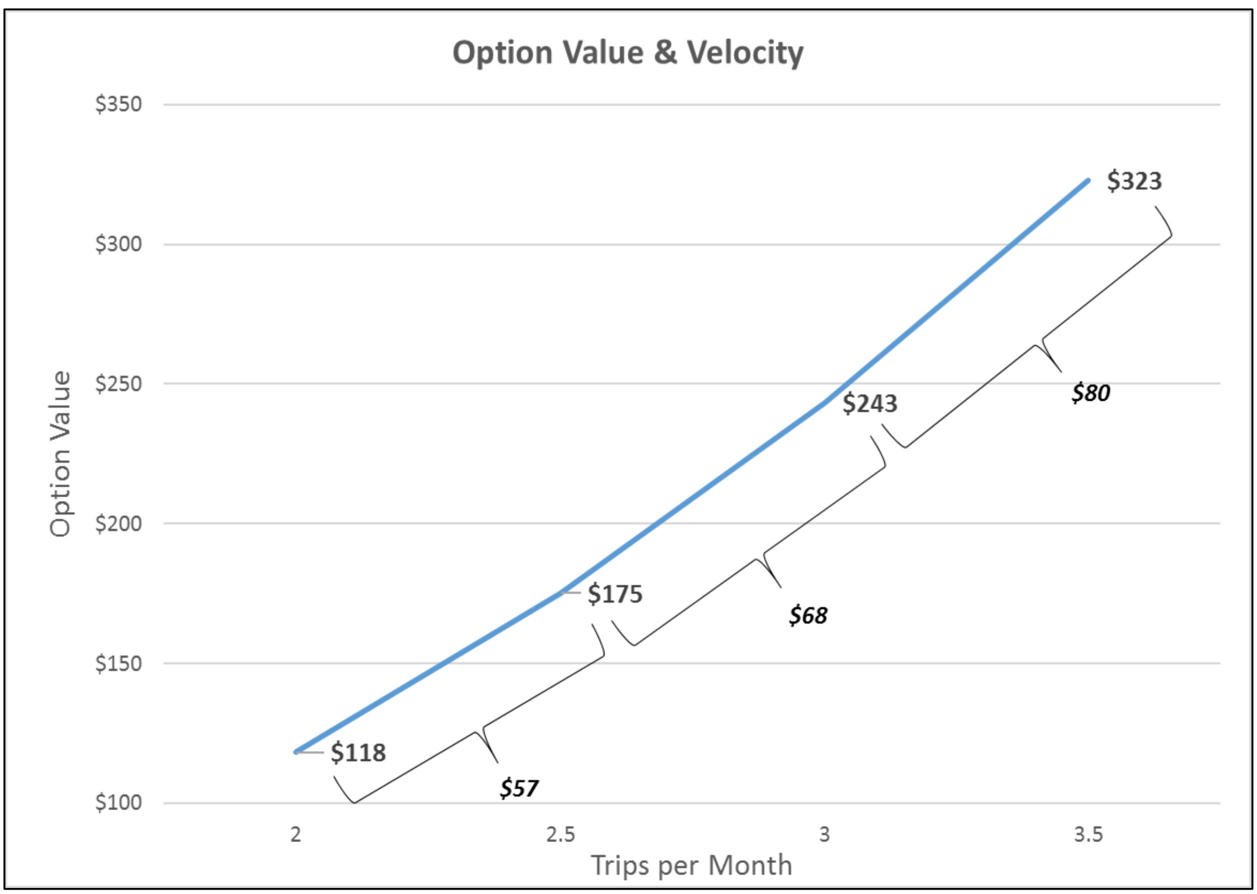

Figure 5.9. Option Values and Velocity

5.3.4. Sensitivity – Futures Price Spreads

Futures price spreads refer to the inter-month price differences in each contract month. When deferred contract months are at a premium to nearby months, it is referred to as a "normal" or positive spread market. When the opposite is true, the market is referred to as "inverted." The same principle applies to basis values, but here we focus on futures. During times with large, positive spreads, the shipper is encouraged to store their grain since they can hedge at a higher price in the deferred months. Inverted markets encourage shipment of grain, since the elevator would be losing money by storing into a contract month with lower prices. Soybeans is a market in particular that exhibits both normal and inverted price spreads at different times. Therefore, it is beneficial to examine how these spreads impact shipping demand, and overall option values. The base case spreads are presented in the table of the previous chapter. For the sensitivity analysis, the inter-month spreads begin at -$0.15, and increase to $0.15.

Results are presented in Table 5.5 and demonstrate a positive relationship between price spreads and option values. In a strongly inverted market, the transfer option is worth $152, and increases to $293 as the market becomes normal with positive spreads. This is largely explained by the impact on ship vs. storage decisions, which is reflected in shipping demand. As shown in Figure 5.10, where shipping demand in cars is on the horizontal axis, the distribution of shipping demand shifts to the left as the futures price spreads increase. In the simulation with negative 15 cent spreads, the elevator is encouraged to ship grain immediately rather than store, and the average monthly shipping demand is 670 cars per month. The simulation with positive 15 cent spreads results in average shipping demand is lower at 593 cars per month. As previously demonstrated, shipping demand and option values have a negative relationship with each other.

Table 5.5. Sensitivity - Futures Price Spreads

Month/Futures Spread	-$0.15	-$0.05	Base	$0	$0.05	$0.15
September	$238	$331	$246	$413	$528	$921
October	$124	$136	$164	$148	$164	$214
November	$53	$98	$143	$127	$163	$246
December	$129	$132	$134	$136	$144	$168
January	$55	$82	$106	$100	$122	$159
February	$109	$110	$108	$113	$116	$131
March	$78	$121	$159	$147	$176	$228
April	$206	$206	$203	$209	$213	$228
May	$172	$234	$297	$282	$340	$415
June	$282	$278	$261	$275	$276	$254
July	$162	$215	$215	$247	$276	$285
August	$213	$231	$184	$244	$256	$262
Average	**$152**	**$181**	**$185**	**$203**	**$231**	**$293**

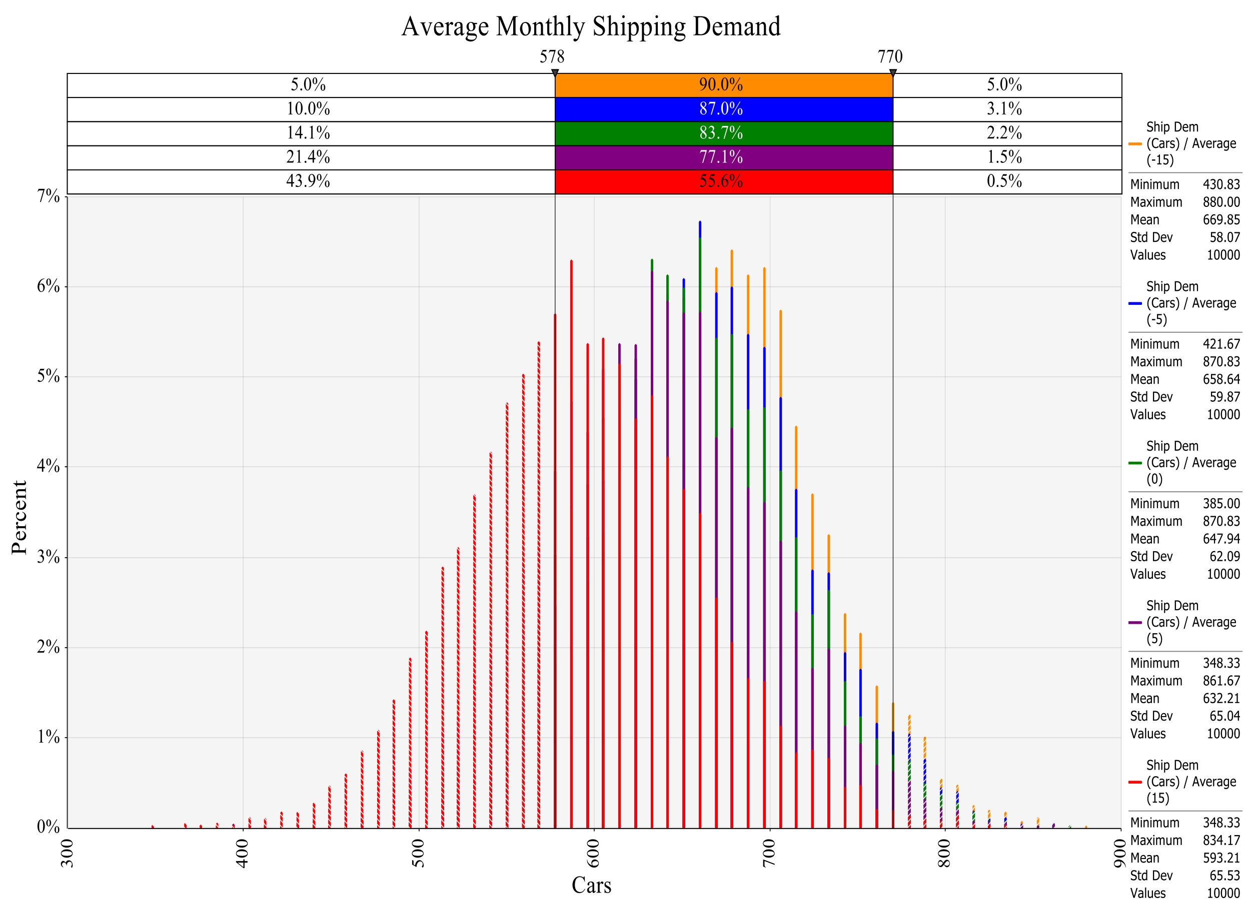

Figure 5.10. Sensitivity - Futures Price Spreads and Shipping Demand (@Risk)

5.3.5. Sensitivity – 2013/2014 Scenario

Late 2013 into 2014 presented a unique situation and many challenges for grain shippers in the upper Midwest. The main factors were a large 2013 harvest and competition for track space brought on from peak oil production in western North Dakota. An inverse in futures prices also encouraged elevators to ship grain at a more rapid pace. This unprecedented track congestion caused low railcar velocity, and extremely high secondary market prices, peaking around $5,000.

Recreating this scenario in the model provides insights into the value of transferability during shocks to the shipping system. While it is impossible to reconstruct every aspect of the 2013/2014 shipping season, four key variables are highlighted: decreased velocity, increased farmer sales, an inverse in futures prices, and large secondary market prices. This is simulated by setting velocity at 2.0 trips per month, secondary market prices at $2,500, and the futures price spreads to -$0.05 from each contract month to the next. Also, the large crop is simulated by increasing the elevator turnover ratio, γ, from six to eight, which increases the annual amount of grain handled, h_a, from 30,000,000 bushels to 40,000,000. Since the situation was unpredictable for the most part, we assume the elevator keeps the same car order strategy and purchases two shuttle contracts in the primary market. Resulting option values, shipping demand, and volatility are presented in Table 5.6.

Table 5.6. Sensitivity - 2013/2014 Scenario

	Option Value	Ship Demand (Cars)	Ship Demand Vol.
September	$407.45	559	40%
October	$57.11	853	47%
November	$44.22	870	47%
December	$45.15	871	42%
January	$42.49	878	38%
February	$39.65	876	35%
March	$45.97	875	33%
April	$59.76	863	32%
May	$84.44	846	31%
June	$142.81	817	32%
July	$162.78	807	34%
August	$251.00	750	38%
Average	**$115.24**	**822**	**39%**

Results show that the transfer option value decreases to $115. This is mainly due to the increased shipping demand from the large crop, and decreased volatility. Also, the decreased velocity means that there are fewer excess car situations, and therefore fewer railcars available for resale into the secondary market. In reality, times of such high secondary market prices may cause the shipper to forgo grain sales and instead sell railcars, which is not accounted for in this model since the primary objective for the elevator is to sell grain. A shipper who is willing to forgo grain sales in this situation would place a much higher value on the transferability. Either way, a shipper who had shuttle contracts during this period had more flexibility than one who relied on secondary market cars, or other instruments.

5.4. Strategic Sensitivity – Railcar Ordering Strategy

This section presents a sensitivity analysis on a key strategic variable, railcar ordering strategy. Strategic variables refer to those that are decided upon by the elevator manager. The base case assumes a typical strategy for each variable based on discussions with the industry sources previously mentioned. However, each elevator makes different decisions, so it is important to analyze the impact of each possibility on the transfer option.

The analysis is set up the same way as the stochastic sensitivity. One at time, multiple simulations are run for possible inputs for each decision. The seed generator is set so that each simulation produces the same stochastic input values. Results and implications for each variable are discussed.

Railcar ordering strategy refers to the amount of shuttle contracts the elevator purchases at the beginning of the marketing year. The base case assumes that the shipper orders enough shuttles to fill as close to 100% of the annual projected shipping demand as possible. Assuming the shipper expects the rail carrier to average 2.5 trips per month, they would purchase two shuttle contracts. For whatever reason, a shipper may decide to purchase enough cars to cover more or less than the projected shipping demand. For the sensitivity analysis, the strategy starts at 60% and increases to 140% of projected shipping demand. Results are presented in the table below.

Results in Table 5.7 show a positive relationship between the number of shuttle contracts and option values. This is explained by the fact that more shuttle contracts provide greater shipping supply. Higher shipping supply then increases the possibility of having excess cars to sell into the secondary market. This has large implications for a one-location grain shipper, since any change in car ordering strategy can cut their shipping supply in half, or double it. Alternatively, if a larger shipper added one or two shuttles to their fleet, the marginal percentage change in shipping supply would be smaller. These sensitivity results show the impact of an elevator's car ordering strategy on the value of transferability.

Table 5.7. Sensitivity - Railcar Ordering Strategy

Month/ Order Strategy	**60% (1 Shuttle)**	**100% (Base, 2 Shuttles)**	**140% (3 Shuttles)**
September	$119	$246	$400
October	$86	$164	$236
November	$86	$143	$225
December	$79	$134	$205
January	$51	$106	$183
February	$55	$108	$173
March	$92	$159	$232
April	$136	$203	$266
May	$227	$297	$359
June	$198	$261	$314
July	$155	$215	$260
August	$111	$184	$234
Average	**$116**	**$185**	**$257**

5.5. Summary

In order to evaluate various shipping instruments available to grain elevators, valuing individual components within each instrument helps to determine the overall value of the contract. One of the common components seen in today's shuttle contracts is the ability to transfer excess cars into a secondary market and receive the resale price. Due to the qualitative and contingent nature of this component, real option analysis is an appropriate valuation technique. An empirical model was defined, along with base case inputs and key parameters. This chapter presented the results from the base case, and the results of a sensitivity analysis on key stochastic and strategic inputs.

The base case results indicate that this transfer option is worth $185 per car, per trip, meaning that the shipper should pay this much of a premium for a contract that allows transferability versus one that does not. On a monthly basis, this transfer option is worth the most in May at $297, and the least in January at $106. Shipping demand was found to have a negative relationship with the option value. During months with high shipping demand, such as harvest, the option is worth less due to fewer prospective cars being available for resale, and vice versa.

A sensitivity analysis was conducted on key inputs to demonstrate the impact of the variable on the option value. The stochastic variables included in the sensitivity section are secondary market prices, shipping demand volatility, velocity, and inter-month futures price spreads. Secondary market prices are shown to have a strong, positive relationship with option values, which is expected. Shipping demand volatility also has a positive relationship with option values, which corroborates with option pricing theory. Also causing increases in option values are increases in rail velocity, due to the fact that it increases shipping demand, meaning that more excess cars are available for sale. Futures price spreads are shown to have a negative impact on shipping demand, which results in a positive impact on option values. This is due to the fact that larger price spreads encourage shippers to store more grain, and vice versa. Results from the 2013/2014 scenario simulation indicated the option value drops to $115 during times of large crops, and increased track congestion.

The impact of the shipper's railcar ordering strategy is also analyzed. Railcar ordering strategy is shown to have a positive impact on option values. This occurs since buying more shuttles increases shipping supply, and therefore the number of excess cars available to transfer. From these results, one may infer that it is best to order as many shuttles as possible regardless of shipping needs. However, there is risk in that if secondary market prices collapse, the elevator could be stuck with lots of extra freight that they either cannot find a buyer for, or must sell at negative values.

CHAPTER 6. CONCLUSION

6.1. Introduction

Grain shippers face many sources of risk and uncertainty in their operations, and these risks are unique to each shipper. Country elevators are essentially the middleman between farmers and end users of grain. They make money by purchasing grain from farmers, selling to the next user, and arranging shipping and handling. Margins for a country elevator are usually quite thin. Therefore, they rely on shipping large volumes to make a profit. In most cases, it is up to the elevator to plan and pay for shipping from their location to the buyer. With narrow profit margins, proper planning of logistic needs can be the difference between positive and negative returns.

In the upper Midwest, logistics planning is more crucial since modes of transportation are limited. Without direct access to a river large enough for barges, shippers must utilize either trucks or railways. Trucks are okay for short hauls, but due to economies of scale, rail is the only viable choice to get grain to the port from inland locations. With soybean acreage on the rise, and the Pacific Northwest (PNW) being the main destination for North Dakota-grown soybeans, producers and shippers will only become more reliant on rail transportation.

In order to plan for logistics, shippers have to not only plan out the quantity of shipping needs, but also value the cost of obtaining railcars. Since each rail carrier offers different contract instruments, and each elevator has different needs, placing a value on rail transportation can be quite abstruse. Due to both spatial and temporal differences in shipping needs among different elevators, rail carriers have been offering various forms of flexibility within their contracts, which add value to the instrument. One of the main flexible components offered by carriers, such as BNSF, is the ability to sell or transfer unneeded cars into a secondary market. This adds value since it gives the shipper the chance to recover some of the sunk costs of purchasing rail service. Without this transferability, the shipper would be forced to either use the cars, cancel them for a penalty, or let them sit idle and pay significant demurrage charges. Also, they may under-order the amount of cars they need, since any excess cars would present a larger cost.

The primary goal of this study is to value this transferability using real option analysis. Determining the relationships between key variables and the transfer value are examined as ancillary objectives. Previous chapters presented the risks inherent for a grain shipper, current railroad contracting mechanisms, an overview of real option pricing, and an empirical model for valuing this transferability as a European put option. Results of the empirical model were then presented for the base case and various sensitivities. This chapter reviews these concepts, including the problem statement, railroad contracting mechanisms, real options, the empirical model, and results, following by the implications for shippers and carriers. A summary then includes the contribution to literature, limitations of the study, and suggestions for further research.

6.2. Problem Statement

Elevators face various forms of risk due to the risky dynamic variables in grain trading. One major source of risk for an elevator is their inventory levels. A majority of country elevator grain purchases come in the form of “spot” deliveries. This occurs when farmers choose to haul in grain and receive the price that the elevator has posted for the day. Since the farmer has control of the decision to initiate a spot delivery, the elevator is uncertain about how much grain they would have on hand at any point in the future The elevator can entice spot deliveries by increasing their bid price, but must then sacrifice some profitability. One way to guarantee grain inventory in the future is to offer various forms of forward contracts. This is useful for planning out inventory levels, but again must offer a price that is attractive to producers. Variable inventory levels make it difficult for elevators to project what their demand for railcars, or shipping demand, would be in the future.

Another major source of risk for a grain shipper is the price they must pay for railcars. This is true for shippers who do not utilize primary market shuttle contracts, and rely on secondary market purchases. Just as grain prices fluctuate daily, so do transportation costs. Although the price the elevator pays depends on the rail carrier and pricing mechanism, there are essentially two costs of railcar shipping: the tariff rate and the price to secure cars (if buying in the secondary market). The tariff rate is what the shipper pays for each move from origin to destination. Every origin/destination combination has a unique tariff rate that is subject to change each month. The cost of securing cars depends on the contract mechanism, and supply and demand factors within the rail market. A shipper who does not forward contract shipping needs is subject to a different price every time they purchase railcar trips. The cost just to secure cars can be anywhere from -$400 to $5,000 over tariff per car. This means the shipper may have to pay over a dollar per bushel just to secure transportation. There are also times when this cost of securing cars is negative, which means that the shipper could be paid just to utilize someone else's unneeded cars. Therefore, the cost of shipping would be less than the tariff rate. The average secondary market price since 2004 is $213/car, versus only $50-$100 in the primary market. Also, a secondary market buyer faces greater price volatility.

To mitigate risk from grain price movements, there are established futures and options markets, as well as forward contracting mechanisms. However, there is no such derivative market for railcars. Therefore, the only way for an elevator to lock in a shipping rate is through some type of forward contract.

Although forward contracting rail service from a carrier provides a locked-in price, the shipper is still exposed to railroad performance risk. Performance risk affects the number of trains that the shipper receives each month. Performance is known as train velocity, and is measured in trips per month. Each time the train completes a cycle from origin, to destination, and back to an origin, is considered one trip. Although an experienced elevator manager would have some idea of the amount of cars they need to utilize, the specific amount is at the mercy of the shipping conditions. These conditions include weather, track congestion, etc. If bad weather occurs, such as an avalanche blocking off track, trains would be backed up. Track congestion from other commodities, such as oil, can also cause bottlenecks and service delays. Therefore, the amount of cars received each month, or shipping supply, is a random or stochastic variable. Combined with inventory level risk, this means that both demand for railcars, and supply of railcars is uncertain for a shipper.

6.3. Current Railroad Pricing/Contracting Mechanisms

Chapter 2 describes the railcar contracting mechanisms currently available to grain shippers. As there are a number of different rail carriers, and each carrier offers their own programs, there are many different railcar pricing and contracting mechanisms. However, since rail carriers own most of the track space, shippers are subject to utilize whoever owns the track on which they are positioned on. In order to meet changing needs of grain shippers, carriers change their car programs throughout time. This study focuses on the current shipping programs offered by BNSF, and specifically their shuttle program. A shuttle refers to a 110-car train unit, which is designed to be kept in constant use. It is intended for elevators that ship large volumes of grain throughout the year. See Table 2.1 in Chapter 2 for details on the BNSF shuttle program.

There are essentially two ways for a shipper to secure shuttles through BNSF: through the primary market, or the secondary market. The primary market is the initial allocation of railcars from the carrier to the shipper. Through an auction system, the winning shipper receives the rights to a shuttle contract lease for one year. The shuttle is meant to be kept in constant use by offering financial incentives for quick loading at the elevator. If the train is not loaded within 24 hours, the shipper must pay a demurrage penalty each hour until the train is released. The primary owner only pays the tariff rate each time they utilize the cars, but are still subject to railroad performance risk. The owner has the ability to switch origins, free of charge, as long as they notify BNSF before it reaches the prior destination. A major component of these contracts, and the focus of this study, is the ability to not only switch origins, but transfer the service to another shipper, which is the basis for the secondary market.

The secondary market refers to transactions between two different shippers. The primary owner of a shuttle contract can sell any unneeded trips to another shipper at a market-based price. This can be negotiated privately between shippers, or done through a third-party broker. During times of high demand for railcars and low railcar availability, prices in the secondary market would be a large premium to the tariff rate. If the opposite is true, the primary owner may have to pay another shipper to utilize the cars in the secondary market. In times of negative secondary market prices, the shipper must weigh their options of selling the cars at a loss, finding a way to utilize them, or pay a steep cancellation fee. Under cancellation, the owner forfeits all of the remaining trips of the contract.

This transferability is key as it allows the primary shuttle owner to receive revenue for any unneeded cars, and eliminate their obligation. There are also times when secondary market prices become high enough that it is more profitable to sell railcars in lieu of shipping grain.

6.4. Real Option Pricing Methodology

Chapter 3 describes real option analysis, including its uses and solution methods. Traditional valuation methods, such as net present value, provide basic formulations for analyzing the quantitative aspects of capital expenditures. However, there are many qualitative aspects of some investments that require deeper analysis in order to estimate the true value. Many investments provide various forms of flexibility, either implicit or explicit, that provide value to the project. For example, making an expenditure now may allow the investor the option to make a further investment in the future, depending on the success of the first project. The value of the initial investment may be dependent on the value of the future investment, and must be considered in the initial cash outlay.

Real option analysis (ROA) has developed as a way to value contingent investment decisions. The more flexibility and uncertainty inherent in a project, the more useful ROA is as valuation tool (Trigeorgis 1996). Using option pricing theory and applying it to real assets, ROA allows for valuation of future decisions that are contingent on prior events.

There are many different types of optionality apparent in capital expenditures. For example, there are options to delay, expand, or abandon an investment. Anyone who has purchased car insurance has purchased a real option, since the owner has the option to sell their car for the full amount after an accident, even if the car's price drops to the scrap value. The insurance payment is contingent on whether an accident occurs or not. Similar to financial options, the more volatile the underlying variable is, the more the option is worth. A car owner with a history of bad driving causes the car's value to become more volatile, which is why they pay a higher premium than someone with a clean driving record.

An option to sell, also called an abandonment or transfer option, allows the owner to get out of an investment in the future if they find it is not profitable, and recover some of the initial cost. This option adds value to the initial investment, since it decreases the amount of risk that the manger is taking on. One of most common ways to calculate the value of a transfer option is with a binomial option pricing model, either stochastic or static.

6.5. Empirical Model

Chapter 4 presents the empirical model for valuing the transferability of primary shuttle contracts as a real option. In financial options, if the underlying futures price drops below the strike price, the owner of a put option can exercise their right to sell at the strike price. The same principle applies to transfer options. If the value of a project drops below a certain level, the owner of the option can sell the underlying asset. This can then be modeled as a put option (Winston 2008, Alizadeh and Nomikos 2009).

Since the owner of a primary shuttle contract has the right, but not the obligation to sell, or transfer railcars into the secondary market, this flexibility provides value since the owner is not required to use their entire supply of railcars. Assuming that the objective for an elevator is to sell grain first, and excess railcars second, the underlying variable for the option is demand for railcars, or shipping demand. If shipping demand is lower than shipping supply, the owner now has excess cars to sell into the secondary market. This concept provides the basis for valuing the transferability of railcars as a real option. The owner is assumed to make the decision regarding excess railcars at the last possible moment. Therefore, this is synonymous to a European put option.

The empirical model consists of two main parts: a material requirement planning (MRP) schedule, and the stochastic binomial option pricing trees. Module 1, the MRP schedule, represents the grain inflows and outflows for a typical country elevator. The purpose is to derive projections for shipping demand, and shipping demand volatility, which are used in the pricing trees. The first part of the MRP schedule projects farmer deliveries for each month. This is based on the elevator storage capacity, an inventory turnover ratio, and data on farmer sales during each month of the marketing year. Futures prices, basis levels at the Pacific Northwest, and storage costs then determine the optimal months to sell grain in. Once this is compiled, an initial shipping demand schedule is estimated. Before the final level of monthly shipping demand is derived, adjustments are made for storage and shipping capacities. Everything is also rounded to units of 110 cars, since shippers must utilize the entire train capacity. Once shipping demand is projected, shipping demand volatility is derived.

Module 2 consists of 12 different stochastic binomial option pricing trees, one for each month. Shipping demand, volatility, time until expiration, and the risk-free rate are used to calculate "up" and "down" factors for each option tree node, as well as the risk-neutral probability. Each month also has a unique strike value, which is the amount of railcars supplied. The binomial lattices are constructed with the first branch of each month being the projected shipping demand from the MRP schedule, measured in railcars. The end nodes represent possible shipping demand levels for each month. The range of shipping demand levels depends on the volatility, and the amount of branches is determined by the option month.

Based on the level of shipping demand at each end node and the strike value, which is the amount of cars supplied, there is either an excess or shortage of cars. In cases of a car shortage, the shipper would buy in cars, and the transferability would have no value. When there is an excess amount of railcars, the shipper then has three alternatives: sell the cars, utilize them, or cancel the contract. Payoffs for all three choices are defined, and the shipper chooses the alternative with the highest value. When selling cars provides the highest payoff, the transferability has value. The value is defined as the marginal difference between selling cars, and the next best alternative. Once values are calculated at each end node, they are discounted back to the present based on the interest rate, and risk-neutral probability.

Once monthly transfer option values are derived, they are converted into per-car, per trip units. The average of all 12 monthly values is used to describe the overall transfer option value. Sensitivities are then conducted on run on key stochastic and strategic inputs to gauge their effect on the option value.

Monthly data for basis levels, farmer sales, and secondary rail prices extends from 2004 through 2016, and railcar velocity data runs from 2011 through 2016. Farmer sales and velocity exhibit strong seasonality, and basis levels have an upward trend. This data and resulting distributions are presented in the tables in Chapter 4.

6.6. Results

The model represents a North Dakota soybean shipper who sells to export terminals in the PNW using primary shuttle contracts that run from September through the following August. Monte Carlo simulations are implemented using @Risk to simulate 10,000 iterations of the MRP schedule and stochastic binomial option pricing trees. The four stochastic variables were PNW basis values, farmer sales, secondary rail market prices, and railroad velocity. Transfer option values are calculated for each month, and the average of all monthly values represents the overall transfer value. Simulation results for shipping demand, shipping demand volatility, secondary market prices, and velocity are also presented. A sensitivity analysis was then conducted on key input variables.

6.6.1. Conclusions from Base Case

The base case assumes the elevator has 5,000,000 bushels in capacity, and that they turn their inventory over about six times each year. They forward contract 25% of their grain receipts, and can ship a maximum of eight trainloads each month. Also, they order enough shuttle contracts to cover close to 100% of their projected shipping demand.

The average value of the transfer option value is $185, meaning that of the total contract price, $185 is derived from the ability to sell excess cars into the secondary market. However, this value varies substantially, as shown in Figure 6.1. The large variance is mainly attributable to large volatility in both secondary market prices, and shipping demand. The lowest possible value is $0, and the highest value out of 10,000 iterations is $947. High values occur during periods of high secondary market prices, low shipping demand levels, high shipping demand volatility, and low velocity, which decreases shipping supply. The 90% confidence interval for the overall value is $14-$461. Also, distribution of outcomes is highly skewed to the right, as shown in Figure 6.1.

The largest monthly value is in May at $297, and the least occurs January at $106. This coincides with low shipping demand in May, and high shipping demand in January. In months with low shipping demand, the elevator has more excess cars to sell, which increases the transfer option value, and vice versa. The high shipping demand in January can be explained by large inventories of grain from the recent harvest. Low shipping demand occurs in the summer into early fall, since farmer sales are mostly completed by then. Secondary rail market prices and shipping demand volatility are shown to have fairly strong positive correlations with the average option values with coefficients of 0.63, and 0.49, respectively.

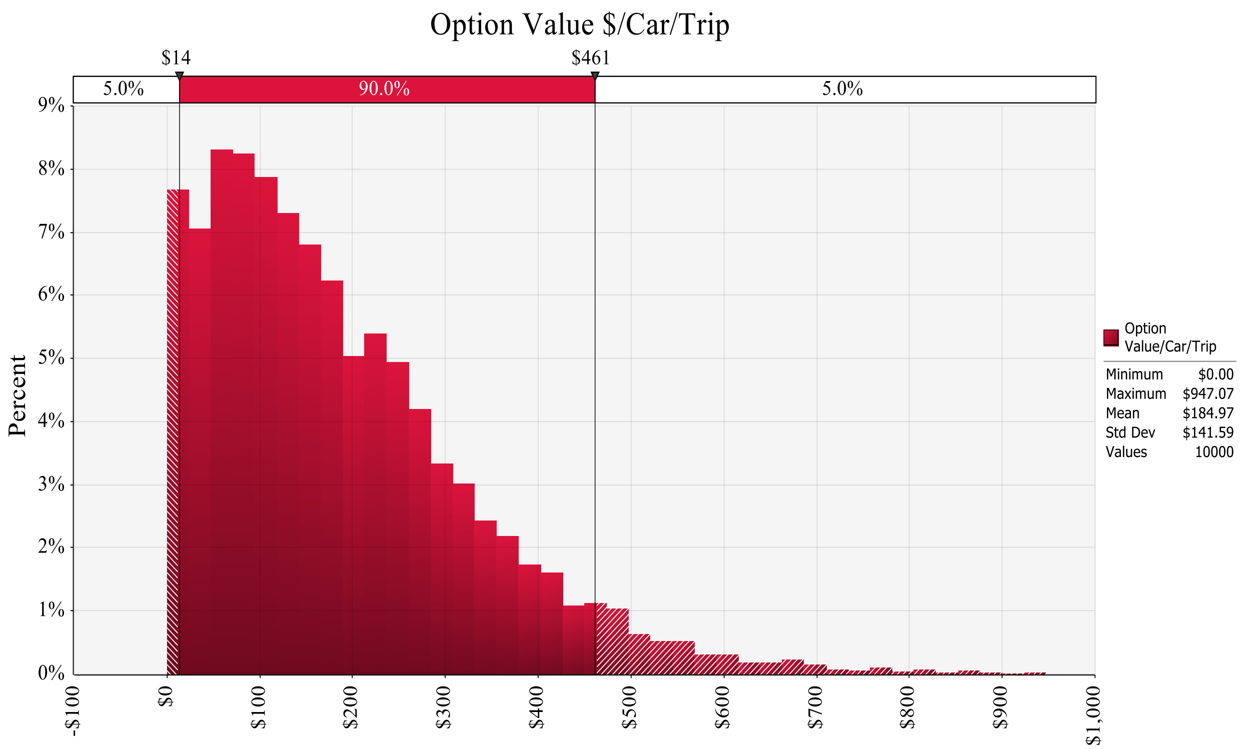

Figure 6.1. Base Case Distribution of Option Values (@Risk)

6.6.2. Conclusions from Sensitivity Analysis

In order to estimate the impact of key input variables on the transfer option value, sensitivity was conducted on secondary market prices, shipping demand volatility, rail velocity, futures price spreads, railcar ordering strategy, and forward grain contracting strategy. The scenario in the 2013/2014 crop year was also recreated to demonstrate how shocks to the rail system impact the transfer option.

Secondary market values demonstrate a positive relationship with the option value, since it directly impacts the revenue the shipper receives for selling excess cars. Shipping demand volatility also has a positive relationship with the transfer option value, which aligns with option pricing theory. Velocity and car ordering strategy both have a positive relationship with the option value, since these variables determine the supply of railcars. The car ordering strategy refers to the percent of projected shipping demand that the elevator forward contracts in the primary market. When supply is increased, there is a better chance that the shipper has excess cars to sell into the secondary market. However, this does not necessarily imply that the shipper should order as many contracts as possible, since they are at risk of the secondary market prices collapsing, and/or not being able to find a buyer in the secondary market. Futures price spreads have a positive impact on the option value, since large price spreads encourage the elevator to store rather than ship grain, which lowers shipping demand. The 2013/2014 simulation indicates that periods of large crops and high track congestion cause the option value to decrease, but this relationship depends on the shipper's strategy. These results are summarized in Table 6.1.

Table 6.1. Summary of Results

Variable	**Relationship with Transfer Option Value**
Base Case	$185 (Average)
Secondary Rail Market Prices	Positive
Shipping Demand Volatility	Positive
Railcar Velocity	Positive
Futures Price Spreads	Positive
Railcar Ordering Strategy	Positive

6.7. Implications of Results

This section highlights the implications of the results from the base case and sensitivity. Implications are important since they link the results to application. Results of the transfer option model have implications for both shippers and carriers.

6.7.1. Implications for Shippers

This option value helps shippers gain insight into the value of various components of the overall contract price. For the transfer option to have value, or to say that it is "in the money," two things need to happen: the shipper must have excess railcars, and selling these excess railcars must be the best alternative compared to utilizing them, or cancelling the contract. Whether or not the shipper has excess cars depends on the relationship between the underlying variable, and the strike value, which in this case are shipping demand, and shipping supply, respectively.

While the overall price of the shuttle contract is determined by the auction process, the transfer option is an implied value to the shipper. Another way to interpret this value is the premium, or marginal difference in a hypothetical contract that offers transferability versus one that does not, ceteris paribus. The value implies that whenever the primary shuttle contract cost is less than the transfer option value, there is extra value for the shipper since the transferability alone is worth, on average, $185. If the contract costs more than the transfer option value, any extra value to be gained by the shipper depends on competing auction bids, and the shipper's forecasts regarding future transportation needs and prices. Since shuttle contracts typically cost between $50 and $150, and the average transfer option value is $185, this flexibility does provide substantial value to the shipper. Also, this raises the possibility that shippers under-value the transferability embedded within these shuttle contracts, or do not fully acknowledge it.

This result only applies to the base case situation. The sensitivity provides insights to how this value changes with different input values. An advantage of this model is the ability to calculate the option value for any range of expectations regarding input variables.

The overall implication for shippers is that contracts with transferability do provide additional value. It allows the shipper to match levels of shipping supply with their shipping needs, and also provides an additional source of revenue. Without the option to transfer excess cars, the shipper would be inclined to forward contract fewer cars, since both cancelling the contract and forcing a grain shipment can be costly. Forward contracting fewer cars then exposes the shipper to more price risk.

6.7.2. Implications for Carriers

These results also have implications for rail carriers. Since the option value alone is worth more than what the contracts usually sell for, it shows that the carriers are doing a good job of designing the instruments so that they provide value for their customers. This implies that the carrier could capture more profitability while still providing additional value to the shipper. However, this is more difficult to value as a carrier, and with an auction-based allocation system, the carrier is not in complete control of the selling price for shuttle contracts. Mainly, it shows that the transferability they offer does provide value for their customers.

An indirect impact of the option is that offering this transferability helps support basis levels for farmers. When shippers are more efficient with transportation needs, they are able to move more inventory, and therefore offer competitive bids to farmers for their grain. However, this idea would need to be studied further.

6.8. Summary

Grain shipping involves many dynamic variables, and in response to the changing needs of elevators, railroad carriers offer various forms of flexibility within their contracts. One of the main components of these contracts allows the shipper to transfer any excess or unneeded railcars into a secondary market. The primary objective of this analysis has been to value this transfer option as a European put using real option analysis. Results indicate the option is worth \$185 per car, per trip, but depends heavily on assumptions about key stochastic and strategic variables that may best be determined by the shipper utilizing the shuttle contract. This section highlights the contribution to literature, limitations of the study, and provides suggestions for further research.

6.8.1. Contribution to Literature

This thesis extends the literature on grain transportation by rail, and real option analysis. Most studies on grain shipping aim to analyze relationships between certain variables, but little has been done in regards to contract pricing, and no research has valued the transferability inherent in current shuttle contracts. This study also provides sensitivity results which describe the impact that key inputs have on the option value.

With the exception of Lee (1999), real option analysis has not been applied railroad shipping instruments for a grain company. Whereas most real option studies use the dollar value of the project as the underlying variable, this application is unique in that it utilizes demand for railcars as the basis for the contingency decision. This is aimed to better reflect the decisions that grain shippers make in regards to railcar sales. This study builds on the work of Lee (1999) by adding a material requirement planning schedule to project shipping needs, and modified option payoff functions to reflect all of the choices available to a shipper under excess-car situations. There have been numerous changes in the shuttle contracting instruments within the last 20 years, which are reflected in the model along with more complete datasets of stochastic variables. This model also includes time series analysis, which is only available in @Risk versions after 2012. This allows stochastic forecasts to better account for seasonality and trend.

6.8.2. Limitations

This study is limiting in that it does not value the entire shuttle contract value, but rather just one component of it. Valuing the whole shuttle contract would require more complex analysis, including bidding strategy. Also, it is difficult to quantify the value of railcars that are used to ship grain, since they are then considered an input for the business rather than a source of revenue.

Since some of the base case assumptions and parameters greatly impact the option value, this model is better suited to provide a guide to valuing the transferability, rather than a definitive result. Therefore, logistics managers must consider inputs that are unique to their business when valuing shipping mechanisms.

The base case result of $185 must be considered cautiously, since it is higher than the normal range of the total shuttle contract cost of $50-$150. Part of this is high result is from the fact that secondary rail market prices rose steeply in the fall of 2016. Since the stochastic projections are based off of the last historical data point, this caused the projected prices to average $411, whereas the entire historical dataset only averages $213. Also, high volatility of shipping demand contributes to the large option value. This is from the "all or nothing" aspect of the MRP schedule. When it is economical to sell grain, the elevator ships the whole inventory, up to the shipping constraint. In reality, shippers have the ability to lower this volatility by strategically evening out the level of shipments each month.

Other limitations include the assumptions about being a soybean-only shipper, and only having one market to sell to. In actuality, nearly all country elevators handle multiple commodities and sell to multiple destinations. However, the assumption about having only one sale market is light since 72% of North Dakota-grown soybeans are sold to the PNW (North Dakota Soybean Council). The model also assumes elevator inventories only consist of spot deliveries and forward contracts. Many elevators also offer other forms of grain contracting strategies such as hedge-to-arrive, storage, and average-price contracts.

Lastly, we assume that there is enough liquidity in the secondary market to find a buyer for every excess railcar that the shipper wishes to sell. In reality, there may be times when there is no one to sell the excess cars to. This impact would lower the transfer option value.

6.8.3. Further Research

Using the framework and concepts from this study, there are many possibilities for future studies. One may be to explore other options embedded within shuttle contracts. While transferability is the main component, the ability to cancel the contract could be modeled as an abandonment option. This requires projections about the future secondary prices at each point in time. Essentially, a different forward curve of prices would need to be projected each month. The transfer option could hypothetically be modeled as an American option, but would require more complex analysis regarding shipping demand projections, and the consideration of early exercise at each node. An American option approach would imply that the shipper can forward sell cars months ahead of time. This study focuses on sellers of secondary railcars, but the same framework can also be applied to a buyer of secondary cars, in which case the transferability would be modeled as a call option. The call option would have value when the shipper is short, or in need of railcars.

The transferability component of shuttle contracts can be studied in many different realms. Quantifying the impact that transferability has on elevator basis levels would provide insights on the overall benefit that these contracts provide. One issue in grain shipping is the seasonality of grain flows, and future studies could examine if offering transferability in shuttle contracts has an effect on this seasonality. While this study shows that transferability has value for the shipper, a cost/benefit analysis for the carrier could be conducted as well. Also, this model could be used in addition to other methods in valuing the entire primary market shuttle contract for a shipper. An extension would be to model secondary rail market values.

This framework provides the possibility of further research on option valuation for shippers involving multiple locations, commodities, and sale markets. The model could be modified to reflect a shipper who is willing to forgo grain sales if it is more profitable to sell railcars instead. This would change the model structure so that the underlying contingency variable is the secondary market price, rather than shipping demand levels.

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