APPLYING OPTION THEORY TO GUARANTEED RAIL MECHANISMS

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Applying Option Theory To Guaranteed Rail Shipping Mechanisms

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ABSTRACT

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Guaranteed transportation has become a key component for grain shippers when planning logistical strategies. The three main types of transportation are non-guaranteed general service, auction-based rate and car guarantees as short-term commitments, and long-term contractual car guarantees. The proper balance of these alternatives can result in more efficient movement of grain from suppliers to end-users.

The primary objective of this research is to develop a valuation procedure for grain shippers to assist in the decision to engage in these contracts. Part of the analysis includes option theory as applied to the transferability of the contract. The other component is the incremental difference between expected payoffs with and without guaranteed contracts. A stochastic simulation model based on inventory positions, transportation decisions, and relevant market data was developed. Simulation matrixes were established to evaluate the effects of key elements of uncertainty within the shipper’s decision. Analyses revealed the transfer option value is dependent on the volatility of shipping demand and the secondary market value for railcars. The guarantee component is highly sensitive to rail performance, inter-month market spreads, and penalties imposed by destination markets. Expectations of each of the key variables need to be included in the proper assessment of transportation alternatives.

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CHAPTER 1
STATEMENT OF THE PROBLEM

Introduction

The railroad industry has recently been scrutinized by both private and public sectors of the United States. Private industry groups, such as grain shippers and other industrial manufacturers, depend on the railroad to transport commodities from origin through the supply chain to the end-users. Recent car shortages have left grain sitting on the ground well after harvest, leading to financial problems for grain handlers holding inventory. As the elevators hold grain due to transportation bottlenecks, their margins deteriorate. Once damage enters the equation, losses can mount substantially. These problems became evident in the post-harvest period of 1997. The Surface Transportation Board declared an Emergency Service Order that directed Union Pacific/Southern Pacific (UP) and Burlington Northern/Santa Fe (BNSF) meet with appropriate agricultural representatives and submit plans for establishing priorities for the shipping of grain (Train-It, 1997).

Reasons behind seasonal car shortages were identified by Norton and Klindworth (1989). First, the demand for railcars is seasonal, as it relates to the seasonal market patterns for farm commodities. Secondly, the export markets for the commodities is dynamic and volatile. They also noted that the turnaround times on cars are relatively stable and are not likely to improve. Lastly, there have been very low levels of investment in grain hoppers, likely due to the seasonal effects of the grain markets. Extra cars are only necessary during peak demand periods or post-harvest. It is difficult to justify additional investment in cars for the relatively short period of use.

The most traditional mechanism in allocating railcars is the General Tariff. This procedure is somewhat like a lottery for those shippers who request railcars for grain shipment. Allocation of the railcars is based on car availability and placement. Therefore, not all shippers who submit requests will receive the cars during car shortages. In the past, shippers felt they could improve their chances of receiving cars if they ordered more than they needed. This situation has been referred to as placing a “phantom order.” These excess orders only complicated the railroad’s ability to efficiently allocate railcars where they were most needed.

These problems led to increased service options from railroads, which are available to shippers for an increased cost. Railroads have recently adopted forward-guarantee mechanisms available at a premium to the General Tariff. In 1987, Burlington Northern developed the Certificate of Transport (COT) mechanism. A COT is an auction-based allocation system in which the highest bidders are awarded the cars. A COT is an example of a short-term contractual agreement between the railroad and grain shippers. The COT program allocates the available railcars to those that value the service the most as reflected in their bids. Its success has challenged other railroads to develop other innovative guarantee mechanisms.

Another example of a guarantee mechanism development on the part of the railroad carriers is a longer-term contract with shippers. All of the major carriers have developed programs in which they lease hopper cars from grain shippers in exchange for a certain number of guaranteed loadings per month. BNSF’s program is called a SWAP. These programs allow railroads to add capacity to their fleet without making the substantial investment in new equipment. Terms and conditions of the contract are negotiated privately between the shipper and railroad. Key components of these contracts are the premium, lease rate, car loadings each month, window of guarantee, and non-performance penalty for each party.

Railroads

The railroad industry is constantly being challenged to operate more efficiently. To do so requires a system of allocating the cars to shippers who need them the most. Premiums paid for guaranteed service are a measure of the service demand. This type of allocation allows the railroad to prioritize shipments when bottlenecks and shortages occur.

Transportation Demand

A key issue for the railroads is that "the real demand to move grain is driven by demand for grain in consuming markets" (Norton, 1998). Commodity markets are characterized with high degrees of uncertainty and volatility. Added uncertainty makes it extremely difficult for shippers to determine their forward demand which, in turn, makes it more difficult for the carriers to plan forward shipments. General Tariff cars are allocated on a relatively fixed, short-term basis. This structure does not allow enough time for the General Tariff market to compensate in periods of high demand. In other words, railroads cannot adjust their General Tariff rate to alleviate some of the pressure caused by the grain market. "Car shortages are a reflection of grain shippers chasing the same bushels of grain demand" (Norton, 2). When the market for commodities is depressed, shippers hold inventory, as grain hopper cars sit idle.

In a July 15, 1998, letter addressed to all grain shippers utilizing Burlington Northern/Santa Fe's services, Steve Bobb, vice-president of the Agricultural Commodities Business Unit, urged shippers to move grain which is already stored so that post-harvest grain will not have to be stored on the ground. Bobb stated, "it was simply impossible to move two harvests at one time" (BNSF web-site: *http://www.bnsf.com*). Bobb also noted considerable investment in additional capacity in the form of locomotives and hopper cars, most of which were sitting idle due to depressed prices. Cars not being utilized is evidence that investment in new railcars is not necessarily a valid solution to the problem. Such investment may help to alleviate bottlenecks in periods of peak demand, however. Bobb addressed some students at North Dakota State University on October 15, 1998. He pointed out that grain sitting on the ground is not a rail-service problem. Instead, it is a marketing problem where increased stocks have led to deflated prices, making it sub-optimal to sell/ship grain (Bobb, 1998).

New Mechanisms

Railroads are challenged with developing new mechanisms for guaranteed shipments. All the Class I Railroads have recently developed guaranteed contracts. They are all in some degree of competition to provide better service. The development of new mechanisms involves analyzing the value of each feature contained in the mechanism. Examples of such features are premiums or discounts applied to the General Tariff rate, window of guarantee, non-performance penalties, and transferability of the contract. As principal features are modified, there is a new value associated with the mechanism. For example, if the railroad develops a tighter window for the guarantee, the carriers should be able to justify charging the shippers a higher premium. The railroads have to be able to quantify this value to determine the new rate.

Grain Shippers

Grain shippers serve as middlemen between farm producers and end-users of grain products. They buy and store grain from the producer and determine when and where it is optimal to sell and ship grain based on market conditions. The shipper also has to decide whether to engage in a forward delivery contract if prices are expected to decline from current levels. Transportation is a key component in the shipper's margin.

Figure 1.1 illustrates the basic decision tree for a typical grain shipper on Burlington Northern/Santa Fe lines. The first mode involves the decision whether to store or ship. Storing allows for future delivery. If the shipper is currently in line for General Tariff cars, he may elect to ship grain in the short-term. If not, he will have to wait another period for the General Tariff cars or else secure forward-guaranteed transportation. It becomes apparent that shipments need to be planned carefully ahead of time.

Modal Choice

Grain shippers are forced to make a transportation decision every time a grain sale transaction is made. For most shippers in North Dakota, the railroad is the only feasible means of transportation to the main export markets, as movement by truck is quite expensive at these distances. In recent crop years, railroads moved more than 95% of North Dakota grain shipped to the Pacific Northwest (Tolliver, 1997). Shippers are highly

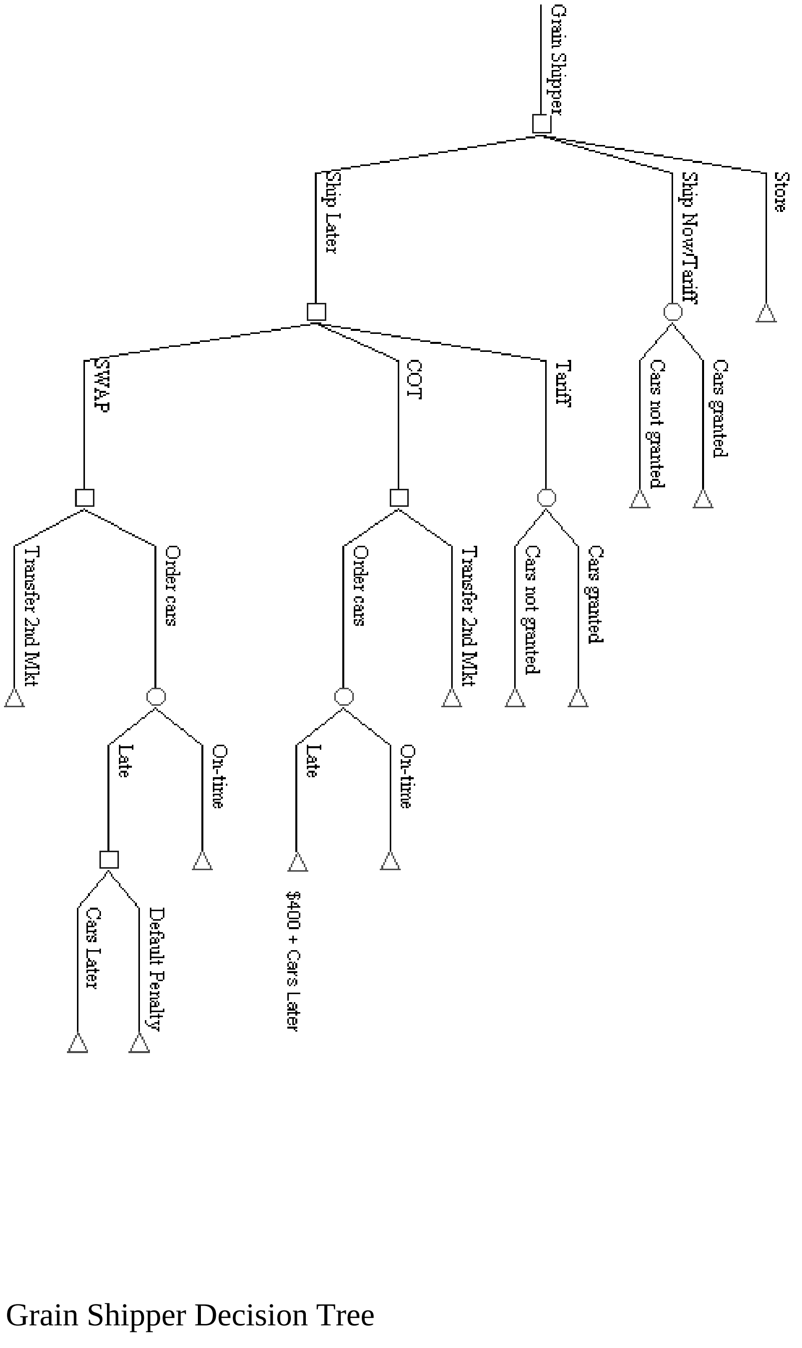


Figure 1.1. Grain Shipper Decision Tree

dependent on the railroad to move grain efficiently.

The General Tariff mechanism does not always allow the shipper to move the grain within the necessary time frame. During peak demand periods, there is a high degree of uncertainty as to whether the cars will be granted. This uncertainty makes logistical planning extremely difficult. Late grain may lead to penalties based on an adverse market movement after the window. Guarantee contracts provide shippers with the option to stabilize their margin. Shippers may be able to offset the late penalties paid with the non-performance penalty received from the railroad.

Guarantee Contracts

One way to improve the service reliability of the railroad is by engaging in either short-term or long-term contractual agreements that guarantee the railcars will be placed within a window of time. This guarantee allows the shipper to manage the shipments with more certainty. There are additional costs associated with such agreements. Each type of contractual agreement contains different features and different costs. Therefore, the grain shipper is faced with a decision involving the tradeoff of cost and service.

One way to make the decision efficiently is to determine the increased value of the guarantee based on the value of its underlying features. When this value is determined, shippers can decide whether to buy the service and at what price.

Benefits of Guarantee Mechanisms

There are benefits to both the railroad and the grain shipper from guaranteed contracts. “The railroad is able to make the system more efficient by having the market participate in the setting of rates through the bid system; providing locked-in rates for forward business by freezing the tariff rate.; guaranteeing performance in the placement of cars through a car guarantee; and permitting better logistical planning by the railroad" (www.bnsf.com).

Railroads are also able to utilize the grain hoppers throughout the year, especially in the case of the longer term agreements. The contract nature of the guarantee provides the necessary information to plan car placement activity in advance. More efficient planning from the railroad leads to more turns per car, or better utilization.

Guaranteed railcars definitely improve the grain shipper's ability to manage logistics. The degree of uncertainty of receiving railcars is reduced through the use of guaranteed mechanisms. Guaranteed mechanisms allow the shipper to forward contract the delivery of the grain with reduced margin risk associated with late penalties. By forward contracting grain for delivery based on the General Tariff procedure, the shipper is exposed to a high degree of risk of not receiving the cars on time.

Costs of Guarantee Mechanisms

There are a few added costs with the guarantee mechanisms. There are administrative costs with developing and implementing the new programs. Negotiating the contracts may take considerable time. In order to be economically efficient, both parties (RR and shippers) need to have an idea of the value and underlying features of the mechanism. Exact valuation may require extensive research. The programs need to be evaluated so that the features can be changed when necessary to compensate for changing market conditions.

Real Options Approach Background

Recent work in finance has resulted in the development of real options. Essentially, it provides a new framework in looking at investment decisions. The motive behind the approach is the inability of traditional discounted cash-flow analysis to capture all of the relevant revenues or expenditures associated with the decision.

The development of real options is based on option pricing theory as applied to real assets. Some investment decisions are contingent upon certain events. Real options can significantly increase the value of a project by eliminating unfavorable outcomes (Harvey, 1997). In looking at research and development, additional investments are made based on the findings of previous research results. If previous results are unfavorable, the additional investment is not made. Discounted cash flow analysis yields a single, expected present value, which will be considerably less than the real option approach.

Much of the work in real options has been applied to natural resource extraction. An example might be the decision to buy land with resource rights, paying for testing to determine the approximate value of the resources contained in the land, and determining whether to extract the resources based on their current market value and the extraction costs. Once the decision to drill is made, the owner has a shut-down or abandon option available as well. All of these decisions should be analyzed using the real options approach to accurately account for the elimination of the large negative outcome.

Types of Real Options include

1. Input Mix Options or Process Flexibility
2. Output Mix Options or Product Flexibility
3. Abandonment or Termination Options

4. Temporary-Stop or Shutdown Options
5. Intensity or Operating Scale (Expand/Contract) Options
6. Initiation or Deferment Options
7. Sequencing Options

The valuation of natural resource extraction is an extension of option pricing theory to real assets. The major difference between stock options and real options is that real options are applicable to real assets. Six variables determine the value of a stock option. They are stock price, exercise price, interest rate, time to expiration, volatility of stock price, and dividends over the option's life. Previous work by Black and Scholes (1973) has led to a calculation using these key variables to determine the value of the option. Proper application of the relevant information results in a real option value. The real option approach can be applied to railcars since they can be considered real assets.

Guaranteed Railcars as Real Options

This section explains the application of real options to guaranteed railcars. The six variables representing the value of a real option can be interpreted from the key features of a guaranteed forward contract for railcar shipments. Table 1.1 compares the key variables in the two option approaches and introduces the application of real options to the guaranteed shipment mechanisms.

The present value of cash flows depends on the inventory position of the shipper. The number of cars contracted for is equal to the expected inventory position at the end of the period. If the inventory position is lower than expected, excess cars are traded in the

Table 1.1. Comparison of Financial Options, Real Options, and Guaranteed Transport Service as a Real Option

Stock Option	**Real Option**	**Guaranteed Railcars**
Current value of stock	Gross present value of expected cash flows	Number of Cars Required (based on actual deliveries)
Exercise price	Investment cost	Number of Cars Contracted (based on expected deliveries)
Time to expiration	Time until opportunity disappears	Time to maturity
Stock value uncertainty	Project uncertainty	Volatility of Quantity of Spot Deliveries
Riskless interest rate	Riskless interest rate	Riskless interest rate
PV of Dividends over option life	PV of Cash flow over option life	PV of Cash flow over option life

secondary market. The transferability aspect contributes to the value of the contract as a put option. The shipper has the right to sell cars in the secondary market similar to a put option on stock.

The exercise price is the number of cars contracted for the guaranteed delivery mechanism, based on expected inventory levels for that period. The time component is the time between when the contract is formed and shipment or transfer occurs. The uncertainty component is the level of spot deliveries for that period. The riskless interest rate is the rate of return on a riskless investment, such as government securities.

Objectives

The objective of this research was to evaluate guaranteed forward railcar shipment mechanisms using option theory. Specific objectives were to

1. Evaluate alternative valuation techniques for shipment mechanisms;
2. Develop a model to depict the value of guarantee mechanism to the shipper;
3. Analyze interactions between key components of the mechanism and how they affect the value of the guarantee; and
4. Compare different mechanisms, options, and features across carriers.

Procedures

In this thesis, a stochastic simulation model was developed and used to evaluate key features of guarantee mechanisms in the shipment of grain. Literature from railroad guarantee mechanisms and the real options framework were used to develop a model of a typical grain shipper and an expected contract value function. The model was designed in a Microsoft Excel format compatible with @Risk stochastic simulation software (Palisade, 1997). The simulation model contained distributions to represent railroad performance as well as secondary market values. A simulation table was used to capture seasonality effects by generating contract values for each month.

The two key components of the model are transfer option value and guarantee value. The option value is calculated using a lattice framework centered around producer spot deliveries. In the final period, the shipper examines the inventory position and relevant transportation position. Any excess cars are transferred to the secondary market. This payoff is then discounted at the risk free rate to calculate the present value.

The guarantee value is calculated as the difference between the payoff of a guaranteed and non-guaranteed shipment. Railroad performance distributions determine whether each type of movement is on time. If both are within the 15 day time frame, the guarantee value is zero. As service reliability for the non-guaranteed mechanism declines, the guarantee value increases.

Organization

Chapter 2 describes the key components of the guarantee mechanisms. Chapter 3 outlines the real options approach and other modeling alternatives. The model and procedures are contained in Chapter 4. Chapter 5 presents the simulation scenarios and results. The summary and conclusions are in Chapter 6.

CHAPTER 2
DESCRIPTION OF SHIPPING MECHANISMS

Introduction

Railroads have been challenged with developing contracts which guarantee the delivery of grain shipments within a certain time window. These contracts have helped alleviate some of the problems associated with post-harvest bottlenecks and car shortages, as they enable the railroads to plan schedules with more certainty than when operating only with General Tariff rates. The challenge for development of these contracts is in valuing individual contract features, as they determine the overall value of the contract. Grain shippers need to know the overall value of the guarantee to determine the optimal transportation strategy for their cash grain position.

This chapter examines rail transportation mechanisms offered by each major carrier and then describes a typical grain shipper. Each type of mechanism has different features, with different implied values to railroads and shippers. The mechanisms range from the general service/no-guarantee to short- and long-term guarantee contracts. The BNSF mechanisms are mentioned first and compared to the other carriers' mechanisms in a later section.

Railroad Mechanisms

General Tariff

The traditional mechanism for rail transportation offered by BNSF is the General Tariff. Generally, moving grain via General Tariff requires shippers to submit car orders one month in advance. Upon receipt, the order is assigned a random number. Car supplies are allocated to each district based on a three-year average of BNSF grain movements in the district. Each shipper in the district is allocated one unit train per month. In times of shortage, the cars are allocated randomly. Once cars have been granted, the shipper can either accept or reject based on current needs.

If the shipper cannot use the cars upon acceptance, they are subject to a cancellation penalty of $200 per car if termination occurs before BNSF is 15 days late filling the order. The alternative to cancellation would be to transfer the cars within the district at a cost of $30 per car. The key distinction between General Tariff cars and contract cars is that there is no guarantee or non-performance penalty on the part of the railroad if the cars are late with General Tariff cars.

Short-Term Guarantee Contracts

The short-term contracts for guaranteed shipments are auction based. These contracts are typically for advanced cars to be used in three-to-five months. The prices are set through a public bidding process with a pre-established minimum acceptable bid. The railroad specifies the number of cars available for the future shipping period three-to-six months in advance within given corridors as demand and market conditions warrant (Priewe, 1996).

The first such contracts were initiated by Burlington Northern and were called Certificates of Transport (COTs). These were developed and used in the late 1980s. Some minor technical provisions of the contract have changed in recent years, but the basic concept has provided the foundation for other carriers to develop similar auction-based guarantee programs. Canadian Pacific/Soo followed with the PERX program, while the Union Pacific developed its Car Supply Vouchers program. The programs are very similar in nature, and the minor differences are evaluated later.

Long-Term Guarantee Contracts

Some grain shippers have found it beneficial to invest in their own fleet of railcars, either through purchase or lease agreements. The long-term contracts require these grain shippers to sublease their cars to the rail carrier. The carrier, in turn, pays an agreed-upon lease rate and guarantees a number of car loadings per month. The loadings are typically stated as the number of loadings per car, usually between 1 and 1.5. The number indicates the number of loadings per month for each car admitted into the program. A rate of 1.2 indicates 120 carloads per month for a shipper who has 100 cars in the program. The duration of the contract is usually between one and three years.

Burlington Northern was the first to initiate these types of contracts, called SWAPS, in the early 1990s. Exact terms of the contracts are not known with complete certainty as they are private in nature. The key features of the contract are the lease payment, guaranteed loadings, performance guarantees, and transferability. CPRS developed a similar program known as GEEPs. The differences in primary features are noted later.

Shuttle Train Contracts

Burlington Northern/Santa Fe developed another type of guaranteed contract called Shuttle Trains in 1998. This type of contract allows shippers to bid for 10 or 20 consecutive loadings of 104-108 car unit trains. Shippers must comply with specific requirements outlined by the railroad. One of the main stipulations is that the cars must be loaded within 15 hours of placement. This loading requirement limits the facilities that can participate to those that are state-of-the-art. There are only 12 facilities in North Dakota that are able to load 440,000 bushels in 15 hours (Vachal et al., 1999).

The contract is for a future time-period, usually one or two months away. The shipper decides when to start the contract with some discretion, but once the trip begins, it does not stop until all trips have been completed. The shipper must notify BNSF with the new destination as follows: “The origin for each subsequent trip must be agreed upon prior to the empties being spotted at the previous origin elevator. Car orders must be placed in a timely fashion. Orders must be in place for current and subsequent trips at a minimum” (*http://www.bnsf.com*).

In essence, the shipper must have the origin-destination pairs well-planned before engaging in this contract. If the cars are not loaded in the 15-hour period, a late charge of $1000/hour is imposed by the railroad (*http://www.bnsf.com*). Should the shipper decide he cannot use all the trains in the contract, he will be charged a cancellation penalty of $200 per car in the 104-car train for each trip remaining (*http://www.bnsf.com*). These fines are set up to induce shippers to incorporate careful logistical planning before committing to this type of contract.

Secondary Markets

A key feature of each of the guaranteed delivery mechanisms is transferability. Secondary markets exist as an outlet for cars which cannot be used by the shipper who has accepted or contracted for them. Typically, the transfer charge is much less than the cancellation or non-performance penalty. The secondary market is more efficient for the carrier as it enables the car to be placed and loaded instead of remaining empty.

A secondary market also exists for the long-term guarantee contracts. The market is made up of two distinct markets: external and internal. The external market exists for those grain shippers who have forecasted a car surplus position in a future time period and wish to relinquish the unneeded cars to someone who can use them. This market is facilitated by transportation brokers, such as Trade West Brokerage Company (Priewe, 1996). The brokers anonymously match buyers and sellers to exchange the instrument. Other brokers doing so are Molson and Joiner.

Phil Coffin, a broker from J.B. Joiner, spoke to the North Dakota Grain Elevator Managers at a workshop on February 17, 1999. He gave a description of how the secondary market is facilitated. It was noted that the primary holder is either out the $300 cancellation charge, or this loss can be reduced through the secondary market. A natural price floor has been set at $-300. A bid of this nature would not likely be accepted as the primary holder would end up losing $300 either way. Therefore, any bid over $-300 would help minimize the loss from the transaction. Coffin pointed out that the secondary market provides a means to correct a mistake in planning.

The internal market exists for large grain companies engaged in the contract that wish to supply their company elevators or customers with the guaranteed cars. Essentially, the commission companies secure freight positions in each market and distribute the cars to the company elevators (Coffin, 1999). The internal market has been seen by the grain companies as a means to strategically service and maintain customers. The cars can be purchased in a short-term spot situation or a long-term arrangement.

Comparison of Railroad Guarantee Features

This section examines the differences in features of the various mechanisms offered by each railroad. It is important to note these differences as the features contribute value to the option. Any feature differences should indicate a different overall value to the shipper and railroad. The railroads are constantly changing these features and should be able to generate values for the changes.

Short-Term Guarantees

The features of the contracts vary slightly across the different railroad carriers. The first difference is the forward order period. BNSF and UP allow the orders up to 6 months in advance. The order period in the CPRS/Soo program is slightly shorter at 4 months. Another difference is the structure for the guarantee. CPRS/Soo and UP are similar with the guarantee being $50/car/day up to a maximum of $250/car and $400/car, respectively. The BNSF COT program is somewhat different. It gives the shipper the full amount of the guarantee ($400/car) on the 16th day if the cars are late. Table 2.1 illustrates the differences among the mechanisms offered by each railroad.

Table 2.1. Comparison of Short-term Guarantee Contracts

Feature	**BNSF-COTs**	**CPRS/Soo-PERX**	**UP-Car Supply Vouchers**
Forward Order Period	Up to 6 Months	Up to 4 Months	Up to 6 Months
RR Guarantee	Full amount on 16th day of $400/car	$50/car up to $250 max/car	$50/car up to $400 max/car
Shipper Prepayment/ Cancellation Penalty	$300/car plus COT premium with no interest paid to customer	$250/car Advanced Freight Deposit	$300/car plus total premium bid amount
Rate		At time of bid	Not guaranteed beyond 90 days prior to shipment

Long-Term Guarantees

Most of the features of the long-term mechanisms are similar in nature. Nearly all of them are negotiated between shippers and the rail carrier, and are not publicly revealed. The main difference lies within the railroad default feature. CPRS/Soo (GEEPS) and UP (Guaranteed Freight Pool) pay $200 for each car short of the guaranteed number of loadings.

The BNSF default program is slightly different. If BNSF knows the cars will be late, it advises the shipper who then has several options: 1) Accept $250 and cancel order; 2) If BNSF is less than 5 days late, lessor can retain order and accept cars late; 3) BNSF advises of being late; shipper can waive penalty and retain order for future use with placement at BNSF's option; 4) Shipper may be allowed to defer 20 percent of guaranteed cars without penalty, but retains order sequence for next shipping period.

The other item that is slightly different for the three carriers is the non-performance/ cancellation penalty for the shipper that does not meet the contracted number of loads. The CPRS/Soo has a flat fee of $200/car. The UP discounts the lease payment to the shipper by a prorated amount based on the number of program cars not loaded. Under the BNSF SWAPS program, the shipper incurs a penalty for failure to order sufficient cars. The shipper also incurs a penalty of up to $250 plus premium for SWAP cars traded on the secondary market. The secondary market provides a way for the shipper to reduce losses from not being able to load all of the cars allocated under these programs. Table 2.2 presents the comparison across each carrier.

Table 2.2. Comparison of Long-term Guarantee Contracts

Feature	**BNSF-SWAP**	**CPRS/Soo-GEEP**	**UP-Guaranteed Freight Pool**
Nature	Negotiated Contract	Negotiated Contract	Negotiated Contract
RR Default	Shipper has a few options if late	$200/car short of guarantee	$200/car short of guarantee
Shipper Penalty	Penalty for not ordering enough cars and $250 penalty for those cars traded in secondary market	$200/car short	Discounted lease based on cars

Typical Shipper

The typical grain shipper is a country elevator. The elevator manager buys grain from producers and is then faced with a marketing and transportation decision. The key variables in the marketing decision are current basis levels, and spreads between nearby and deferred futures prices. The shipper also has to determine the optimal mode of transportation based on cost and timing considerations.

Forward Position

Once grain is obtained from the producer, it is generally hedged with futures contracts. Futures is a legally binding contract that calls for the delivery of a specific quality and quantity of grain at a specific place in the future. Once the futures contract is in place, the shipper has essentially “locked-in” the price. The elevator’s profits will depend on the change in basis over time, or the relationship between the net local price and the central market price (spot price-futures price). If the position is not hedged, the commodity price fluctuates with the market (Priewe, 1996).

Transportation Options

After the decision to sell has been made, the shipper must determine the mode of transportation to use. The typical shipper is assumed to primarily be using rail for its transportation. At this point, another decision has to be made: the shipper must determine whether to purchase rail transportation via a general service or some type of guaranteed contract as described before. Usually, the general service is cheaper, but the chance of receiving cars is less than with the guarantee. This reliability difference is why the value of the guarantee is so critical.

Decision Criteria

Probably the most obvious variable in the shipper's decision criteria is cost or profit. It is the most evident and easily compared across the mechanisms. Another key component is the shipper's forward position. Forward delivery commitments are typically shipped via guaranteed freight to stabilize the shipper's margin. If the shipper relies on the general service to deliver the grain on time and the cars are not placed, late penalties can be incurred. Late penalties are simply extra costs which decrease the shipper's margin.

Reliability of rail service is another component in the decision process. During peak demand periods, the reliability of service can be low. Timely placement of cars becomes difficult as bottlenecks occur. It is especially necessary for shippers to engage in guaranteed transportation contracts during these periods, as they are typically given priority over general service cars.

Portfolio of Transportation Options

It is unlikely that shippers would use only one form of delivery mechanism offered by the railroad. It is more likely that shippers would use some combination of General Tariff, short-term guarantee, and long-term guarantee agreements. Priewe analyzed the tradeoffs among the different mechanisms. Essentially, the longer-term contracts limit risk, but also reduce the expected payoff. The proper balance of shipments depends on the risk preferences of the decision maker (Priewe, 1996).

Forward Delivery Hedged With Guaranteed Mechanisms

Those shippers who contract for future delivery of grain should utilize some degree of guarantee mechanisms. It may not be optimal to pay the premiums for all shipments to be guaranteed, but using these mechanisms allows the manager to stabilize the margin on the transaction. Without the guarantee feature, the shipper may be subject to adverse late penalties. Guarantees help alleviate some of this downside risk.

Tradeoffs

As with any logistical decision, there are tradeoffs involved. The most common tradeoff is cost and service. Guarantee mechanisms provide increased service on the part of rail carriers. However, the increased service levels may require the shippers to pay a premium relative to the current general service rate and assume obligation to ship in a future period. The shipper must determine the benefit from the increased service reliability and compare it to the additional cost.

The longer-term contracts allow for stable shipments of grain throughout the year. Steady shipments may involve shipping grain when the market prices indicate it is sub-optimal to do so. Again, there is increased service in the form of reliability, but it may cost more in the form of lower grain prices received. In contrast, spreading the transportation requirements over the year allows the shipper to take advantage of discounted rates during slow shipping periods. The shipper has to evaluate the tradeoff of storage cost and transportation rates. These and other tradeoffs are examined through the use of option theory in Chapter 4.

Key Features

In order to determine the value of the guarantee mechanisms, the key features should be identified. Probably the most obvious is the premium. The premium is the difference between the current General Tariff rate and the guarantee contract. Time is another key component. Time variables include duration of the contract, either short-term or long-term, and the window of the guarantee are both time-related. They may be slightly different across each carrier. The non-performance penalty from the railroad is another key feature. This penalty indicates the obligation on the part of the railroad if the shipment is late. Transferability is a feature of each mechanism that allows it to be sold in a secondary market.

Summary

Railroads have recently developed innovative guarantee components as shipping alternatives. The adoption of these new programs has led to increased service reliability from the rail carriers through increased planning efficiencies. Shippers can utilize these different mechanisms in aligning their logistical needs.

Determining the proper balance of transportation requires a valuation procedure. Real option theory can be applied to this type of analysis. Certain features of the contracts exhibit option-like characteristics. This thesis focuses on the transferability aspect of the contracts. The other key component is the service reliability of the rail carrier. The shipper receives a non-performance penalty when cars are late. This value is incorporated into the guarantee valuation procedure.

The focus of this chapter was on the menu of programs available to shippers from the major rail carriers.

CHAPTER 3
REAL OPTIONS STUDIES

Introduction

Many business decisions depend on a manager’s expectation of future occurrences. For elevators, critical variables include price, weather, and service reliability. Many of these decisions are contingent, meaning that the final outcome depends on unfolding events. Managers need to be able to attach values and probabilities to different events in order to make such decisions.

During the 1990s, techniques have been developed in place of traditional discounted cash flow methods for financially evaluating such decisions. The real options approach is one of them. The methodology of real options focuses on the total risk of an investment. This chapter explains the real options approach to valuing business decisions and reviews the literature of related topics.

Financial Options

This section describes the general framework of option-pricing theory. The underlying math is omitted for simplicity, but can be found in nearly all texts written on option theory after 1973. Most of the work in options theory has been applied to financial markets. An option is a security that gives its owner the right to trade in a fixed number of shares of a specified common stock at a fixed price at any time on or before a given date. Trading the shares in is referred to as exercising the option. The fixed price is termed the strike price while the given date is called the expiration date. A call option gives the owner the right to buy shares while a put option gives the owner the right to sell shares.

Brenner outlines some founding work in option theory, which is summarized here. Black and Scholes developed an equation in 1973 which helped determine the value of a financial option. This equation was the first completely satisfactory equilibrium option-pricing model. Merton extended the model in several ways that same year. Sharpe suggested a way to simplify many of these developments in 1975. Essentially, with five known variables, the value of a non-dividend paying option can be found in a table or through math manipulation. These variables are the stock price, exercise price, interest rate, time to expiration, and volatility of stock price. The only difference in options with dividends is the payment schedule. This work was the foundation of many subsequent academic studies in option-pricing theory (Brenner, 1983).

Evolution of Real Options

As knowledge of option-pricing theory expanded, researchers began investigating ways to apply the underlying theory elsewhere. “The real-options revolution arose in part as a response to the dissatisfaction of corporate practitioners, strategists, and some academics with traditional techniques of capital budgeting” (Trigeorgis 1996, 14). Trigeorgis (1996) also recognizes, “standard discounted cash flow criteria often undervalued investment opportunities, leading to myopic decisions, underinvestment, and eventual loss of competitive position, because they did not properly value important strategic considerations (15).

Decision scientists argued the problem was in the underlying valuation methods and suggested the use of simulation and decision tree analysis. Option valuation can be seen operationally as a special, economically corrected version of decision-tree analysis that is better suited in valuing a variety of corporate operating and strategic options (Trigeorgis, 1996).

Decision tree analysis allows for a certain degree of flexibility. A manager can sometimes delay his decision until new information develops, sometimes referred to as a "wait and see" approach. Flexibility allows the manager to improve a project's upside potential while limiting the impact of the project's downside losses (Flatto, 1996). This evaluation procedure results in a project with a higher expected value and causes the distribution to be skewed to the right. Figure 3.1 illustrates the importance of valuing flexibility, as noted by Flatto. The first figure does not account for flexibility and results in a standard "bell-curve." The second figure accounts for flexibility and shows the change in expected value and its distribution. The down-side risk is limited, while the upside potential is unlimited. This adjustment causes the expected value to change.

There are problems associated with flexibility. It is generally measured qualitatively, while strategic decisions are primarily based on quantitative analysis. It is for that reason that the concept of real options was developed. The purpose of real options is to measure the flexibility quantitatively, thereby generating a dollar value associated with the flexibility (Flatto, 1996).

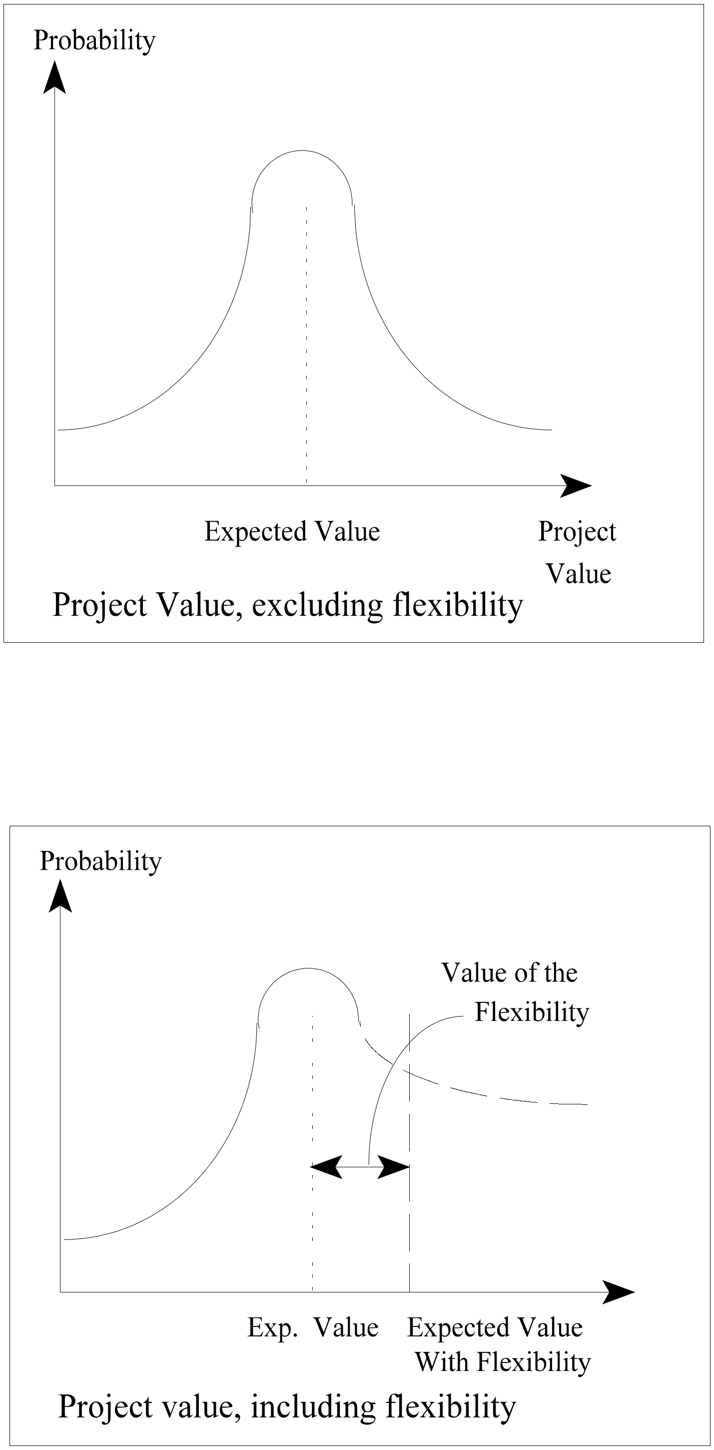


Figure 3.1. Valuing Flexibility

This section summarizes the literature reviewed by Lenos Trigeorgis (1996), in the book titled *Real Options*. Work by Black, Scholes, and Merton lays the groundwork for option pricing. Cox, Ross, and Rubinstein developed a binomial approach which led to a more simplified valuation of options in discrete time (Trigeorgis, 1996). Geske examined a compound option (an option to acquire another option), which may be applied to valuing growth opportunities that are available only after earlier investments are undertaken. Carr (1988) combined the previous work to value sequential (compound) exchange options, involving an option to acquire a subsequent option to exchange the underlying asset for another risky alternative. This work has the potential to value investments with a series of investment outlays that can be switched to alternative states of operation and to help value strategic inter-project dependencies (Trigeorgis, 1996).

Types of Real Options

Real options fall into several categories. They can either be individual or multiple interacting options. Harvey outlines differences between the various types. The first type is input mix or process flexibility. It involves the option to switch among various inputs used in the production of output. These options are particularly important in agricultural settings, such as a cattle producer switching among competing feed sources based on relative market prices. Another type of real option is an output mix or product flexibility. It involves using the same facility and inputs to produce various outputs. Product flexibility options are prevalent in industries where goods are typically bought in small quantities or where demand is volatile (Harvey, 1997).

Another category is the abandonment or termination option. Traditional capital budgeting assumes that a project operates in each year of its lifetime. However, the firm may have the option to cease a project during its life. This option gives the right to sell the cash flows over the remainder of the project's life for some salvage value, similar to an American put (Harvey, 1997). If the present value of expected cash flows falls below this liquidation value, the asset may be sold. These options are important for large, capital-intensive projects such as nuclear plants, airlines, and railroads. Another example would be introduction of a new product in an uncertain market.

Table 3.1 illustrates an abandonment option for a chemical company introducing a new product. The example was adapted from Campbell Harvey's class notes. It also compares the traditional discounted expected cash flow to the idea of valuing flexibility. The underlying assumptions are listed first. The first stage involves a development phase for one year. The second year is when the chemical is actually marketed. The discounted cash flow does not take into account the option to abandon the project if it is unsuccessful in the first year. Abandonment is usually allowed, unless the project was contracted for the entire year. When flexibility is taken into account, the project is worth much more. Without the flexibility calculation, the project would likely be foregone due to a negative Net Present Value (NPV). Figure 3.2 outlines the time frame of the cash outlays with the associated probabilities used in the example.

Temporary-stop or shutdown options apply to production facilities that have the capability to stop production. Stopping an operation is done when revenues do not cover variable costs. These options are usually linked to volatile output prices, such as the price

Table 3.1. Chemical Example

Cost of development phase (Yr 1)	$75,000	
Production & Development (end of Yr 1)	75,000	
Cash flow with continued success	250,000	
Cash flow if direction changes from success	125,000	
Cash flow with continued failure	-100,000	
Cash flow if direction changes after failure	100,000	
Probability of success		0.75
Probability of failure		0.25
Probability of continued success/failure in Year 2		0.8
Required rate of return		9.50%
Expected NPV using traditional discounted cash flow analysis	-11,355	
Expected NPV valuing flexibility	18,279	

Formulas used:
(Cash flows are stated in 000's)

Expected NPV-DCF analysis

$$E[NPV] = -75 + (-75)/1.095 + \{.75(0.8*250 + .2*125) + .25(.2*100 - .8*100)\}/(1.095^2)$$
$$= \$-11{,}355$$

Flexibility

$$E[NPV] = -75 + (.75*-75)/1.095 + \{.75(.8*250+.2*125) + .25(0)\}/(1.095^2)$$
$$= \$18{,}279$$

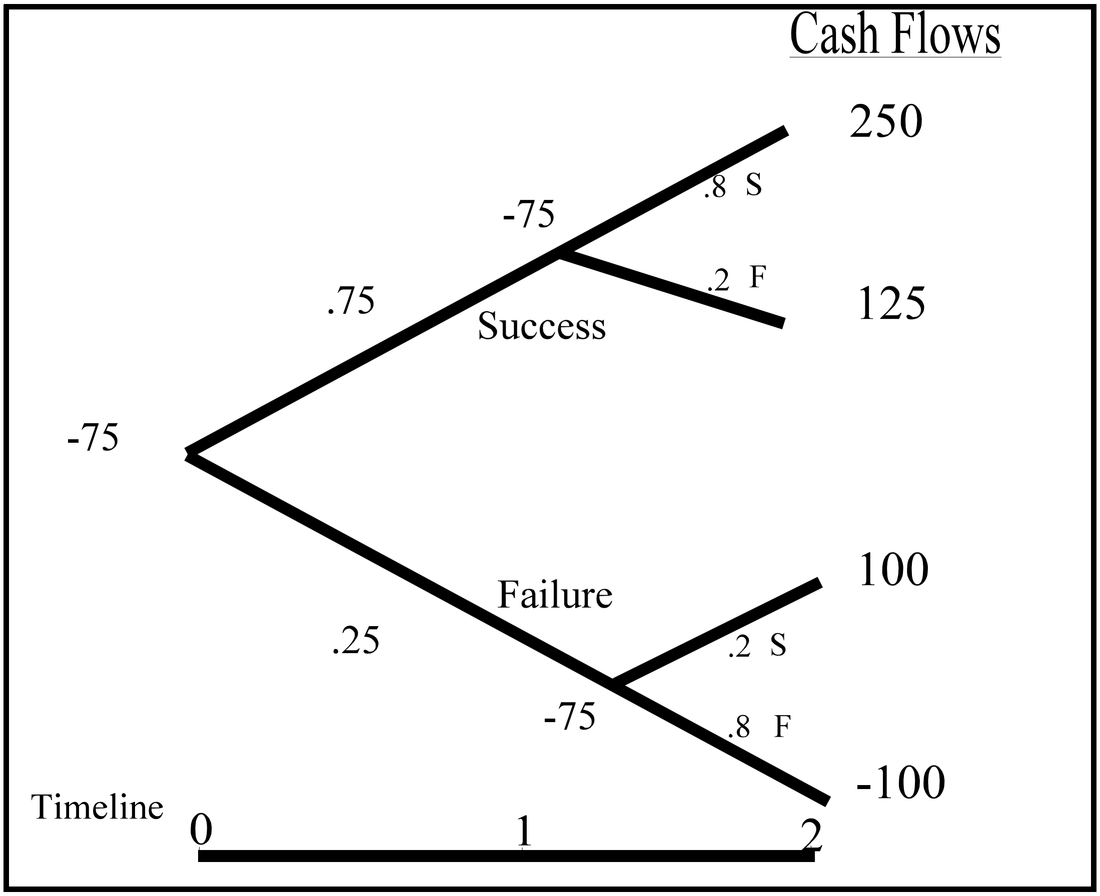


Figure 3.2. Abandonment Option-Chemical Example (numbers in 000's).

of oil for an oil well. The same holds true for a farmer who determines the cost of fertilizing, watering, and harvesting exceeds the sale price of the product. “Explicit recognition of this type of flexibility is critical when choosing among alternative production technologies with different ratios of variable-to-fixed costs” (Harvey, 1997, 7).

Related to this type of flexibility are intensity or operating scale options. These options apply to production facilities that can expand or contract the scale of the project. Examples are changing the output rate per unit of time or changing the total length of production run time. The option to expand is similar to a call option as the owner has the right, but not the obligation to expand, based on project conditions. In the same manner, the option to contract the operation can be viewed as a put option because it reduces losses as output price continues to decline. Facilities that have both the option to contract and expand are a switching option. Restarting operations when the project is currently shut down is a call option. Shutting the project down is the put option. This option is similar to a company holding a portfolio of both put and call options.

A manager who has the choice of when to start or halt an operation holds an initiation or deferment option. The purchaser of an off-shore lease can choose when, if at all, to develop property. These options are valuable in natural resource extraction where the firm can delay mining until market conditions are favorable. Another type of option is a sequencing option. This option is an important variable in corporate strategy. If a company is planning to produce and market a number of new products, the resources needed for research and development for all of them at the same time would be quite costly. Instead, the firm would be better off concentrating efforts on an individual item and taking a “wait and see” approach with the others. By spending all the resources at once, the firm gives up the option not to spend certain resources.

Sequencing options are a type of interproject option. The key distinction of an interproject option is that it is created from the development of another project. Research and development is the primary example. The real value in research and development is in the options created to undertake projects based on the findings.

The value of the firm can exceed the market value of the current projects because the firm may have the opportunity to undertake additional positive-returning projects in the future. Managers retain the option to exercise only those projects that appear to be profitable at the time of initiation. This situation is commonly referred to as a growth option (Harvey, 1997). Again, failure to recognize flexibility will undervalue the projects.

It is noted that these real options are not necessarily independent of each other. In fact, many real applications contain multiple embedded options that are tied together. It is important to link these relationships together when conducting the financial analysis.

Applications of Real Option Valuation

There is a vast array of literature written on applications of the real options methodology to corporate decisions. This section examines a few of them with the intent to illustrate how theory and practice have come together. The underlying calculations are omitted.

Flatto describes a simplistic example of a real option as the decision to build a wood burning stove or one that can burn either wood or coal. The stove that burns both fuels costs more, but it adds flexibility to the project. The owner can determine which fuel to use, wood or coal, depending on the going market price. The real option calculation gives the owner the ability to determine the value generated by the flexibility. The flexibility value is compared to the additional cost of the flexible stove, and the purchase decision is made.

One of the more popular applications of option theory is that of the petroleum industry. Kemna examines three cases of real option applications in the petroleum industry, specifically operations within the Shell company. The three types of options analyzed are timing, growth, and abandon. There is also a comprehensive Internet site devoted to real options in general, and specifically in the petroleum industry. This site provides an excellent starting point in conducting research of the real options methodology. The web address is *http://www.puc-rio.br/marco.ind/main.html* (Dias, 1995).

Flood uses option theory to evaluate deposit insurance. Option theory can be used in this context because of the limited liability property common to both options and common stock. There is an implied "expiration day" payoff for deposit insurance that can be modeled as an ordinary put option. The payoff values are associated with different claims which can then be compared. Altering key components or parameters of the claim from either side can have dramatic effects on the value of the claim. Option pricing theory provides a consistent method of determining the sensitivity of each parameter on the claim (Flood, 1990).

Wilson, Dahl, and Gustafson (1995) apply option theory to export credit guarantees. The theory was used to evaluate the provisions of U.S. export credit guarantees. A model is developed to analyze and compare the U.S. programs to those of competing countries. Such government guarantees exhibit a form of limited liability similar to a common stock put option (Wilson, Dahl, and Gustafson, 1995). The features that vary across the exporters are coverage levels on freight and insurance, and some form of exchange rate guarantee. As countries vary their financing features of the program, flexibility is added. The Black-Scholes option model was used to estimate the value of program features, and comparisons were made across exporting countries (Wilson, Dahl, and Gustafson, 1995).

Tirupattur et al. (1997) apply these techniques to the implicit features of recent U.S. farm programs, specifically the Deficiency and Findley programs. Such analysis allows for comparisons to be made with market-oriented alternatives. The features that distinguish these programs from an exchange traded option include path-dependent payoffs (dependent upon an arithmetic average of prices), upper and lower bounds on the payoff region, and upper limits on total payoffs. The comparison provides measures of the expected costs to the government and the value of the programs to the producer.

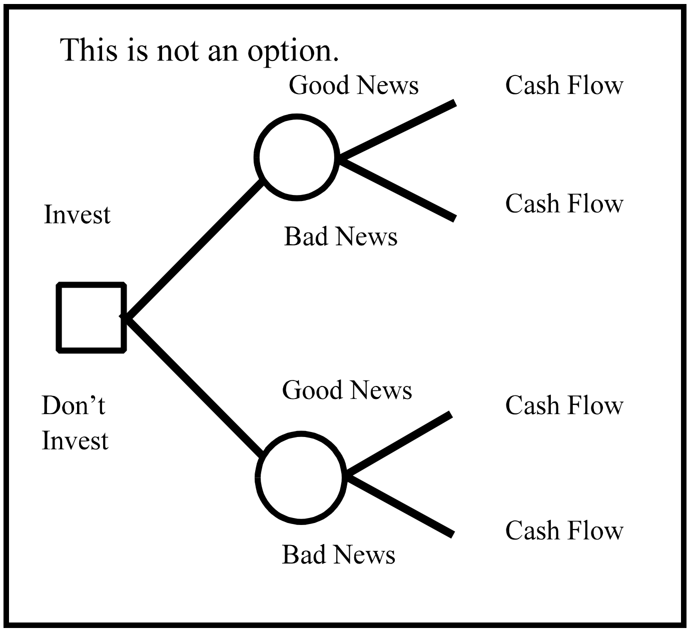
Kulatilaka examines the case of a duel-fuel industrial steam boiler as an option to switch between alternative fuels. This option is similar to the wood-burning stove already mentioned. In this case there are three alternatives: a boiler that runs on residual fuel only, one that runs on natural gas only, and a dual-fuel boiler that can run on either based on current costs. The presumption behind the analysis is that price differences between the installed cost of the two types of technologies should be roughly equal to the incremental value of flexibility (Kulatilaka, 1993). The operator of the flexible boiler can purchase energy for the cheaper of the fuel sources, where the gas price is fixed and the oil price is market-driven. When the boiler is fueled with oil, the operator has the right to buy an asset (energy) for the minimum of a strike price (fixed gas price) or the market price of the asset (oil price) (Kulatilaka, 1993). The payoff is nearly identical to a call option.

Real Options, Decision Tree, and Discounted Cash Flow Analysis

This section explains the differences between the real options, decision tree, and discounted cash flow methods. The main difference is that real options have the capability to value flexibility, which is otherwise unaccounted for in the other methods. Decision tree analysis is not entirely separate from the real options approach, however. The real options approach is more like an economically corrected version of decision tree analysis (Trigeorgis, 1996). Figure 3.3 differentiates between two generic decision trees. One exhibits option characteristics while the other does not.

Developing a decision tree is useful in identifying the variables and relationships within the project or firm, and can set the foundation for the real options analysis. Two of the key variables within the analysis are the present value of cash flows and uncertainty. Decision trees can be drawn out to illustrate the possible cash flows and the associated probability distributions. From this point, simulation software can be utilized to calculate the expected cash flows from the project.

The real options approach allows the manager to eliminate certain negative outcomes, as noted previously. The discounted cash flow analysis (DCF) does not account for the flexibility, and the extreme negative outcomes are part of the calculation. Instead, the DCF assumes management’s role to be passive once the original investment decision



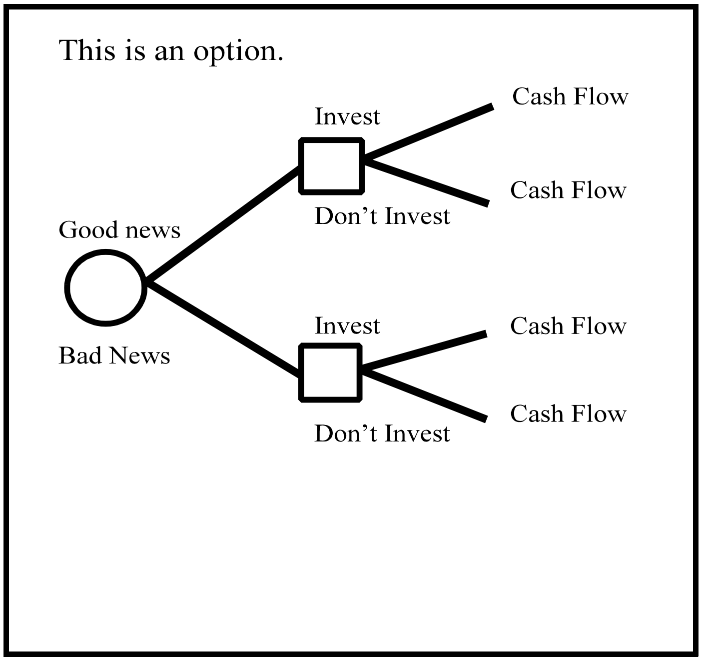


Figure 3.3. Decision Tree Comparison.

has been made (Edleson, 1994). By allowing management to respond to surprises and avoid the negative outcomes, the value of its opportunities will be much higher than the standard net present value calculated (Edleson, 1994). It is for this reason that the valuation techniques for making certain corporate decisions have shifted towards option value theory (Flatto, 1996).

Kemna points out that DCF is a simplified technique, which is appropriate for the analysis of a broad range of problems under passive management. Option theory should be used within DCF analysis when future decision points influence the riskiness of the investment. Discounted cash flow analysis has been sufficient in evaluating most expansion projects, but systematically undervalues the benefits of waiting (Kemna, 1993).

Risk Neutral Valuation and Risk Adjustment

This section describes the underlying assumption of the risk component in the real options framework. Cox and Ross note that an option can be replicated with a portfolio of traded securities with similar characteristics, thereby creating a synthetic option (Trigeorgis, 1996). Such analysis is independent of risk attitudes and considerations of capital market equilibrium. Risk adjustment allows for present value discounting, using the risk-free interest rate, of expected future payoffs where actual probabilities are replaced by risk-neutral ones. This probability adjustment is a fundamental characteristic of arbitrage-free price systems involving securities which are traded (Trigeorgis, 1996).

> According to Trigeorgis:
> “The existence of a traded twin security that has the same risk characteristics with the non-traded real asset in complete markets is sufficient for real-option valuation. Any contingent claim on an asset, traded or not, can be priced in a world with

> systematic risk by replacing its expectation of the cash flow with a certainty-equivalent growth rate and then behaving as if the world were risk-neutral." (1996, 17)

This adjustment is similar to discounting certainty-equivalent cash flows at the risk-free rate, rather than the expected cash flows at a risk-free rate.

Compound or Interacting Options

The section on types of real options discussed each type individually. However, in many cases of real applications, there may be more than one source of option value, and there are certain options which interact with one another. These options are referred to as compound or multiple options. According to Trigeorgis, "managerial flexibility embedded in investment projects typically takes the form of a collection of real options" (1993, 2). These types of options are known as compound or interacting options. Trigeorgis notes that "the incremental value of an additional option, in the presence of other options, is generally less than its value in isolation, and declines as more options are present" (1993, 2). Ignoring a particular option may lead to a small valuation error, but Trigeorgis (1993) identifies certain situations where the opposite behavior is exhibited.

It is important to note the interaction between the multiple options because evaluating each option individually and summing these values can substantially overstate the value of the project. The results from interaction can affect the direction or sign as well as the magnitude. Trigeorgis (1993) notes four key variables in the degree of interaction between real options. They are

1. Whether the options are of the same type (two puts or two calls) or opposites,
2. The separation of their exercise times (European vs. American),
3. Relative degree of being “in or out of the money,” and
4. Their order or sequence.

These variables all affect the degree of overlap between the exercise regions and the probability of joint exercise of both options. If the two options examined are opposite (put and call), the motivating factors for exercising them are opposite. These opposing factors reduce the conditional or joint probability of exercise, thereby reducing the degree of interaction, and results in an option that is approximately additive.

When analyzing two options of the same type, different results are attained. Two put option scenarios are the option to abandon and the option to switch use. Some conditions may occur that would make exercise of either option optimal. In this case, the combined value of the two options would simply be the higher of the two option values. In the two put option case, the conditional probability of exercising one put, given earlier exercise of the other, would be high. Therefore, the summation of the separate values would be overstated.

Trigeorgis (1993) examines the effects of interacting options using a generic project with numerical results. The option value is stated as the difference between the “expanded NPV,” or the value with the real option calculation, and the “passive NPV,” which is the simple net present value without any flexibility in the project. Five types of options are evaluated: defer, abandon, contract, expand, and switch use. Each type of option is analyzed individually first, then in each possible combination with the other types to value the interaction between them. Sensitivity analysis is conducted to examine the effects of the key variables of interaction. Trigeorgis concludes “despite interactions, projects seen as collections of real options preserve a number of the familiar option properties” (1993, 2).

Solution Techniques

There have been recent developments in the area of numerical analysis techniques that take advantage of risk-neutral valuation, which is an underlying component of option-pricing theory. According to Trigeorgis (1996), there are two types of numerical techniques for option valuation:

1. Those that approximate the underlying stochastic processes directly and are generally intuitive, and
2. Those that approximate the resulting partial differential equations.

Monte Carlo simulation, along with the standard binomial lattice method and the log-transformed binomial approach, can be used to analyze the first category. The second method is better suited to value complex projects with multiple embedded real options, a series of investment outlays, dividend-like effects, and option interactions (Trigeorgis, 1996, 21). “Binary option pricing models approximate the expected price of the option by using the lattice method, which simulates the Wiener process of the stock price. Monte Carlo methods simulate possible price paths the stock might take.” The next section outlines the binary option pricing and Monte Carlo methods.

Binary Option Pricing Model

The binary option pricing model is one method to determine the true value of an option. In option literature, this model is referred as the binomial option pricing model.

Benninga et al. (1996) use this terminology for the case when the binary tree of stock prices recombines, and the more general case is referred as the binary, or two-state option pricing model. Benninga et al. state, “For a non-path dependent option, the binary option pricing model,with appropriately chosen parameters, will converge to the standard Black-Scholes formula” (1996, 254). The Binary model is more general than the Black-Scholes and can be used to price a variety of path-dependent options for which no analytic pricing formulas exist. (Benninga et al., 1996)

Binary Option Approach

The binary option pricing model assumes two possible future states of the world that define security returns and that the price of any security in the economy can be expressed as a linear combination of the prices of two basic securities known as the stock and the risk-free asset. The return over a short time (defined as one plus rate of return) is either up (denoted u) or down (denoted d), depending on the state of the world. “If the stock price at time t is S, the stock price at time t+1 will be Su or Sd. If the risk-free interest rate is r over the same period of time, then a risk-free asset whose value is 1 at time t will be R=1+r at time t+1. The expected return to an arbitrary security that returns x if the stock price is up and y if the stock price is down will be given by px+qy for some values of p and q. These values, called spanning state prices can be found by expressing the value of the stock and the risk-free asset. For the stock, pSu +qSd=S. Therefore,

$$pu+qd=1 \text{ and } pR+qR=1$$

It follows that

$p=(R-d)/(R^*(u-d))$ and $q=(u-R)/(r^*(u-d))=(1/R)-p$

Because $pR+qR=1$, asset valuation in binomial framework may be viewed as taking the discounted expected asset payoff when probabilities are assigned to payoffs. This method is referred to as pricing by using an equivalent martingale measure, part of the risk-neutral pricing model.

If an option is not path dependent, the binomial option pricing model is appropriate. Options which are path dependent should be valued using the binary option pricing method. These approaches are very similar, but the binary method is more computationally intensive. At any time $t=0,1,2,...$, the possible states are $u^i d^j$, where $i+j=t$. Binary trees are useful in depicting an option value over time. For each state, the corresponding state price, or the value at time zero or today, of a future dollar is $p^i q^j$.

Benninga et al. (1996) outline an example of six different securities (types of options). Both European and American options are examined as puts, calls, and lookback options. Benninga et al. (1996) define the option price as the maximum of two variables, the exercise value or intrinsic value associated with exercising the option, and the option value associated with letting the option expire. “The stock price distribution generated by the binomial model converges to the same lognormal distribution. Therefore u and d can be related to the observed stock price volatility and to the risk-free interest rate r” (Benninga et al., 1996, 257). Benninga et al. (1996), describe how to implement the binomial approach into *Mathematica*.

Monte Carlo Approach

Another method of valuation for options is using Monte Carlo simulation. The value at time zero of a European option that pays off F_T at time T is

$$F = E\{F_T e^{-rT}\},$$

where E denotes the expectation operator in a risk-neutral world and r is the risk-free interest rate. F_T depends on the value of an underlying stochastic variable, such as the stock price or a function of stock price. Assuming the risk-free rate is known with certainty, the formula can be rewritten as

$$F = B_0 E\{F_T\} = e^{-rT} E\{F_T\},$$

where B_0 is the price of a zero-coupon discount bond that matures at time T.

Simulation software such as @RISK can be used to perform the Monte Carlo technique. The path of the stochastic variable is simulated over a large number of random paths. This results in a sample mean that is close to the actual mean. This approach has the additional benefit of providing an estimate of the error by giving the standard error of the sample mean. "Another advantage of the Monte Carlo method is the ability to price options using different stochastic assumptions, even observed probabilities, and to include multiple stochastic variables without the need to develop a formal model" (Benninga et al., 1996, 267).

Monte Carlo has been applied to numerous industry areas. Winston has done extensive work with @RISK. He presents these applications in *Simulation Modeling Using @RISK*, and *Financial Models Using Simulation and Optimization*. These examples provide a starting point for analyzing risk within business investment decisions.

Summary

Many business decisions regarding future investment outlays contain contingent opportunities. Discounted cash flow methods are usually applied to such decisions. However, there are certain events that cannot be accurately accounted for with discounted cash flow analysis. Other methods are now being investigated. One such method is the real options approach. Essentially, real options involves applying stock option-pricing theory to real investment decisions.

Natural resource extraction is a major area of exploration in real options. Other applications are capacity expansion/contraction, switching inputs or outputs in production processes, research and development investment, and abandonment scenarios. Most of the literature on real options is academic in nature. However, the real options approach is becoming more acceptable to industry as a counterpart to traditional methods.

There are certain features within guaranteed rail service contracts that can be viewed as real options. One such feature is transferability. Transferability can be modeled as a European put option. Chapter 1 explains the analogy of real options to this application. Table 3.2 provides a summary of the details. The model is developed in Chapter 4.

Table 3.2. Guaranteed Rail Service Contract as a Real Option

Real Option	**Guaranteed Railcars**
Gross present value of expected cash flows	Number of Cars Required (based on actual deliveries)
Investment cost	Number of Cars Contracted (based on expected deliveries)
Time until opportunity disappears	Time to maturity
Project uncertainty	Volatility of Quantity of Spot Deliveries
Riskless interest rate	Riskless interest rate
PV of Cash flow over option life	PV of Cash flow over option life

CHAPTER 4
REAL OPTION MODEL OF GUARANTEED SHIPMENT MECHANISMS

Introduction

Monte Carlo simulation modeling can be used to analyze risk associated with certain business decisions. It has distinct advantages over other solution techniques. Linear progamming can be used to define an optimal solution based on deterministic input variables. These types of models are useful when all of the variables are known with a high degree of certainty. However, these optimization models have difficulty accounting for stochastic or risky variables, which are components of many business decisions. Such situations are better analyzed using simulation. Winston applies these techniques to many disciplines (1996, 1998). This type of analysis is conducted using spreadsheets and an “add-in” program called @RISK.

The Real Options methodology has relevance to a few applications in the area of rail shipments. Chapter 3 outlined the framework and applications of Real options. The primary embedded option in these instruments is the transferability aspect. Excess cars can be sold in the secondary market if necessary. The other option-like component is another timing option. The timing option is not evident in the case of the short-term guarantee, but is a key distinction in the long-term contract. If the railroad does not deliver the cars on time or within the window, the shipper has an option. He can either be reimbursed by the non-performance penalty and relinquish the right to the cars, or he can retain his right to the cars until a later date. This contingent decision is made based on market expectations and the expected inventory position.

This chapter presents a stochastic simulation model of a grain shipper's logistical decisions. The first section outlines the framework and objectives. The next section gives a brief introduction to @RISK and its applications. Finally, a description of key modeling parameters and their relevant sources is provided.

Model Specification

Basic Model Structure

The model is designed to simulate a grain shipper's logistical system as a Materials Requirements Planning (MRP) system (Ballou, 1992). A monthly inventory position is developed based on average forward purchases and spot deliveries for a typical country elevator in North Dakota. The inventory position defines the shipping demand for each month. Futures prices and basis levels generate the market position. The shipper utilizes either all short-term guarantee contracts or long-term guarantee contracts. For a detailed comparison of transportation strategies and their outcomes, see Priewe (1996).

Transportation, storage, interest, and other relevant costs are subtracted from the market price to generate a monthly net price received. Inter-month price differentials are compared to determine shipping demand by month. Distributions for railroad performance are then used to determine if the cars are on-time or late. The guarantee value is defined as the difference between the expected payoff of a guaranteed instrument and the General Tariff instrument. The option components are then added to generate the overall value. These option components are defined in a later section.

The base case contains variables which represent a typical country elevator in North Dakota. Sensitivity is conducted on key variables to reflect characteristics of different market participants such as an exporter or domestic processor.

Guarantee Component

The model is used to analyze a decision to forward purchase rail transportation based on expected monthly grain receipts. The analysis is framed around incremental differences between shipping alternatives. There are two main components that give value to the guarantee mechanism. The first is the value generated by the guarantee structure, which is calculated based on railroad performance. The value of the guarantee is stated as the difference between the payoff of a non-guaranteed position and the payoff with a guaranteed position. The other component the transferability of the shipping instrument. A shipper can “trade” excess transportation capacity in the secondary market. This transaction is valued using option pricing theory.

The model builds upon previous work and methodology applied to this area. Wilson and Dahl specify a simple model to value a guaranteed railcar contract using discrete measures of performance (1997). “Factors influencing the value of a guaranteed forward contract service include inter-month price spreads in the commodity market, costs associated with not receiving cars (storage, interest, and demurrage), and the probability of timely car placement under traditional allocation mechanisms” (1997, 7). The model uses discrete probabilities and expected payoff functions in determining the value of a guaranteed freight position relative to a non-guaranteed transaction. Essentially, the intrinsic value of the guarantee is defined as the difference between the expected payoffs of the two transactions.

Wilson and Dahl define the value of a guaranteed transaction as the difference between the expected payoffs of a guaranteed and non-guaranteed shipment. They define this value using equation 1.5:

$$T_{ij}^{g}-T_{ij} = (1-R_{1})[P_{j}^{\,t+1} - P_{j}^{\,t+2}) + (r + S + D) +(\pi^{N} - \pi^{g})]$$

where
T_{ij}^{g} = value of guaranteed forward car service
T_{ij} = expected payoff without guaranteed service
$(1-R_{1})$ = probability of receiving non-guaranteed cars in next period versus the probability of receiving cars on the want date (R_{1})
$P_{j}^{\,t+k}$ = commodity price at destination market j, and t+k indicates k time periods forward
r = interest cost
S = storage cost
D = cost of demurrage
$(\pi^{N} - \pi^{g})$ = margin difference between guaranteed and non-guaranteed transaction

Railroad performance expectations are defined using discrete probabilities, based on responses from industry contacts. The payoff function was modified by replacing the discrete probabilities with continuous distributions that were estimated by Best-fit, representing the fleet performance of BNSF from August-October 1998. This methodology is explained in a later section.

The overall value of each monthly contract is the simple summation of the two values generated: the value from the guarantee and the “transfer option value.” The base case assumes all transportation is contracted with the short-term guarantee. The long-term guarantees have another option-like component that is evaluated in the sensitivity analysis. Unlike the short-term mechanism, the shipper has a contingent decision to make if the railroad is late. He can relinquish the right to the cars and accept the non-performance penalty, or waive the penalty and retain cars for a forward period. This component is assumed to be additive in nature with the transferability component. Any interaction between the two "options" is difficult to quantify and omitted from the analysis (Trigeorgis, 1993).

Real Option Component

The "transferability" feature of the guaranteed mechanism is valued using option-pricing theory. This methodology is explained in Chapter 3; it involves applying financial option-pricing techniques to real business investment decisions. There are numerous uncertainties involved when shipping grain. For simplicity, spot deliveries by producers were chosen as the single source in developing the option model.

Spot deliveries trigger shipping demand, which is a key component of the model. The volatility of the real option is defined as the standard deviation of monthly spot deliveries. Different market participants have varying degrees of certainty of shipping demand. Country elevators have a higher degree of uncertainty because of the randomness of producers that deliver to the spot market. Exporters are characterized with a more stable shipping demand. Domestic processors have very little deviation in shipping demand due to production planning. In this case, the shipper has a monthly forward transportation contract that can either be used to ship grain or sold in the secondary market.

The duration of the contract is three-to-five months. The ability to transfer excess cars is only available until 10 days prior to the shipping window that the contract applies to (*www.bnsf.com*). For simplicity, it is assumed that the shipper makes his decision whether to transfer at the last possible moment. There is a higher degree of certainty about the inventory position at that time. Based on this assumption, the option can be modeled as a “European” option.

European options can only be exercised at one moment in time. Without the simplifying assumption, the option would be more suited to an “American” option. The American option would take account of early exercise or transferring the contract before the last moment. The framework would be more complex in that case. The uncertainty lies within the quantity of spot deliveries. At time zero, the shipper has an idea of what that quantity is going to be, but is not able to observe the actual amount until the shipping period. For this reason, it is assumed that the transfer decision is made at the last possible moment.

The model is structured as a binomial lattice or tree. See Table 4.1 for the inputs to the lattice. Figure 4.1 is a generic example of the lattice variables, while Figure 4.2 outlines a section from the August lattice. The lattice in Figure 4.2 illustrates the behavior of spot deliveries over time. Winston shows how to value an American option using this type of lattice approach (1998). These same techniques can be applied to the European transfer option. The only difference is the payoff structure. The European payoff is calculated at the final period and discounted to time zero. The American payoff would involve a comparison of the transfer value or value of maintaining use of the cars at each node. This comparison is not easily incorporated with the inventory assumption, as it requires more analysis of interaction between inventory positions across months.

Table 4.1. Input Variables for Lattice

Quantity (X)	Expected Spot Deliveries: August	223,125 bushels
Interest Rate (r)	Interest Rate	10%
Sigma (volatility)	Uncertainty of spot deliveries	15%
Time	Time to expiration (5 months)	5/12
Delta-t	Time between periods/branches (2 weeks)	1/26
U	Multiplier when moving “up” EXP(sigma*SQRT(deltat))	1.031092193
D	Multiplier when moving down (1/u)	0.96984538

Adapted from Winston 1998.

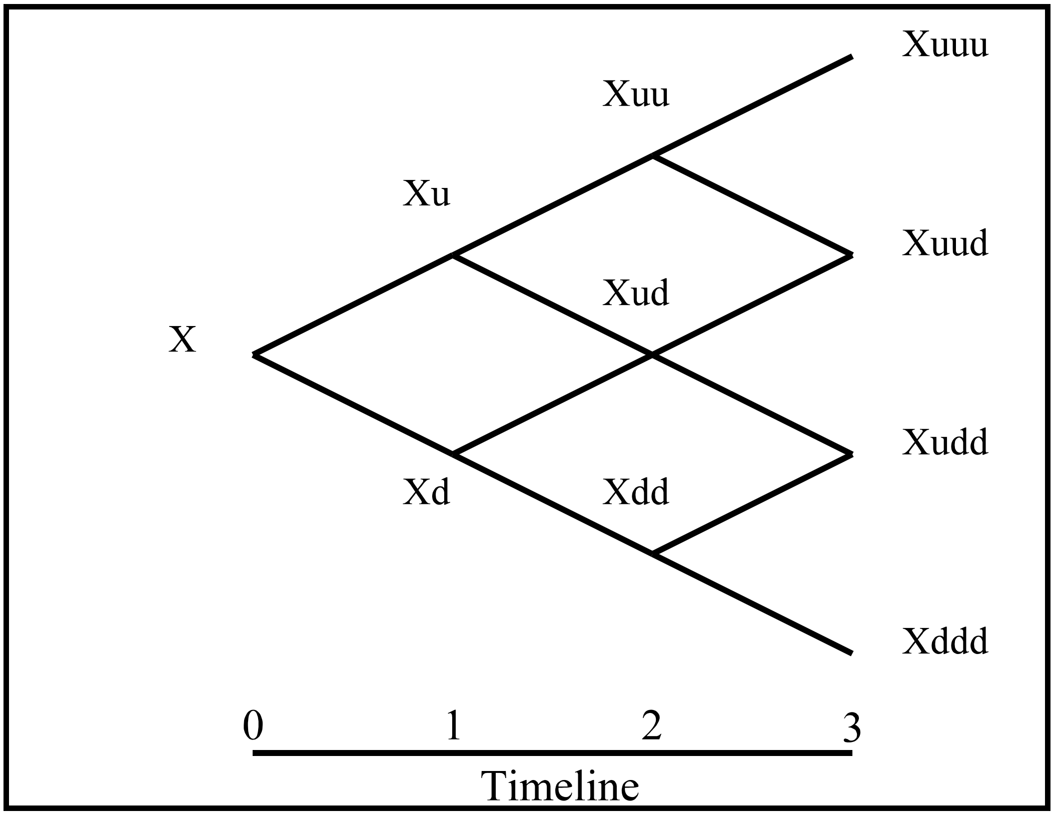


Figure 4.1. Binomial Lattice.

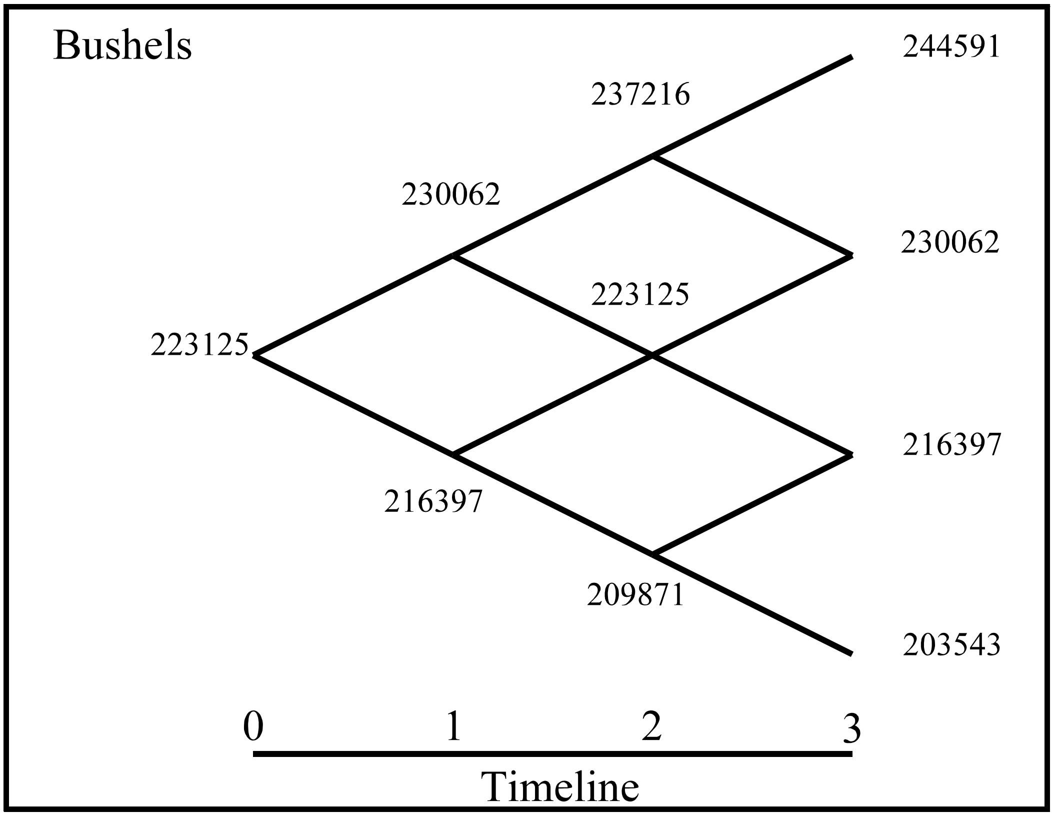


Figure 4.2. Lattice Using Data from Table 4.1.

When using option pricing theory, only one variable of uncertainty can be evaluated; otherwise, the calculations get quite cumbersome. For purposes of this analysis, monthly spot deliveries were selected as the single area of uncertainty. At time zero, the expected spot deliveries is entered. From that point, the tree branches out in a series of “up” and “down” moves. Each branch represents a moment in time, specified as a two-week period. The number of branches is somewhat irrelevant. The key component is the time to expiration, which is defined as 5 months. That is the time over which uncertainty evolves. In this case, as the expiration date approaches, the shipper is more certain about the inventory position. The result is a distribution of possible spot deliveries for a specified month.

Shippers are assumed to have forward contracted transportation needs equivalent to the sum of forward purchases and expected spot deliveries in time zero. Depending on which path this variable travels, at the exercise date of the option, the shipper has a surplus or a shortage of railcars. Any excess cars are assumed to be transferred to the secondary market.

In the event of a shortage of cars, the shipper would either carry the stocks to the next period or secure cars through the secondary market. This instance is not accounted for in the analysis because all shippers have equal access to the secondary market. A shipper currently utilizing contracted cars would not have an advantage in securing cars, so the incremental difference is zero. The payoff is calculated in the final period as follows:

$V_T = \text{Maximum } [(C_C - C_R)*S\pi, 0]$

where

V_T = Value at expiration
C_C = Number of cars contracted based on expected deliveries
C_R = Number of cars required based on actual deliveries
$S\pi$ = Secondary market profit per car ($300 + bid)

These values are then discounted by the risk-free interest rate to determine the present value of the option. At this point, the value generated is in absolute dollars. This value is divided by the number of cars contracted for to determine the value on a per car basis, which is used in further analysis. This option value is incorporated with the other part of the model, which generates the value associated with the guarantee component.

There is another component contained within the guarantee contracts. The shipper must pay a $300 performance bond on the cars purchased for future delivery. This amount is then subtracted on the freight bill at time of shipment. If the cars are not used, the shipper forfeits the $300. This prepayment/reimbursement is also incorporated into the analysis and defined as the present value of total refund. The payoff at the final node is specified as $[300*\{\text{minimum}(C_R, C_C)\}]$ where C_R is the number of cars required and C_C is the number of cars under contract. The payoff is then discounted similar to the transfer option.

The long-term guarantee component is valued somewhat differently. The option is the choice between the penalty or keeping the cars for a forward period. The decision is valued with a maximum statement, whereby the two payoffs are compared. The guarantee value is calculated much like that in the base case as the difference between the expected payoffs.

Simulation Method

The “add-in” program @RISK facilitates the use of spreadsheets for simulation analysis. Simulation involves random sampling from specified distributions. The results of a simulation are useful in determining how sensitive output parameters are to stochastic input parameters.

Inputs

The action of pulling sample numbers from distributions is referred to as an iteration. For each iteration, the spreadsheet is recalculated. Both input and output values can be collected. It is recommended that 300-500 iterations are used to generate accurate results (Palisade, 1997). For this analysis, 1000 iterations were selected. There is also a setting for sampling type: Latin Hypercube or Monte Carlo. For all practical purposes, Latin Hypercube is recommended unless Monte Carlo is explicitly needed (Palisade, 1997). A random number generator seed option can be used to draw the exact sequence of random numbers across multiple simulations. This function stabilizes the simulation environment when analyzing parameter changes.

Outputs

The results of a simulation contain reports and statistics on input and output parameters. The mean, minimum, maximum, standard deviation, and percentiles are all presented in the statistics report. The data report contains the inputs and outputs calculated for each iteration in the simulation. Further analysis can be done using the sensitivity function. There are graphing capabilities which illustrate sensitivity through correlation or regression.

@Risk and BestFit

BestFit is another program developed by Palisade to be used in conjunction with @Risk. It is important to use accurate distributions in the model to represent the supporting data. BestFit allows the user to import raw data and generate probability distributions. Statistical tests are conducted to evaluate 26 different distributions in relation to the raw data. The distribution is chosen by the user and can be used in an @Risk model.

Model Description

The model was developed in a Microsoft Excel spreadsheet compatible with the @RISK stochastic simulation method. There are three basic modules: 1) information about certain parameters is received; 2) information from data fields is collected for estimation and sampled; and 3) outputs are derived, and the data are recorded.

Module 1: Input Parameter Values

The following input variables must be specified: railcar capacity in bushels, non-performance penalty per car on guaranteed mechanism, General Tariff rate, handling charge, margin difference between guarantee and non-guarantee transactions, ship demurrage costs, storage costs, and interest costs. Another key component is the expected inventory position of the elevator one-year forward. This inventory position allows the analysis to be broken up by monthly contracts. The position is defined as the summation of expected spot deliveries and forward purchases. The standard deviation of spot deliveries is also determined by the inventory position. Table 4.2 presents the fixed input variables for the model. Table 4.3 outlines specific parameters for each month, including price,

Table 4.2. Fixed Inputs for Model
(See Table 4.1 for Lattice Variables)

Parameter	**Value**
Car Capacity	3300 Bushels
Auction Based Contract-RR Guarantee	$400/car
Long-term Contract-RR Guarantee	$250/car
Monthly Market Variables: 1998 Market Year. Numbers reflect August 1998	
Futures	$3.18/bushel
Basis	$0.46/bushel
Tariff	$1.00/bushel
Handling Charge	$0.08/bushel
Margin Difference (Guarantee vs. Non-G)	$0.02/bushel
Demurrage	$0.12/bushel
Storage	$0.03/bushel/month
Interest	$0.0143/bushel/15 days
Inventory Position:	
Forward Purchases	95,625 bushels
Average Spot Deliveries	223,125 bushels

Table 4.3
Detailed Monthly Inputs
1998 Cropyear-Base Case

Month	**Price($/bu)**	**Basis($/bu)**	**Secondary Market Mean ($/Car)**	**Secondary Market S.D. ($/Car)**
August	3.18	0.46	6.60	13.72
September	3.22	0.37	73.87	25.72
October	3.25	0.30	180.37	32.54
November	3.28	0.44	167.88	37.14
December	3.31	0.34	120.83	31.10
January	3.33	0.32	98.09	31.37
February	3.34	0.32	109.91	116.03
March	3.36	0.42	59.4	119.14
April	3.38	0.52	-60.21	55.55
May	3.40	0.58	-80.15	17.19
June	3.42	0.50	-79.03	5.29
July	3.44	0.52	-51.82	13.88

basis, and secondary market values.

Module 2: Data Fields and Sampling

Data fields are referenced within the model for distribution parameters of the following: simulation table which represents each month, mean and standard deviation for the secondary rail market, and railroad performance distributions for each mechanism. These distributions are presented in Table 4.4. Random sampling is performed for the specified distributions within the model. The following variables are included: month, secondary rail market, and railroad performance.

Module 3: Calculations

@RISK calculates the values associated with both components of the model based on the input values generated in the simulation. The transfer value and guarantee value are then combined to reflect the overall value. These values are generated using a simtable to reflect each month of shipment.

Output Information

The outputs specified in the model are the transfer option value; the guarantee value; and the summation of these two, or the overall value. The simulation results can then be interpreted as values by month, such as Simulation 1 gives the value for an August contract, and so on. Statistics reports display mean, minimum, maximum, standard deviation, and percentiles for all specified inputs and outputs.

Table 4.4. Input Distributions

Variable	**Distribution**
Simtable (Representing each Month)	Risksimtable({1,2,3,4,5,6,7,8,9,10,11,12})
General Tariff Performance	RiskGamma(8.38, 1.58)
Auction Based (COT) Performance	RiskPearson6(180, 17.61, 0.45)
Long-Term (SWAP) Performance	RiskWeibull(9.15, 7.95)
Secondary Market (Transfer)	Risknormal(Monthly Mean, Monthly S.D.)

Parameters and Data Sources

This section presents parameters, sources of data, and derivation procedures. Secondary market rates and railroad performance variables are presented. Most of the other supporting data were found in Steve Priewe's thesis titled *Analysis of Rail Options for Shipping Grain*. Shipping costs and elevator inventory positions are derived directly from this previous framework. Market prices reflect the conditions present in the 1998-99 Crop year (*Agweek*).

Secondary Auction-Based Market

The secondary market distributions were derived using data compiled from industry sources from 1996-1998, primarily consisting of the COT market results (Wilson). The data set consists of "Bids" and "Asks" for particular shipping windows. The secondary market variable in the model follows a normal distribution with a mean and standard deviation estimated by the data. These parameters vary by month, to reflect seasonality.

Railroad Performance

The distributions for railroad performance were derived from a data set provided by Burlington Northern Santa Fe that describes daily fleet performance across mechanisms for the period August 20, 1998-October 22, 1998 (Wilson). This time frame is short and reflects a period of particularly reliable performance, so further sensitivity is conducted to reflect changes in shipping conditions. The days-late variable indicates the number of days past the stated want date each type of car is arriving at its origin.

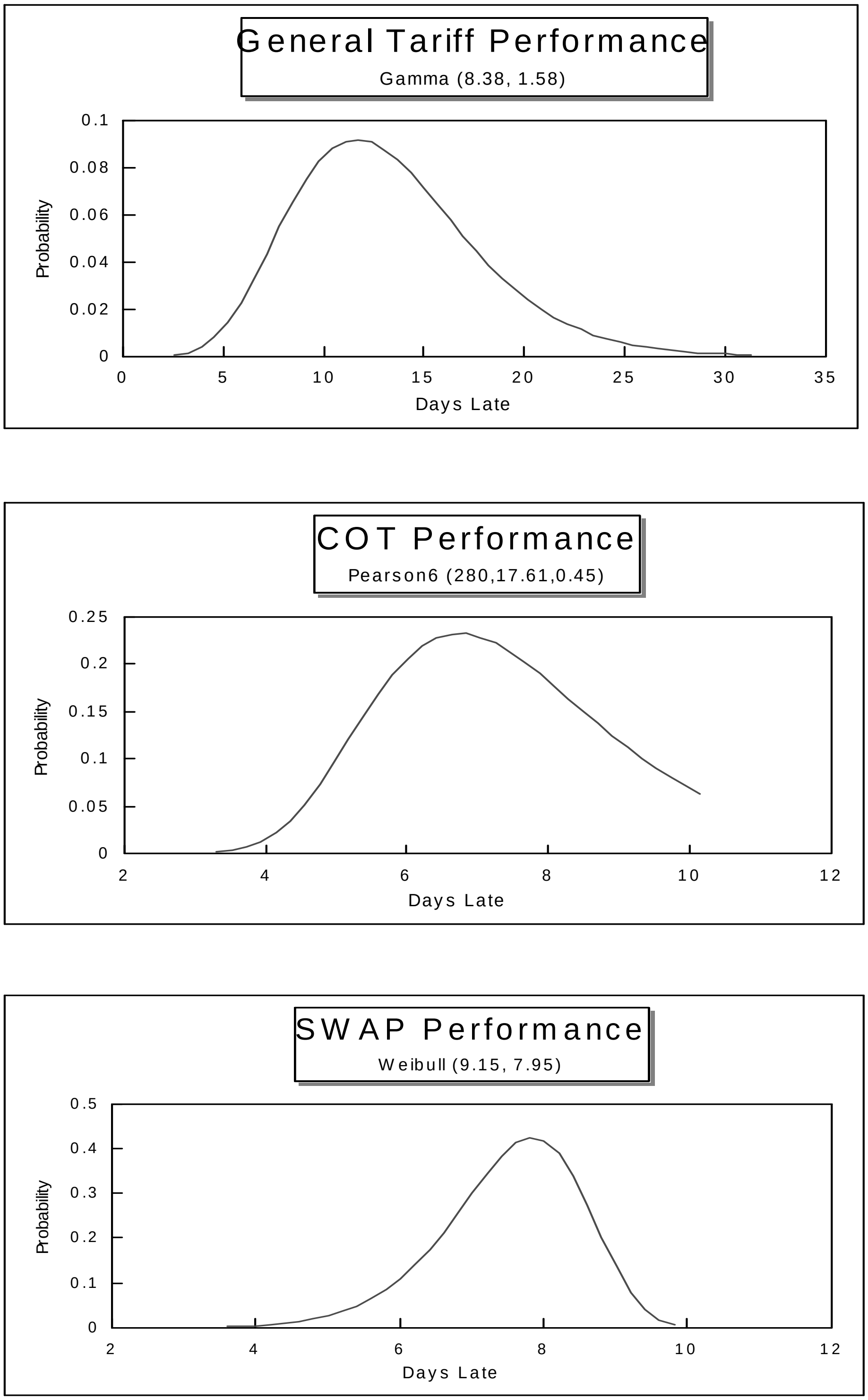
BestFit was used to estimate appropriate distributions for each mechanism. The General Tariff performance is characterized by a Gamma distribution with a mean of 13.24

days and a standard deviation of 4.57 days. In other words, on average, General Tariff cars arrive 13 days past the stated want date with a standard deviation around 4.5 days. The shot-term, auction-based guarantee contract exhibits a Pearson 6 distribution with a mean of 7.59 days and a standard deviation of 1.98 days. The long-term guarantee contract exhibits a Weibull distribution with a mean of 7.53 days and a standard deviation of 0.99 days. Figure 4.3 presents the distributions. Figure 4.4 compares the performance of each mechanism through a cumulative probability function.

The graphs reveal the effect of prioritized shipment mechanisms. Guaranteed shipments exhibit a much tighter distribution centered around 7-8 days, well under the penalty window of 15 days. The non-guaranteed mechanism, however, is much less reliable. The mean is close to the 15 day time frame. The General Tariff is is also characterized by a wider distribution in relation to the other mechanisms.

Market Prices

Market prices were established using futures price estimates and terminal basis data. These variables represent the market conditions faced by an elevator manager in central North Dakota who ships primarily to Minneapolis, MN. Futures prices and basis data were set for monthly periods. These values are fixed in the base case to approximate the market conditions for the marketing year of August 1998 to July 1999. Relevant inter-month spreads represent those of the 1998-99 crop year. Basis levels for April-July were represented by historical data since the cash markets had not yet occurred. The parameters are adjusted in the sensitivity analysis section.



General Tariff Performance

Gamma (8.38, 1.58)

COT Performance

Pearson6 (280,17.61,0.45)

SWAP Performance

Weibull (9.15, 7.95)

Figure 4.3. Rail Performance.

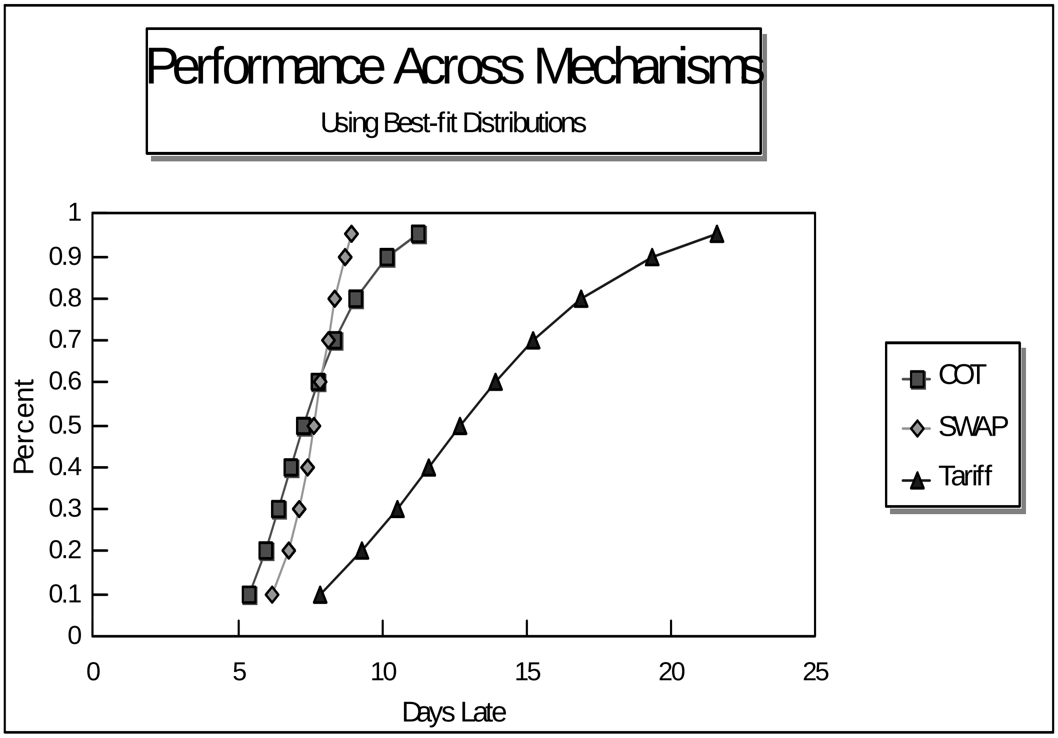


Figure 4.4. Performance Across Mechanisms.

Shipping Costs

Although grain shippers face uncertainty about tariff rate changes, the rate was fixed for this analysis. The tariff rate is fixed at $1.00 per bushel for shipping from central North Dakota to Minneapolis. Priewe examines the effects of increasing tariff rates (1996). It is also assumed that the auction-based car premiums are relatively fixed. The margin difference between the guarantee and non-guarantee transaction is further analyzed in the sensitivity section.

Inventory Position

The inventory position illustrates the monthly projected spot and forward purchase receipts. Priewe used various sources to determine average spot and forward purchase deliveries to a typical unit-train elevator. The monthly averages are presented in Table 4.5.

The standard deviation for spot deliveries is calculated as one-sixth the difference between the minimum and maximum. This deviation is modified to reflect the standard deviation as a percentage volatility for use in the transfer option calculation. Trial and error was used to determine a volatility which yielded approximately the same minimum and maximum values. Volatility is analyzed in the sensitivity section to reflect differences across market participants.

Table 4.5. Monthly Spot Deliveries

Month	**Spot Deliveries (bushels)**	**Minimum**	**Maximum**
August	223,125	178,500	267,750
September	308,438	246,750	370,125
October	269,063	215,250	322,875
November	249,375	199,500	299,250
December	275,625	220,500	330,750
January	308,438	246,750	370,125
February	183,750	147,000	220,500
March	210,000	168,000	252,000
April	157,500	126,000	189,000
May	111,563	89,250	133,875
June	196,875	157,500	236,250
July	131,250	105,000	157,500
Annual Total	2,625,000	2,100,000	3,150,000

CHAPTER 5
SIMULATION SCENARIOS AND RESULTS

This chapter outlines scenarios and results from the grain shipper model. The first section presents the base case results. Key parameters are identified in the second section and used for sensitivity analysis. Results of changing these parameters are presented in the final section.

Base Case Scenario

The model was designed to calculate monthly values for a shipper utilizing guaranteed railroad mechanisms. The value is comprised of three key elements: the transfer option value defined as a real option, the value associated with the deposit refund, and the guarantee value which is the difference in expected payoffs of a guaranteed and non-guaranteed shipment. The option value can be stated as an absolute dollar value, or divided by the number of cars used to calculate the value on a per car basis. The same holds true for the value of the deposit refund. The guarantee component captures the value of increased customer service and the guarantee structure on a per car basis. The three are then added to derive the overall value of the instrument.

The initial simulation was conducted on the base case model for the input and output distribution parameters outlined in Chapter 4. The numbers used reflect market conditions for the 1998-99 crop year. Parameters were changed to account for different positions across the 12-month simulation. Certain parameters had an effect on one of the components, while the other remained constant. The results section concentrates on only the output that was influenced. Estimates of the value of the transfer option value are presented first and followed by the guarantee value.

Transfer Option Value

The lattice structure of the model calculates the real option value associated with the decision to use guaranteed contracts in shipping. The output can be stated in absolute dollars or on a per car basis. Values for each month and their standard deviation are presented in Table 5.1.

The October contract has the highest absolute dollar value at $531, while the low is in May at $75. The standard deviations for October and May are $36 and $6, respectively. Again, these values are stated in absolute dollars. The results are consistent when looking at the per car value. October is the high at $4.56/car while May is $1.55. See Table 5.1 for detailed monthly results.

The results vary over the course of the year because of monthly delivery characteristics. The transfer option value is a function of expected spot deliveries combined with the secondary market rate. All of the other components, such as volatility, interest rate, and time frame, are held constant. Essentially, the option value indicates the value of overestimating shipping demand. The absolute dollar figure is sufficient to draw comparisons across each month.

Total Refund

The $300 performance deposit is included in the analysis. The shipper pays it at the time of purchase and receives it in the form of a discounted freight bill when the cars

Table 5.1. Base Case: Transfer Option Values

Month	**Cars Required**	**Option Value: Abolute Dollars**	**Standard Deviation**	**Option Value: $/Car**	**Standard Deviation**
August	97	$259.82	$11.63	$2.69	$0.12
September	134	$487.22	$33.52	$3.65	$0.25
October	117	$531.45	$36.01	$4.56	$0.31
November	108	$487.64	$38.72	$4.52	$0.36
December	120	$465.63	$34.42	$3.90	$0.29
January	134	$518.78	$40.88	$3.89	$0.31
February	80	$320.19	$90.57	$4.03	$1.14
March	91	$303.85	$100.47	$3.34	$1.11
April	69	$140.59	$32.58	$2.06	$0.48
May	49	$74.68	$5.84	$1.55	$0.12
June	86	$173.07	$4.14	$2.03	$0.05
July	57	$129.58	$7.25	$2.28	$0.13
AVERAGE	95	$324.37	$36.34	$3.21	$0.39

are placed. Failure to use the cars results in forfeiture of the deposit. The shipper receives reimbursement from the secondary owner if a sale occurs in the secondary market. The secondary owner then receives the reimbursement from the carrier.

This component is a simple discounted value of the end terminal payoff. The most the shipper will receive from the initial contract is $300/car contracted for. The $300 from excess cars is incorporated into the transfer option payoff.

The deposit refund value remains the same throughout the year. It is the present value of receiving the $300 refund at time of shipment. The simple calculation results in the same value on a per car basis, regardless of the number of cars used each month. The value in each case is $285/car.

Guarantee Value

The other part of the model involves a comparison of the payoffs with and without the guarantee mechanism. The base case simulates a shipper's decision to use the auction-based guarantee contract. The value is calculated using the framework outlined by Wilson and Dahl (1997). The payoff function is modified by incorporating the probability distribution generated by BestFit rather than simple discrete probabilities. The analysis is based on incremental differences between expected payoffs from using general service and guaranteed service contracts. The guarantee provides a form of insurance in times of low service reliability. With reliable general service, there is little advantage in using guaranteed contracts. Results indicate low values for the guarantee value due to reliable rail service. The values and standard deviations are presented in Table 5.2.

Table 5.2. Base Case: Guarantee Value and Maximum Bid

Month	**Guarantee Value ($)/car**	**Standard Deviation**	**Maximum Bid ($/car)**	**Standard Deviation**
August	74.50	203.22	62.83	203.23
September	58.51	179.67	47.79	179.68
October	-143.91	127.01	-153.72	127.00
November	80.66	212.30	70.81	212.31
December	28.24	135.36	17.77	135.37
January	4.86	101.58	-5.62	101.59
February	-88.66	50.25	-99.00	50.23
March	-95.43	58.87	-106.45	58.84
April	-57.29	28.65	-69.59	28.65
May	80.53	212.11	67.71	212.12
June	-17.91	69.67	-30.24	69.67
July	60.84	183.11	48.76	183.11
AVERAGE	-1.26	130.15	-12.41	130.15

Represents optimal shipping period; guarantee mechanisms undervalued due to reliable General Tariff service.

The results indicate high standard deviations for the guarantee value. Such high deviations are due to the payoff structure that is specified in the model. The important variables are the railroad performance distributions for guaranteed and non-guaranteed shipments. If both are on time, the guarantee value is recorded as zero. Higher values are generated when the non-guaranteed mechanism is late. The range of possible results is large, as indicated by the standard deviation.

The high for the year is in November at $81/car with a standard deviation of $212. The low occurs in October at ($144) with a standard deviation of $127. Since the railroad performance distributions are the same throughout the year, the main variables here are market prices in relation to nearby markets.

The annual average is quite low at only $-1.25/car. However, the base case includes distributions for rail performance which represent an optimal shipping period of August-October 1998. The General Tariff performance distribution equates to a 70% probability of showing up within the 15-day period. This distribution causes the guarantee value to be somewhat deflated relative to previous years. Again, these distributions are modified in sensitivity to approximate values in times of adverse shipping conditions.

Total Contract Value

The total value of the contract is the sum of the three components: transfer option value, present value of total refund, and present value of guarantee. When combining the values, the option value must be converted to dollars per car to match the guarantee value. Results indicate the greatest value is associated with the October contract. The combined value is $371. However, the true value is $300 less to account for the prepayment. The actual value is $71/car. For purposes of the analysis, the components are evaluated separately to reflect only those outputs that are affected.

Simulation Scenarios

This section presents the sensitivity analysis conducted on key parameters of the model.   The parameters were selected based on their influence on either the option value or the guarantee value. The two key areas explored are shipper characteristics and railroad mechanism design. Results are reported for the component that was changed.

Option Value

When implementing option pricing theory to applications, there are a few tests that can be conducted to prove validity of the results. Sensitivity analysis was performed on key variables within the option component. They include volatility, secondary market, time to maturity, risk-free rate, and strike price.

Volatility. The base case model is designed to represent a country elevator's logistical system. One of the key variables in the transfer option calculation is volatility. In this case, volatility represents uncertainty in spot deliveries in forward months, which is a direct reflection of forward shipping demand. The base volatility is 15%. Other market participants differ with respect to this variable.

Major exporters would have less volatility in their shipping demand. Domestic processors have little or no uncertainty of forward shipping demand. Their production processes are quite stable and resource requirements do not fluctuate with current market conditions.

From the base of 15%, sensitivity was conducted moving in 5% increments in both directions. This adjustment generates results for volatilities from 5% to 30%. For illustration purposes, 10% represents an exporter, while 5% represents the domestic processor. The higher numbers were included to represent other participants who have more volatile shipping demands.

The results are presented in Table 5.3. Since volatility is contained in the option formula, the numbers represent the entire option value in absolute dollars. As volatility increases from 5% to 30%, the option value increases from $3.77 to $1100. These values translate into a $0.04 and $11/car basis. There is a direct relationship between volatility and option value. This is consistent with information presented in Hull, "An increase in volatility will cause an increase in the value of a European put" (1998, 195).

As shipping demand becomes more volatile, the transfer option becomes more valuable. However, the results should not encourage excess purchasing of cars for the sake of capturing profits in the secondary market. There is the possibility of not being able to match with a buyer, in which case the primary owner would forfeit $300.

Secondary Market. The secondary market provides a means for shippers to trade excess capacity in the rail market. Transferability is a key feature of the mechanism design, as it allows shippers the ability to obtain some market value for cars that they cannot use. If they are unable to sell them, they are forced to cancel the shipment at a charge of $300/car. In this instance, the secondary market allows shippers the ability to minimize their loss.

The secondary market distributions for the base case were derived from an existing data set. Only three years of data were available for the secondary market. Commodity

Table 5.3. Sensitivity Results: Average Option Value

Parameter	**Value**	**Option Value ($/car)**
Volatility	5%	0.04
	10%	1.17
	15%	3.21
	20%	5.67
	25%	8.20
	30%	10.96
Time to Maturity (months)	3	2.98
	4	3.18
	5	3.21
	6	3.14
	7	3.08
	8	3.06
	9	3.03
Risk-free Interest Rate	6%	4.80
	8%	3.95
	10%	3.21
	12%	2.57
	14%	2.03
Strike Price (% Expected	50%	1.01
Transport Need Contracted)	75%	2.07
	100%	3.21
	125%	4.23
	150%	5.48

market conditions varied over these three years, which resulted in wide fluctuations in the secondary market for rail across the time frame. The distributions were assumed normal with the estimated mean and standard deviation. The mean was kept the same, while the standard deviation was allowed to fluctuate from 75% to 125% and 150% of base.

The average standard deviation for the entire option value in the base case is $41. This deviation decreases to $27 at the 75% level, while it increases to $45 and $54 at 125% and 150%, respectively. This sensitivity provides analysis of risk in the secondary market and its effect on the option value.

Time to Maturity. Time to maturity was also evaluated. The standard contracts are based on 3-6 month contracts depending on the carrier. The base case represents a 5-month period. This time component was varied from 3 months to 9 months. Results indicate the high to be at the 5-month level. The relationship between European put and call options and expiration date is not certain (Hull, 1998).

Risk-free Rate. The effects of changing interest rate were also analyzed. The base case represents an interest rate of 10%. This rate was evaluated from 6-14% in 2% increments. As the risk-free rate increases, the value of the European put declines. The option value declines from $485 at 6% to $206 at 14%. Hull indicates an inverse relationship between risk-free rate and European put value (1998).

Strike Price. The strike price in this example is defined as the cars contracted for delivery. The base case represents a situation where the shipper contracts 100% of the expected inventory position with guaranteed cars. The strike price was modified to represent a more flexible shipping strategy. The percentage contracted was varied from 50% to 150% of expected inventory position. Intuitively, contracting more than necessary allows more access to the secondary market. Results indicate that, as strike price increases, the option value increases. Hull indicates a direct relationship between strike price and European put value (1998).

Guarantee Component

This section outlines the simulation scenarios conducted on the guarantee component of the model. Areas examined are carrier performance, guarantee level, market penalty, market spread, and additional risk. Results are presented on an average basis. The combined results are presented in Table 5.4.

Carrier Performance. One purpose of developing the guaranteed mechanisms for shipping grain was to allow for more efficient planning by railroads. The idea behind the auction-based contracts is to facilitate a market where the shipper who has the highest perceived value, as reflected by the bid, receives cars first. The basic concept is the general tradeoff of cost and service. The contract provides for increased reliability of service, usually at a higher cost than the non-guaranteed movement.

Railroad performance is a stochastic variable in the model. Probability distributions were estimated for each type: General Tariff, auction-based (short-term), and the long-term contractual arrangement. The distributions in the base case represent a time period in which few shippers were moving grain due to a larger than normal carry in the market (August-October 1998). Performance was quite reliable during this period. The value of a guaranteed contract is a function of the relative performance of guaranteed versus non-guaranteed movements. Therefore, the annual average guarantee value in the base case is Table 5.4. Sensitivity Results: Average Guarantee Value

Parameter	**Value**	**Guarantee Value ($)**
Railroad Performance (days added to general service)	15	490.80
	30	853.24
	45	1298.83
	60	1585.38
Guarantee Level (RR Non-performance penalty: $/car)	200	397.61
	300	417.18
	400	436.75
	500	456.32
Destination Penalty(c/bu/15 days)	0	77.75
	4	197.15
	8	316.54
	12	435.94
Market Spread(c/bu/month)	-12	869.99
	-4	631.20
	4	392.40
	12	153.61

quite small, at only $-1.26. These distributions were adjusted to represent tighter shipping periods, where the performance is not as reliable. The distributions were adjusted by adding a certain number of days onto the end of the distribution (i.e., =Risknormal(5,2) + 5). This adjustment has the effect of keeping the same shape of the distribution, while shifting the mean to the right. It was assumed the guaranteed mechanism would receive priority over any non-guaranteed contracts. Six days were added to the distribution for COT performance, while the General Tariff was shifted by 15, 30, 45, and 60 days. The results indicate a much higher value for the guaranteed movement under such performance periods.

A simple annual average was calculated as the output. By adding the large numbers to the General Tariff distribution, payoffs were defined for each level based on 15-day periods. Each additional period caused more storage, interest, and demurrage charges. As a result, the later the cars were, the larger the guarantee value was. The annual average moved from $-1.26/car in the base case to $491/car with 15 extra days. It increased to $853 and $1298 at values of 30 and 45 extra days. With performance being shifted by 60 days, the guarantee value was $1585/car.

Railroad Penalty. Designers of railroad mechanisms examine the inherent components of these contracts on a continual basis. Certain conditions might arise where they feel a need to adjust them. A key feature of the guarantee contracts is the non-performance penalty imposed on the railroads if the cars arrive after day 15. The penalty is incorporated into the shipper’s payoff function after that time period. Essentially, the penalty is designed to alleviate some of the market penalties the shipper would be faced with in that situation. If the guarantee level increases, the guarantee value associated with the contract should also increase.

Sensitivity analysis was conducted to examine this relationship using the range of $200-600/car, in increments of 100. Rail performance has to be somewhat poor in order for these penalties to be incorporated into the analysis. The distributions for performance were shifted for both the guaranteed and non-guaranteed instruments, by 6 and 12 days, respectively.

The base case is the current penalty imposed by BNSF in its COT market, $400. Results indicate a direct relationship between the guarantee level and guarantee value. At $400, the guarantee value is around $436/car. A $200/car penalty results in a guarantee value of $398/car. The $600/car penalty yields a value of $476/car.

Market Penalty. Another risk that a shipper is faced with is a market penalty should the grain not arrive at destination on time. The buyer can assess a penalty based on a market movement between when the grain was to arrive and when it actually arrives. As this value increases, the guarantee value should also increase. Again, rail performance was shifted to see the true effects.

Sensitivity was conducted using values from 0-14 cents per bushel for every 15-day period. The results indicate a direct relationship between the two. For each additional 2c/bu increase, the guarantee value increases by approximately $60/car. At zero, the guarantee value is $77/car. At 15c/bu, the value is nearly $500.

Market Carry/Inversion. A major component in the calculation of the guarantee component is the difference between a nearby and deferred market. Intuitively, if there is a severe market inversion, shippers are being penalized for storing grain. Instead, they should be shipping any stocks on hand. In this situation, a guaranteed mechanism would be much more valuable because the shipper can take advantage of the current price level. An inversion would lead to a tight shipping period, in which guaranteed mechanisms would receive priority over non-guaranteed shipments.

On the other hand, the market could be characterized by a large carry, or incentive to store grain. In this situation, it is more profitable to store grain now and sell it at a later date. A large carry occurred in the 1998-99 data which is presented in the base case. The distributions used for railroad performance represent this type of market, when little grain is shipped. Wilson and Dahl present this logic as well (1997).

Sensitivity was conducted to reflect varying degrees of the carry and inversion in the market. Rail performance is adjusted by 6 and 12 days for guaranteed and non-guaranteed shipments once again. The analysis examines 7 different markets; the carry is set at -12 cents/bushel/month and increases to -8, -4, 0, 4, 8, and 12. The negative carry represents an inverted market. The results are presented in Table 5.4. The average guarantee value is greatest with the 12 cent inversion at $870, while the large carry of 10 cents results in a value of $153.

Additional Risk. The guarantee component is discounted at the risk-free rate. However, there may be additional risk contained in the transaction. The discount rate was adjusted to reflect for such situations. The interest rate was varied from 6% to 14% in 2% increments. Additional risk was then added (.005%, 2%, and 3.5%). Results indicate an inverse relationship between the interest rate and the present value of the guarantee component.

However, the effect is quite small due to the short time frame involved. The results are summarized in Table 5.5.

Summary

Simulation analyses served as a method to examine relationships between the option value and guarantee value associated with guaranteed shipments of grain as elements of uncertainty vary. Some general trends were identified as the parameters were adjusted.

The option calculation component of the model was checked against option pricing literature. The effects of changing volatility, strike price, interest rate, and time to maturity are all consistent with the relevant literature. As volatility increases, the value of a European put increases. There is a direct relationship between strike price and option value. The risk-free rate and option value are inversely related in this case. The time to maturity relationship is uncertain with a European put.

Sensitivity analysis was conducted on parameters characterizing a grain shipper. As the volatility for shipping demand increases, the value associated with the transfer option also increases. Certain market participants are able to utilize the secondary market to trade excess shipping capacity (Coffin, 1999). The inter-month spread was also analyzed. In the base case with 1998-99 data, there was a significant carry in the market. A large carry signals shippers to store grain to capture increased price levels in the future relative to the current market. In this case, the value of a guaranteed mechanism would be lower because a non-guaranteed mechanism would actually provide for a higher received price when it

Table 5.5. Sensitivity of Risk Adjustment on Guarantee Value/Max Bid

	Interest Rate		
Risk Adjustment	**6%**	**8%**	**10%**
.05%	177.95	174.12	170.33
2.0%	176.80	172.98	169.20
3.5%	175.65	171.85	168.08

arrives later. Results show this inverse relationship between market carry and guarantee value. Market penalties were selected to measure their effect on the guarantee value. There is a direct relationship between the market penalty and guarantee value. However, the effect is minimal.

Further sensitivity was conducted to measure the effect of parameters of the underlying railroad contracts. The secondary market exists as a means for shippers to trade excess capacity in the form of forward rail transportation. The bids in the secondary market can be interpreted as a generic measure of shipping demand. Therefore, they are dependent on grain market conditions. Each month was evaluated to capture any seasonality effects. The distributions for the market value were adjusted to examine the effect of changing their standard deviations. The secondary market value has a direct relationship with the option value calculated. The standard deviation of option value increases with the increase in standard deviation of the secondary market value.

Railroad performance was also adjusted to reflect varying levels of shipping conditions. As the service reliability decreases, the value of the guaranteed contract increases relative to the non-guaranteed position. The guarantee level of the railroad was also adjusted with the poor performance distributions. Analysis revealed a direct relationship between the guarantee level and the guarantee component.

CHAPTER 6
SUMMARY AND CONCLUSIONS

Review of Problem

Grain shippers are faced with numerous forms of uncertainty when planning logistical strategies. When grain is shipped, the first decision made is what mode to ship by. The most common modes in the upper midwest are truck and rail. Rail is usually cheaper, but is less reliable than truck. Therefore, shipping via rail requires detailed planning of operations.

Railroads have been scrutinized for providing poor service to their customers. During times of high shipping demand, it becomes difficult to move expanded grain demand in a timely fashion. Grain that is stored on the ground will remain there until the bottlenecks can be alleviated. All major rail carriers have responded to this criticism by adopting innovative guarantee contracts that improve reliability and entice more shippers to utilize their service.

Each carrier has some form of general service. These contracts are offered without any guarantee component. There are two other forms of guaranteed service, short- and long-term arrangements. Typically, short-term contracts are for 3-5 months forward and auctions are used to allocate cars to the shippers. Long-term contracts are monthly obligations for as far forward as 3 years. Shippers are obligated to move a certain amount of grain each month, while the rail carrier is obligated to provide the cars to do so.

It is important for each party to know the value of these instruments. The shipper has to have some way to calculate the value to make an informed decision in bidding or negotiation. At the same time, railroads have to know the value of underlying features of the mechanisms, so they can adjust them if necessary.

Transferability is key component of these instruments. It allows shippers access to sell excess cars in the secondary market. Option pricing theory can be applied as a valuation procedure. The transfer option can be compared to a European put option on stock. Without transferability, shippers would accrue large cancellation penalties if capacity planning mistakes occur. Less shippers would be inclined to use this type of service with that additional risk.

Objectives

The objective of this research was to evaluate guaranteed forward railcar shipment mechanisms using option theory. Specific objectives were to 1) Evaluate alternative valuation techniques for shipment mechanisms; 2) Develop a model to depict the value of guarantee mechanism to shipper; 3) Analyze the interaction between key components of these mechanisms and how they affect the value of the guarantee; and 4) Compare different mechanisms, options, and features.

Procedures

In this thesis, a stochastic simulation model was developed and used to evaluate key features of guarantee mechanisms in the shipment of grain. Literature from railroad guarantee mechanisms and real options framework was used to develop a model of a typical grain shipper and an expected annual net payoff function. The model was designed in a Microsoft Excel format compatible with @Risk stochastic simulation software. The simulation model contained distributions to represent railroad performance as well as secondary market values. Simulations were used to capture seasonality effects by generating contract values for each month.

The two key components of the model are transfer option value and guarantee value. The option value is calculated using a lattice framework centered around producer spot deliveries. In the final period, the shipper examines the inventory position and relevant transportation position. Any excess cars are transfered to the secondary market. This payoff is then discounted at the risk-free rate to calculate the present value.

The guarantee value is calculated as the difference between the payoff of a guaranteed and non-guaranteed shipment. Railroad performance distributions determine whether each type of movement is on time. If both are within the 15-day time frame, the derived value is zero. As service reliability for the non-guaranteed mechanism declines, the guarantee value increases.

Sensitivity analysis was conducted to reflect the influence certain parameters have on the option value and guarantee value. Volatility was selected to represent differences in shipping demand across market participants. Other option variables, such as interest rate, time to maturity, and strike price, were also evaluated. The secondary market distributions were adjusted in the analysis.

Sensitivity analysis was also conducted on variables which contribute to the guarantee component. Rail service reliability was adjusted to reflect changes in shipping conditions. The guarantee level offered by the railroad was also evaluated. Inter-month spreads were adjusted to reflect different market conditions. Market penalties are included in the analysis to represent penalties imposed by destination markets for late grain.

Review of Results

Simulation analyses served as a method to examine relationships between the option value and guarantee value associated with guaranteed shipments of grain as elements of uncertainty vary. Some general trends were identified as the parameters were adjusted.

The option calculation component of the model was checked against option pricing literature. The effects of changing volatility, strike price, interest rate, and time to maturity are all consistent with the relevant literature. As volatility increases, the value of a European put increases. There is a direct relationship between strike price and option value. The risk-free rate and option value are inversely related in this case. The time to maturity relationship is uncertain with a European put.

Sensitivity analysis was conducted on parameters characterizing a grain shipper. As the volatility for shipping demand increases, the value associated with the transfer option also increases. Certain market participants are able to utilize the secondary market to trade excess shipping capacity (Coffin, 1999). The inter-month spread was also analyzed. In the base case with 1998-99 data, there was a significant carry in the market. A large carry signals shippers to store grain to capture increased price levels in the future relative to the current market. In this case, the value of a guaranteed mechanism would be lower because a non-guaranteed mechanism would actually provide a higher received price when it arrives later. Results show this inverse relationship between market carry and guarantee value. Market penalties were selected to measure their effect on the guarantee value. There is a direct relationship between the market penalty and guarantee value. However, the effect is minimal.

Further sensitivity was conducted to measure the effect of parameters of the underlying railroad contracts. The secondary market exists as a means for shippers to trade excess capacity in the form of forward rail transportation. The bids in the secondary market can be interpreted as a generic measure of shipping demand. Therefore, they are dependent on grain market conditions. Each month was evaluated to capture any seasonality effects. The distributions for the market value were adjusted to examine the effect of changing their standard deviations. The secondary market value has a direct relationship with the option value calculated. The standard deviation of option value increases with the increase in standard deviation of the secondary market value.

Railroad performance was also adjusted to reflect varying levels of shipping conditions. As the service reliability decreases, the value of the guaranteed contract increases relative to the non-guaranteed position. The guarantee level of the railroad was also adjusted with the poor performance distributions. Analysis revealed a direct relationship between the guarantee level and the guarantee component.

Implications

This analysis provides a valuation procedure for developing a forward transportation position when shipping grain. The focus involves a comparison of expected payoffs when shipping with and without a guaranteed mechanism. Another component is the transferability characteristic. The secondary market allows a shipper some flexibility by providing a channel to sell excess cars. This study provided a greater understanding of factors which contribute value to the guarantee component, such as market conditions and railroad service reliability. It also explored an application of real options methodology. The information can be used by grain shippers and railroads.

Shippers

Shipping grain requires working knowledge of current market trends, forward inventory positions, rail service reliability, and relevant cost components. Moving grain in peak demand periods necessitates careful planning from an operations perspective. General service contracts may be sufficient during off-peak periods, but shippers need to be able to fully assess the situation to make an informed decision.

Railroads

Railroads must constantly evaluate the efficiency of underlying features of each type of guaranteed instrument. It is important to understand the value contribution for these components so that they can be changed if necessary. The key variables are cancellation penalties and non-performance penalties. Another area of concern is the shipping window. Currently, a 15-day window is used and defined as first-half and last-half of the month. However, BNSF has indicated plans to implement 3-10 day periods each month. This modification may have an effect on the instrument value.

Limitations of Study

This research served as an exploration of real options methodology as it applies to forward guaranteed transportation contracts. Relationships between market prices, railroad performance, inventory positions, and cost components were captured. There are some limitations that restrict its real-world application.

The data used in the research is a limitation. The monthly inventory positions were derived from aggregated data for all unit train facilities in North Dakota. The secondary market data represent average monthly bids for 1996-1998. More observations would improve the validity of the data. Railroad performance distributions were derived using three months of data from 1998 (August-October). These data represented a period of high service reliability and were, therefore, adjusted in sensitivity analysis to account for less than optimal performance.

The option framework has its limitations as well. When applying option pricing theory, it is important to select one area of uncertainty. It is difficult to distinguish a single variable in this case. For purposes of the research, producer spot deliveries were chosen. The results of the option value procedure are not entirely applicable but do provide a standardized comparison for seasonality in the market. There are other areas that could be explored using this type of approach.

Need for Further Research

The option-based framework of the analysis could be applied to other components of the problem. Transferability was examined in the case of the shipper having excess cars. However, there is the case of being short cars as well. A shortage of transportation would create a carry-over of stocks to the next time period or require the purchase of additional cars in the secondary market. The features of the long-term agreements characterize them as a compound sequential option. The valuation of this type of option is difficult and requires in-depth analysis. This type of option application is currently being explored in numerous areas and will continue to provide alternative techniques for analyzing business decisions.

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