Agribusiness and Applied Economics Report No. 794 January 2020

Dynamic Changes in Rail Shipping Mechanisms for Grain

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ACKNOWLEDGEMENTS

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ABSTRACT

Grain shipping involves many sources of risk and uncertainty. In response to these dynamic challenges faced by shippers, railroad carriers offer various types of forward contracting instruments. An important feature of the US grain marketing system is that there are now a number of pricing mechanisms used by most rail carriers. These include varying forms of forward pricing and allocation mechanisms. In the United States, these have evolved since the late 1980's and have had a number of important changes in their features over time. The operations and impact of these mechanisms are not well understood, but yet are frequently subject of public criticism and studies, and at the same time revered by (some) market participants. These mechanisms serve a number of important functions that are critical to the grain marketing system. These include allocating capacity across shippers, allocating shipments temporally and seasonally, as well as geographically, in addition to determining price or value of the service.

The purpose of this study is to provide a comprehensive review, description and analysis of these mechanisms. Specific objectives are to 1) Document the evolution and operations of these mechanisms over time and across carriers; 2) Determine and describe the impacts of these practices on basis, both spatially and temporally, and on trading firms and other market participants; and 3) Summarize and assess the operations on these mechanisms relative to alternative pricing mechanisms.

Multiple empirical models were developed and used to analyze two important aspects of this problem. One is the role and relationship of the shipping costs on basis values. These results show that basis is more complicated than previously modeled. Export basis are mostly impacted by export competition, imports, and the seasonal characterization varies across marketing years. In addition, the export basis is simultaneously dependent on the origin basis. Last, there is an important relation among rail velocity, and the secondary car market, which is simultaneously determined with the export basis. Other models examine the impact of these mechanisms on shipper conduct, specifically, how risks and rail mechanisms impact shipper strategies. The last section provides a discussion of summary and conclusions, and of future issues.

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INTRODUCTION

In response to the dynamic challenges faced by shippers, railroad carriers have developed various forward contracting instruments. An important feature of the US grain marketing system is that there are a number of pricing and allocation mechanisms used by most rail carriers. These include varying forms of forward pricing and allocation mechanisms. In the United States, these have evolved since the late 1980's and have had a number of important changes in their features over time. Operations and impacts of these mechanisms are not well understood, but yet are frequently subject of public scrutiny and studies, and at the same time revered by (some) market participants. These mechanisms serve a number of important functions that are critical to the grain marketing system. These include allocating capacity across shippers, temporally/seasonally, geographically, in addition to determining price or value of the service.

The purpose of this study is to provide a comprehensive review, description and analysis of these mechanisms. Specific objectives are to 1) Document the evolution and operations of these mechanisms over time and across carriers; 2) Determine and describe the impacts of these practices on basis, both spatially and temporally, and on trading firms and other market participants; and 3) Assess the operations of these mechanisms on shipper behavior.

In the first section below, we provide background information, and a summary of previous studies. Then, the report provides a detailed description of the pricing mechanisms currently being used in the United States. In the following sections we present results of multiple empirical models which were developed and used to analyze two important aspects of this study. One is the role and relationship of the shipping costs and performance on basis values. These results show that basis is more complicated than previously modeled. Export basis are mostly impacted by export competition and imports, in this case by China and the seasonal characterization varies across marketing years. In addition, the export basis is simultaneously dependent

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[1] This project was funded as a USDA/AMS Cooperative Agreement # 16-TMTSD-ND-0004.

This report includes a project summary of four other separate research reports. These include:

Prithviraj Lakkkakula and W. Wilson. 2020. Origin and Export Basis Interdependencies in Soybeans: A Panel Data Analysis, *Journal of Agricultural and Resource Economics*, .*(forthcoming).*

Prithviraj Lakkkakula and W. Wilson. 2019. Simultaneity of Basis and 2nd Car Market Values, Department of Agribusiness and Applied Economics Report No. ___*(forthcoming).*

Bullock, D. and W. Wilson 2019. Factors Impacting the Export Basis for Soybean, Department of Agribusiness and Applied Economics Report No. 788 and paper presented at the 2019 NC134 Annual Program, Minneapolis, April 2019.

Landman, D. and W. Wilson. 2019. Real Option Values of Rail Car Guarantees, Department of Agribusiness and Applied Economics Report No. ___ *(forthcoming).*

Klebe and Wilson, 2019 Optimal Grain Purchasing Strategy Under Risk, 2019, North Dakota State University.

[2] Constructive comments on an earlier version were from Dr. Siew Lim, North Dakota State University.

on the origin basis. Last, there is an important relation between rail velocity, and the secondary car market, which is simultaneously determined with the export basis. The other analysis examines how these mechanisms impact shipper strategies. The last sections of the report provide a discussion of summary and conclusions, and of future issues.

BACKGROUND AND PREVIOUS STUDIES

Background

Increased volatility in the market for railcars has required grain shippers to pay more attention to their car ordering strategies. Their approach to ordering railcars can be the difference between efficient commodity movement through the supply chain, or piles of grain sitting on the ground. This can be due to the shipper not having enough storage, not having enough cars ordered to meet their shipping demand, or that the cars they ordered being late. In response to these numerous risks, railroad companies developed various contracting instruments. These transaction mechanisms (contracts) differ across carriers and change over time. Among these contract agreements are different terms and conditions, some of which provide shippers with managerial flexibility (i.e., the option to transfer).

In an industry as dynamic as grain merchandising, managers face many decisions, and each of these involves some level of risk. When it comes to ordering railcars, there are various sources of uncertainty that affect returns to a shipper. Among many, three of the major sources risk are: 1) farmer deliveries (i.e. and therefore, inventory levels) are random and risky, 2) prices of railcars in the secondary market change daily, and 3) railroad performance.

The first issue results in random inventories, and stems from the fact that farmers are somewhat unpredictable in the timing of their grain deliveries. Anytime a shipper is long (short) grain, they are short (long) freight, and therefore exposed to risk or price changes and rail performance. Although elevators offer a variety of contracts to producers that ensure grain delivery during a given timeframe, a large portion of farmer sales are the result of “cash” or “spot” deliveries.

Due to that some railroad carriers offer yearlong contracts means that elevator mangers must make car ordering decisions months or years in advance to ship inventory that they are unsure they will have. Alternatively, if a shipper does not order enough cars, they may not be able to move grain in a timely manner.

The second major source of logistic uncertainty is that prices for rail service fluctuate (depending on the carrier and pricing mechanism). Rail rates are comprised of three elements: tariff, primary auction price, and/or the secondary market rate.[3] A shipper who forward contracts cars directly with the rail carrier pays the tariff and the primary auction price. Shippers who do not forward contract with the railroad, and instead utilize cars on an as-needed basis, pay the tariff and secondary market value. Volatilities of tariff rates and primary auction rates are negligible, but secondary market rates fluctuate significantly.

[3] These are in addition to fuel service charges (FSC) which application varies across carriers. This impact is not included in this study.

The tariff rate is the base cost to ship trains to a destination. Each carrier has their own specific pricing mechanism, but in general, primary market shippers pay a premium over the tariff to reserve cars. Most carriers utilize auction allocation systems that award rail service to the highest bidder. However, this premium is usually minimal and does not vary much.[4]

A third major source of risk that grain shippers face is railroad performance. Other studies have referenced this phenomenon, using different terms such as efficiency, late car placement, car performance, trips per month, and velocity, among others. Rail performance is important since it ensures efficient grain flows in a timely matter.

There are many reasons that railcar performance can fluctuate. It can be short-term factors, such as inclement weather, or other factors like track congestion and unexpected changes in demand. The American Association of Railroads uses a measure called "revenue ton-miles per train-hour" that is a composite measure of train speed and revenue tonnage. While these methods are good indicators of railroad performance from a business standpoint, grain elevators are concerned about performance in terms of on-time arrival of railcars, which is noted by the Surface Transportation Board (STB). Each week, all major U.S. carriers submit a report to the STB detailing, among many other things, how many cars are late (outstanding orders) and the average number of days late for outstanding car orders. This metric detail how many cars have been ordered for a specific delivery window and are currently late. This is important as it provides transparency to railroad efficiency measures.

A common metric used to indicate performance is "trips per month" (TPM) or velocity. The TPM determines how many cars are needed to fill in a given month based on how many shuttle round trips are expected. Velocity, or TPM, is an important variable that is discussed more later in this report.

The fact that numerous factors impacting shipping demand are random, including basis, farmer sales and deliveries, shipping costs, and car placement, requires shippers to strategically plan out their shipping demands based on forecasted levels of grain supply and demand. Not only are railcar prices uncertain, the probability that railcars are placed when needed by the elevator changes over time as well. Another source of uncertainty lies in the fact that elevators cannot predict the amount of grain that farmers deliver. This means that not only are shipping costs uncertain, but inventory levels are also random. These factors, along with other sources of risk, require shipper managers to carefully plan out their railcar ordering strategy.

[4] As an example, in early October of 2016 when heavy rains and snowfall caused service disruptions in Montana. In a podcast to shippers, John Miller of BNSF explained that these storms caused rail tack switching mechanisms to malfunction and power outages to occur, which forced delays to some trains. In addition, BNSF crews and maintenance teams had difficulty getting to the affected areas due to white out conditions caused by the storms. Since Montana is a key shipping corridor to the Pacific Northwest, this caused a delay in service and secondary market prices shot up to $1,675 over tariff.

By comparison, Union Pacific's cars, which were not affected by the storm, were trading at $100 under tariff during the same time. To put that into perspective, that is a 45 cent/bushel difference in service prices that shippers under each carrier would have to pay, mainly due to adverse weather conditions (R. J. O'Brien, 2016).

Previous Studies on Rail Pricing Mechanisms

There have been several strains of research on rail pricing mechanisms. Each are discussed below.

Deregulation and Railcar Allocation Mechanism Design and Pricing

A number of studies analyzed impacts of deregulation on rail demand and pricing. Wilson and Wilson (2001) analyzed the innovations in rail pricing and examine the behavior of rail rates from 1972–1995, using a nonlinear regulatory adjustment mechanism to represent the effects of partial deregulation. Results indicated that rates fell dramatically over time, and there are differences across the commodities in magnitude. They also found that the effect of partial deregulation on rates and productivity, while large, dissipates over time. Miljkovic (2001) analyzed rail pricing practices to determine differences across railroads and export destinations. Results indicated that rail demand equations are positively influenced by the barge rates.

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

Wilson and Dahl (2005) analyzed the impacts that guarantee mechanisms have on the grain industry. They provided a description of the evolution of these mechanisms, and how they impact shippers. Other studies had concluded that auctions are effective in car allocation. Wilson and Dahl (2015) highlighted the fact that each shipper would have a different bidding strategy. They further highlighted the importance that informational advantages have in competition between elevators.

Rail Pricing and Logistical Supply Chain Management

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

Wilson, Carlson, and Dahl (2004) demonstrated that shippers who utilize forward freight are provided with better service reliability, and that managers need to take rail performance into account when making car ordering decisions. According to the study, "…. demurrage costs can be reduced by adopting the anticipatory strategy. In fact, ordering cars naively and ignoring railroad performance, results in higher costs."

Previous Studies on Basis in the Grain and Oilseed Sector

There are several strains of literature related to this study. One is the empirical analysis of basis. There have been numerous studies on basis behavior, and factors impacting its behavior. Second is the impacts of rail (transport) on basis values. While historically these have not been so common, there were a number of studies on this topic concurrent with and following the 2013/14 marketing year.

Basis at the Futures Delivery Market

As a precursor to some of the empirical analyses of the basis, it is important that the basis has a highly predetermined behavior when evaluated at the delivery market of the futures contracts. This is fundamental to the studies that follow.

The basis at the delivery market has a prescribed behavior which typically evolves in response to arbitrage pressures. Each futures market has a predetermined delivery charge. Due to arbitrage pressures, typically this basis converges to the delivery charge during the delivery option month.[5] Simply, due to arbitrage, it is expected that during the delivery period (or on the first day of delivery), $B_d = DC_d$ where B is basis, DC is the delivery charge and d is a subscript referring to the delivery market, d. In periods prior to delivery, the basis may fluctuate, but, generally conforms to the cost of storage from the period prior to delivery, until delivery occurs in which case the storage costs are nil.

In addition to this relationship, intermonth price spreads (i.e., the difference in futures between successive delivery months) reflect the cost of storage and are impacted by the supply and demand for space. There is an elaborate theory explaining these market structures. Equilibrium intermonth price differentials are largely determined by the supply and demand for storage. This relationship is fundamental to most commodity market analysis.[6] Hieronymus summarizes these concepts:[7]

…the nearby basis and spreads boil down to the supply and demand for space. When stocks at the terminal are large and grain is flowing to market rapidly, the cash price is weak in relation to the nearby futures and spreads are wide. But when stocks are small, the commodity is flowing to market slowly, and demand for shipment is vigorous, the price of storage decreases.

And, Leuthold, Junkus and Cordier (1989) indicated:

…the basis along with price spreads among futures contracts indicate the availability of commodity stocks. Large bases and price spreads represent either an abundance of

[5] The delivery process is described in Klemme, Peck and Williams (1991), Coyle (2007), and Adjemian et al (2013).
[6] This was illustrated in early writings on this topic including Working (May 1949), and followed by Gray, R. and Peck,A. ((1984), and many others.

[7] Hieronymus (1971), *op. cit.* at 160.

stocks, or that the future market is providing an incentive to store the commodity for later release. Small or negative bases and price spreads associate with a shortage of stocks. The market is signaling for the release of stocks ….

There are a couple compounding factors that impact this general behavior. One is the introduction of the variable storage rate (VSR) for Chicago contracts. During the 2008-2010 time period, the cash price for SRW wheat in Toledo was significantly below the futures price at expiration (i.e., a weak basis) – more than $2.00 at one point. This meant that commercial end-users of wheat for years could buy wheat for below the futures prices. [8]

In response, and with industry consultation and CFTC approval, the CME created the VSR as a mechanism to encourage better convergence, implementing it with the July 2010 contract.[9][10] The VSR "is a market-based determinant of maximum allowable storage charges for outstanding wheat shipping certificate." Greater maximum allowable storage rates are triggered to allow greater storage returns when intermonth spreads are wide. And, the maximum allowable storage charge is reduced when the inter-month spreads are narrow or inverted. After implementation of the VSR and other improvements to the contract, the performance of the contract improved significantly.

The concept of convergence is focused on the basis behavior at the delivery market. For other locations, there are a number of other factors that are important and do not necessarily adhere in any way to a normal converging pattern. For locations other than the delivery market, there are a number of important factors that vary temporally and spatially. These include spatial competition, discounts for quality, handling and shipping costs all of which are not fixed for locations away from the delivery location.

Factors Impacting Basis at Non-delivery Locations

Other studies have explored the behavior of the basis and to assess factors impacting its variability. An early study by Taylor and Tomek (1984) developed an econometric model to forecast the corn basis at a specific location in New York. They found that U.S. production, feed deficit in New York and open interest were each significant in explaining the basis. However, the model was limited in usefulness in that the explanatory variables were not easily predicable.

Parcell (2000) analyzed the impact of the Loan Deficiency Payment (LDP) program in Missouri on corn and soybean basis. Their econometric model includes lagged basis, futures, days to expiration, and location dummy variables, among others. Results indicated the LDP had only a minor impact on local basis values. Lara-Chavas and Alexander (2006) used an event study to assess impacts of Hurricane Katrina on the basis for corn, soybean and wheat. They found that Katrina had a larger impact on wheat futures than the other markets. Generally, they found an absence of abnormal returns in futures and basis for this market. They provided a number of explanations including that only logistics was affected, not the supply and demand for the

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[8] Seamon (2010); Adjemian, M., Garcia, P., Irwin, S. and Smith, A. (2013).

[9] The VSR is described in detail in CME Variable Storage Rates (VSR), http://www.cmegroup.com/trading/agricultural/grain-and-oilseed/variable-storage-rate.html.

[10] Adjemian, et. al, *op. cit*. at 8–16.

commodity. Finally, Zhang and Houston (2005) analyzed how soybean production in South America and futures volatility impacted the basis. Though not exactly clear, it appears the basis they analyzed is the "basis of the spot market located near the CBOT." Their model found that both of these variables had a negative impact on the basis.

These studies relate to the current analysis in two respects. First, while Lara-Chavas and Alexander (2006) rejected the impacts of Katrina on markets, they did allude that it may have impacted the transportation and logistics sector. Second, Zhang and Houston found that South American production had an impact on the basis near the CBOT futures market. Our model focuses on each the impacts of transport and logistics on basis, as well as the impacts of Brazil on the export soybean basis.

Export Basis

Some studies have analyzed basis variability at specific locations away from the delivery market. Tilley and Campbell (1988) analyzed the US Gulf HRW basis. They found that the weekly variability was mostly explained by exports, free stocks, and the grain embargo. These were in addition to selected monthly variables included to capture seasonality in the basis. Notably shipping costs were not included in that analysis.

Haigh and Bryant (2000) analyzed the effect of barge and ocean freight price volatility in international grain markets using a Vector Error Correction GARCH-in-Mean model. Results indicated both barge and ocean price volatility influence grain prices. However, barge price volatility's impact is greater on both grain prices and marketing margins compared with ocean price volatility. Miljkovic, Price, Hauser, and Algozin (2000) sought to determine the factors that influence the grain exports from the Midwest and Mexican Gulf using a 3SLS (Three stage least squares) model of a system of 4 equations (each pair of supply and demand equations). The results indicated that lagged dependent variables coefficients show that they are significant in explaining both barge and rail demand. Export-related variables show no significance in demand equations but a minor influence in supply equations. Seasonality may not play an important role.

Another related and more recent study included all these variables, notable export and origin basis, in addition to shipping costs to evaluate spatial arbitrage opportunities in soybean (Skadberg et. al 2015). Export locations at the US Gulf and PNW were included, and origin basis at a large number of interior origins. Shipping costs from each origin to destination included rail tariff rates, fuel service charges and 2nd market values for rail shuttles. The model was specified as a spatial stochastic optimization model using copula distributions to determine the most likely spatial arbitrage opportunities. Copula distributions were used and accounted for the interrelations among basis values and shipping costs, implied in some other studies. The model explicitly captures the relation between origin and destination basis, and shipping costs, in addition to spatial arbitrage and competition, as well as the interdependencies among these values, and risks. Several results are fairly important. Origins in the upper Midwest have become highly dependent on the Pacific Northwest as a destination market. Second, arbitrage payoffs vary regionally. The results show how vertically integrated trading firms can capitalize on spatial-arbitrage payoffs. Finally, impacts of 2nd car markets are illustrated.

Impacts of Rail (Shipping Costs) on Basis, Shippers and Producers

A number of studies have been conducted with the goal of examining the relationship between rail prices and basis levels/prices to producers. Wilson and Dahl (2011) was one of the first studies analyzing the interrelationships between basis and shipping costs. They found that basis has become more volatile over time, and is impacted by factors such as shipping costs, ocean rate spreads, export sales, railroad performance, and others. In addition,

(1) all marketing costs had increased;

(2) increases in rail tariffs were less than those for barges;

(3) 2nd car market values, on average, declined;

(4) fuel service charges had moderate changes in absolute terms; and

(5) handling margins have had fairly substantial increases, particularly at ports.

The econometric results indicate that the following variables were significant in explaining variability in origin basis values: shipping costs, Gulf-PNW ocean rate spreads, outstanding export sales, shipping industry concentration, rail performance (measured as cars late), the ratio of stocks to storage capacity, futures prices, and futures and destination spreads. These results validated other studies about increases in basis volatility and the importance of export sales on basis. It also suggested performance in rail car shipments to be less of a determining factor in basis whereas other studies found the impact to be much greater.

Rail service disruptions caused by increased traffic from competing commodities, such as oil, have been reported to have impacts on elevator prices, and has been a popular research topic. Rail performance was an issue during the 2013/2014 crop year when record supplies of grain, and increased demand for tanker cars to transport Bakken oil led to bottlenecks in grain transportation. In a report from the Burlington Northern Santa Fe (BNSF) railroad to the United States Transportation Board (STB) dated June 27, 2014, the largest railroad in North Dakota stated they had 4,942 past due cars scheduled for grain shipment in the state, and the average length of tardiness on these cars was 32 days.

There has been an ongoing debate about who is responsible for these periods of backlogs in grain shipping. Johnson (2014) stated that the consequences of these shortages were ultimately passed on to the farmer in the form of depressed basis levels. In addition to lower interior basis, bases levels increased at terminal and export markets since those shippers could not source grain and had to bid more aggressively.

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

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

These situations precipitated a number of studies on how rail performance was alleged to impact origin basis levels. Olson (2014) estimated that rail disruptions caused an aggregate loss to farmers statewide of $67 million, or a little bit over $2,000 per farm. This study did not analyze a direct relation between railroad price, performance, and basis. Rather it assumed that basis would be the same as an analogue year,[11] and then made derivations. Usset (2014) used similar methods to estimate the impact of the 2013-2014 rail disruptions on Minnesota producers. Comparing 2014 to years with similar grain supply/demand levels, he estimated that farmers lost 40 cents/bushel on soybeans, 30 cents on corn, and 41 cents on hard red spring wheat. The Agricultural Marketing Service of the USDA (2015) estimated the losses to be three percent of all farm cash receipts but acknowledged the difficulty of pinpointing the exact cause of these losses. In another resulting study for the American Farm Bureau Federation, Kub (2015), further reviewed the 2013/2014 situation, but also argued that increasing infrastructure of truck, rail, barge, or pipeline transportation would reduce congestion impacts on grain flows.

Villegas (2016a and 2016b) concluded that oil traffic, among other factors, is a determinant of wheat basis, and that this relationship is stronger in upper Midwest states, like North Dakota. Villegas (2016a and 2016b) concluded that oil traffic is a determinant of wheat basis, and that this relationship is stronger in upper Midwest states, like North Dakota. The latest major example of this phenomena in the Upper Midwest was during the 2013-2014 marketing year when increased rail demand from oil and coal led to disruptions in grain shipping. Unable to move their inventory, shippers bid less aggressively for grain.

Hart and Olson (2017) addressed impacts of transport disruptions on local basis values. Corn, soybean and wheat basis patterns were analyzed in major producing areas. A model was estimated including indicators of ethanol and livestock production, the S&P, diesel, oceans shipping costs from the US gulf to Japan, the 2nd rail shuttle value, and indicators for months, winter, drought, hurricane. Among other conclusions, the results showed that both ocean shipping costs and shuttle premiums were largely significant and had a negative impact on local basis values. The wheat analysis included basis values at Portland and Minneapolis, export sales, rail tariff rates, 2nd rail shuttle values, among others. The results showed that export and terminal basis values, as well as shipping costs impact local basis values.

These studies motivated much discussion during these years. With exception of Wilson and Dahl (2011) and Hart and Olson (2017), and for comparison to the current study, it is important that these studies really conduct 'analogue year' analysis, using an *a priori* chosen year to be the analogue. Simply, the method is to choose a single similar year, and compare the market of the current 2013/14 year to the similar year. Second, none of these studies (except,

[11] In a later section, we define and analyze the concept of analogue year in detail.

as noted, Hart and Olson 2017) included any measure of the cost of shipping in tariffs, fuel service charge's (FSC) or secondary markets, yet, they are seeking to determine the impact of shipping costs on basis values.

There were several other important facts concurrent with the study period (2013/14) included in these studies. These include:

1) USDA and the grain industry severely underestimated production in the spring of that year. Specifically, USDA and the trade all underestimated crop size in May, and in September/October USDA raised production estimates significantly for corn, soybean and wheat. Final estimates, corn, soybean and hard red spring ("HRS") wheat yield estimates increased by 2 to 3 percent, total supplies of corn, soybean and HRS wheat increased by 2, 3 and 7 percent respectively; and estimates of corn exports increased by 43 percent and estimates of soybean and HRS wheat exports increased by 14 and 4 percent respectively;

2) The sharp increase in imports of wheat from Canada was a result of concurrent and similar problems in Canada. The result was to divert shipments to/through the US marketing system. These reached a peak in September 2013 to January 2014. The impact of this was for increased pressure on the United States logistical system, which reduced local prices;

3) There was a large Brazil soybean crop in those years, and concurrently, a substantially improved logistical performance in that country. The impact of this was for downward pressure on port basis values in the US (PNW), which competes directly with Brazil in China, and resulted in downward pressure on origin basis;

4) MIR-162 in corn resulted in China rejections of corn, notably from the PNW and to which the basis declined from +250c/b to <100c/b. These cancellations commenced in November 2013 and continued through May of that year.

Each of these had impacts on port and local prices, notably at the country level. Solely looking at local basis, would not capture this impact. Finally, handling margins are important in determining local prices, and ignoring these seems to be problematic, particularly as it pertains to insinuating the impacts of rail pricing. Indeed, margins vary spatially, temporally, and with spatial concentration; and during part of this period were relatively high (Wilson and Dahl 2011). Ignoring them would mask the impacts of shipping costs on basis values.

Summary Observations

A few observations of these studies are important as it relates to the current study. For locations other than the delivery market, there are a number of important factors that vary temporally and spatially. These include spatial competition, discounts for quality, handling and shipping costs all of which are not fixed for locations away from the delivery location. It is important these are captured in any evaluation of non-delivery basis values.

Most of these studies are largely domestic and focused on origin basis. In some cases, these use the export basis as an explanatory variable for the origin basis. Only a couple of the studies focus on a destination basis, or export basis.

For basis values not at the delivery market, a number of other factors are critically important. These include impacts of shipping costs both intra and inter-country. These are largely ignored or proxied using more generic indexes. Finally, some of the studies sought to evaluate the impacts of shipping disruptions on basis values. In some cases, these were done by analogue year comparisons. In those cases, shipping costs were not measured, but instead were captured via the assumed analogue year comparison.

GRAIN PRICING AND LOGISTICS PLANNING

Grain Pricing

Typically, grain pricing is defined as a simple price spread between a single hub (terminal market) and a local price. However, including other components of price makes the definition of local and export basis more complicated. Below is a chronology that typifies the current pricing regime (and as summarized in Table 3.1.):

1) Basis pricing at the delivery market for a futures contract:

$B_d = DC_d$

where B is basis, DC is the delivery charge and d is a subscript referring to the delivery market, d.

2) Basis pricing with simple shipping costs at an origin absent of spatial competition:

$B_o = (B_1\text{-}(RR+2^{nd})_1\text{-}H_1)$

where B_o is the origin basis, B_1 is the basis at terminal market 1, RR is the rail tariff to terminal market 1, and 2^{nd} is the value of freight in the secondary market and H_1 is the handling margin.

3) Basis with spatial competition and more complex shipping cost regime:

$B_o = \text{MAX } [(B_1\text{-}(RR+2^{nd})_1\text{-}H_1), [(B_2\text{-}(RR+2^{nd})_2\text{-}H_2),\dots [(B_n\text{-}(RR+2^{nd})_n\text{-}H_n)]$

where values are as previously defined, and subscripts 2, …n are to represent values at competing terminal or export markets.

Here, a local basis would be derived from the following calculation which captures that at any time a shipper has n markets they could ship to, the local basis is derived from an evaluation inclusive of impacts of rail tariffs (RR), and the 2^{nd} car market, fuel service charges (if applied), in addition to local handling charges (notwithstanding premiums and discounts that vary across terminal markets); and here margins (H) are important. Margins are highly variable temporally and spatially. Thus, at least a portion of the greater spread (dependent variable) would be attributable to the handling margin.

Table 3.1. Taxonomy of Grain Pricing in Basis and Shipping Costs and Relations.

	Basis derivation	Implications
	Define: B=basis, c=cash, f=futures, T=tariff rail rate; M=margin; d1,d2 are 2 different destinations, FSC is fuel service charge; Car is car premium	
1	$B_o=C_o-F$	Conventional: Basis is constant; highly predictable;
2	$B_o=B_d-M-T-F$	Little more complex
3	$B_o=MAX[(B_{d1}-T_1), [(B_{d2}-T_2), [(B_{d3}-T_3)] -M-F$	Multi-markets: makes basis at origin more dependent on basis and shipping costs to multiple markets. More volatility in basis!
4	$B_o=B_d-[R_t-FSC-Car]-M-F$	Numerous rail mechanisms make greater uncertainty in some elements of shipping costs; for those shippers not covered, values have greater volatility (risk)
5	$B_{o,t+n}=B_{d,t+n}-$ $[R_{t+n}-FSC_{t+n}-Car_{t+n}]^*-(M+RP)-F_{t+n}$	Forward transaction results in volatility in basis values resulting from un-covered shippers having to infer expectations of relevant values; including an implicit risk premium in margins

Value of Guaranteed Shipments

An important feature of this study is that car market mechanisms provide alternatives for guaranteeing, or more generally, assuring rail car placement. While this is not perfect, it results in price differentials between shipments with or without use of these mechanisms.

In an earlier study, Wilson and Dahl (2005) developed a model to explain these differences, and it is expanded and to the current regime and illustrated below. The value of a guaranteed railcar placement to shippers involves a myriad of factors, each of which has an impact on the shippers' payoffs. Because fundamental factors determining value vary across shippers and through time, the values of these mechanisms vary similarly.

This is very similar to the current regime of shipping. Shippers confront two alternatives: using the primary instrument or buying trains on the secondary market. The former provides some quantity risk to the shipper due to the velocity. In contrast, use of the secondary market has virtually nil quantity risk, but shipments under this mechanism are normally at premium.

An algebraic representation of a shipper's payoff function was developed to represent the value of these mechanisms for a known quantity. Following Wilson and Dahl (2005, 2011), the payoff for a transaction using a shipping mechanism that is assured, or, guaranteed i.e., as in the current secondary rail car market which is specified as G. The value of the payoff (θ^G) of a guaranteed transaction is given by

$$\theta^G = B_d^t - B_0^t - (RR_{1d} + v2) - H_1 \tag{3.1}$$

where B_d^t is the destination basis, B_0^t is the basis at the origin, RR_{1d} is the rail tariff at the terminal market 1, and $v2$ is the value of freight in the secondary market and H_1 is the handling margin. Manipulation of the equation (3.1) yields the value of guaranteed freight:

$$(RR_{1d} + v2) = B_d^t - B_0^t - H_1 - \theta^G \tag{3.2}$$

In equation (3.2), both B_d^t and $v2$ could be simultaneous.

For a non-guaranteed transaction, i.e., one that is subject to velocity variability, the equivalent payoff function includes the risk of not receiving cars $(1 - VEL)$, where VEL equals the probability of not receiving cars and is derived from the distribution of velocity. This payoff function includes a margin if cars are not received on their want date, implying they are received during the next period. The expected payoff function for a non-guaranteed transaction ($E(\theta)^N$) is shown below

$$E(\theta)^N = VEL(\theta^G + v2) + (1 - VEL)(\theta^{G,t+1} + v2 - H_1 - S - D)$$

$$E(\theta)^N = VEL(B_d^t - B_0^t - RR_{1d} - H_1) + (1 - VEL)[(B_d^{t+1} - B_0^t - RR_{1d} - 2H_1 - S - D)] \tag{3.3}$$

where S represents the storage cost while D represents the cost of demurrage.

In case of a risk neutral shipper, the payoff of a guaranteed transaction and the expected payoff of a non-guaranteed transaction are equal, that is, $\theta^G = E(\theta)^N$. Substituting both guaranteed and non-guaranteed payoff functions in the above expression and solving for expected value of the freight results in

$$E(v2) = (1 - VEL)(B_d^t - B_d^{t+1} + H_1 + S + D) \tag{3.4}$$

where $E(v2)$ represents the maximum value of freight that the shipper would be willing to bid in the secondary market.

Equation (3.4) indicates that the value of a secondary instrument increases with 1) increase in the probability of not receiving trains $(1 - VEL)$ in the primary market on the want date; 2) increase in the difference between the basis at the destination, between time t and $(t + 1)$, that is, $(B_d^t - B_d^{t+1})$; and 3) increase in the time-dependent handling margin (H_1), storage (S), and demurrage costs (D).

Logistics Planning

The risks described above provide complications to shippers in creating their logistics plan in grain. The methodology commonly used for this purpose is the MRP (Materials Requirements Planning).[12] [13] The MRP model is a representation of grain inflows and outflows for a typical shuttle origin elevator in the upper Midwest. The purpose is to determine future demand for railcars, and the volatility of demand. Based on shipper parameters, futures market prices, basis levels at the sale market, storage costs, and other factors, the model derives the number of trains a shipper would require in each of the next 12 months. Demand for railcars is a key variable since it determines if the shipper would have excess cars to sell into the secondary market or not.

These are illustrated in Tables 3.2, 3.3 and 3.4. The first is a market with a normal carrying charge market in the futures markets. The model is comprised of inventories and purchases by month, futures and basis and shipping costs including secondary market values. A number of calculations are made including: 1) potential shipping demand is derived; 2) the net price is derived for each month, relative to the cost of storage; 3) from which an evaluation is made about whether it is profitable to store or ship (these are alternatives); 4) from which the shipping demand is derived for each month forward, 5) inventory not shipped is beginning stocks in the next period; and 6) all these are evaluated subject to storage and shipping capacity restrictions Shipping demand is also impacted by storage and shipping capacity: if inventories exceed storage capacity, the shipper would ship even if it were more profitable to store. If it was profitable to ship, the shipper would be restricted by the amount of their shipping capacity (e.g., 4 trains/month).

The concept is fairly clear: if it is profitable to store, and there is adequate storage capacity, then store, otherwise, ship. Thus, shipping and storage are alternatives to each other in a very complicated way.

The results illustrate:

1) In the first case (Table 3.2), the secondary market is a flat $400/car. Returns to storage are evaluated, and shipping plans are derived subject to inventories, storage and shipping capacity. Shipments are shown on the far-right column. In this case, shipments would be for 2 trains in January 2 in March, and 1 each in May through October;
2) In the second case (Table 3.3), the only change is to create a negative secondary market at -$200/car. In this case there are very minor changes in the return to storage. Shipments change however, with 1 train in each of December and January 2 in March, and 1 each in May to October. Thus, there is a minor change in optimal shipping plans in the early months; and

[12] The MRP model is used extensively in logistics planning. It is used in particular in our courses on commodity trading at NDSU, and represented there using simple XLS, as well as @risk models and real option models (discussed below).

[13] Texts that treat MRP models include Ballou, and Ptak and Smith (2011) among others.

3) In the third case (Table 3.4), the change is for a large premium for secondary market values in January through March. The effect of this, compared to the first case, is to 1) accelerate shipments into December, and 2) defer, as much as possible, shipments from January to March to May and the months that follow. Thus, the effect of an unexpected increase in secondary market values is to encourage the shipper, to revise its nearby demands relative to deferred.

Of course, this is what should occur in cases where there is an inflated secondary market value, which is inverted. Here, the shipper, would defer shipping to a later period, and, would sell their secondary instrument. In this temporal allocation of shipments, the shipper having the greatest demand for whatever reason, gets access to trains.

The most important factors determining variability in shipping demand are random and correlated. In rank order, probably the most important random variables are 1) farmer deliveries for spot shipment; and 2) intermonth spreads in futures, basis and secondary markets. The important strategic variables are farmer deliveries on contracts (fixed price, NPE, HTA etc.), and how many trains to buy for each month forward. Of course, these would be in addition to storage and shipping capacity, each of which constrains a shipper's strategy. Last, shippers that have multi-origination capability, have greater flexibility among these alternatives, than, a single location shipper. All of these are compounded by variability in velocity which impacts the distribution of car supply.

Table 3.2. MRP of a Shipper's Demand for Trains in a Carrying Charge Market and Positive and Flat Carry in the Secondary Market.

	Storage Capacity Bush	Shipping Capacity	Beg. Inventory Bush	Farmer-Deliveries Contract Bush	Spot Bush	Total Inventory Bush	Prices/Costs Futures C/b	Basis PN C/b	RR Tariff C/b	Shuttle $/car	Shuttle c/b	Net C/b	Diff C/b	Int C/b	Ret. to Store C/b	Shipping Demand Bush	Cars	Shuttles
Decembe	1000000	1452000	100000	118125	275625	493750	1050	75	400	400	12	713	3	2.97	0	0	0	0
January	1000000	1452000	493750	132188	200000	825938	1053	75	400	400	12	716	0	2.98	-3	825938	250	2
February	1000000	1452000	99938	78750	183750	362438	1053	75	400	400	12	716	7	2.98	4	0	0	0
March	1000000	1452000	362438	90000	210000	662438	1060	75	400	400	12	723	0	3.01	-3	662438	201	2
April	1000000	1452000	0	67500	157500	225000	1060	75	400	400	12	723	4	3.01	1	0	0	0
May	1000000	1452000	225000	4813	111563	341376	1064	75	400	400	12	727	0	3.03	-3	341376	103	1
June	1000000	1452000	0	84375	196875	281250	1064	75	400	400	12	727	-4	3.03	-7	281250	85	1
July	1000000	1452000	0	56250	131250	187500	1060	75	400	400	12	723	0	3.01	-3	187500	57	1
August	1000000	1452000	0	95000	225000	320000	1060	75	400	400	12	723	-19	3.01	-22	320000	97	1
Septemb	1000000	1452000	0	130000	310000	440000	1041	75	400	400	12	704	0	2.93	-3	440000	133	1
October	1000000	1452000	77000	120000	270000	467000	1041	75	400	400	12	704	0	2.93	-3	467000	142	1

Table 3.3. MRP of a Shippers' Demand for Trains with Discounted and Flat Secondary Market.

	Storage Capacity Bush	Shipping Capacity	Beg. Inventory Bush	Farmer-Deliveries Contract Bush	Spot Bush	Total Inventory Bush	Prices/Costs Futures C/b	Basis PN C/b	RR Tariff C/b	Shuttle $/car	Shuttle c/b	Net C/b	Diff C/b	Int C/b	Ret. to Store C/b	Shipping Demand Bush	Cars	Shuttles
Decembe	1000000	1452000	100000	118125	275625	493750	1050	75	400	-200	-6	731	3	3.05	0	493750	150	1
January	1000000	1452000	130750	132188	200000	462938	1053	75	400	-200	-6	734	0	3.06	-3	462938	140	1
February	1000000	1452000	99938	78750	183750	362438	1053	75	400	-200	-6	734	7	3.06	4	0	0	0
March	1000000	1452000	362438	90000	210000	662438	1060	75	400	-200	-6	741	0	3.09	-3	662438	201	2
April	1000000	1452000	0	67500	157500	225000	1060	75	400	-200	-6	741	4	3.09	1	0	0	0
May	1000000	1452000	225000	4813	111563	341376	1064	75	400	-200	-6	745	0	3.10	-3	341376	103	1
June	1000000	1452000	0	84375	196875	281250	1064	75	400	-200	-6	745	-4	3.10	-7	281250	85	1
July	1000000	1452000	0	56250	131250	187500	1060	75	400	-200	-6	741	0	3.09	-3	187500	57	1
August	1000000	1452000	0	95000	225000	320000	1060	75	400	-200	-6	741	-19	3.09	-22	320000	97	1
Septemb	1000000	1452000	0	130000	310000	440000	1041	75	400	-200	-6	722	0	3.01	-3	440000	133	1
October	1000000	1452000	77000	120000	270000	467000	1041	75	400	-200	-6	722	0	3.01	-3	467000	142	1

Table 3.4. MRP of a Shippers' Demand for Trains with Inflated and Inverted Secondary Market Values.

	Storage Capacity Bush	Shipping Capacity	Beg. Inventory Bush	Farmer-Deliveries Contract Bush	Spot Bush	Total Inventory Bush	Prices/Costs Futures C/b	Basis PN C/b	RR Tariff C/b	Shuttle $/car	Shuttle c/b	Net C/b	Diff C/b	Int C/b	Ret. to Store C/b	Shipping Demand Bush	Cars	Shuttles
Decembe	1000000	1452000	100000	118125	275625	493750	1050	75	400	400	12	713	-136	2.97	-139	493750	150	1
January	1000000	1452000	130750	132188	200000	462938	1053	75	400	5000	152	576	0	2.40	-2	462938	140	1
February	1000000	1452000	99938	78750	183750	362438	1053	75	400	5000	152	576	7	2.40	5	0	0	0
March	1000000	1452000	362438	90000	210000	662438	1060	75	400	5000	152	583	139	2.43	137	0	0	0
April	1000000	1452000	662438	67500	157500	887438	1060	75	400	400	12	723	4	3.01	1	0	0	0
May	1000000	1452000	887438	4813	111563	1003814	1064	75	400	400	12	727	0	3.03	-3	1003814	304	3
June	1000000	1452000	0	84375	196875	281250	1064	75	400	400	12	727	-4	3.03	-7	281250	85	1
July	1000000	1452000	0	56250	131250	187500	1060	75	400	400	12	723	0	3.01	-3	187500	57	1
August	1000000	1452000	0	95000	225000	320000	1060	75	400	400	12	723	-19	3.01	-22	320000	97	1
Septemb	1000000	1452000	0	130000	310000	440000	1041	75	400	400	12	704	0	2.93	-3	440000	133	1
October	1000000	1452000	77000	120000	270000	467000	1041	75	400	400	12	704	0	2.93	-3	467000	142	1

RAIL PRICING AND SERVICE MECHANISM IN THE UNITED STATES

Prior to the 1980s, the primary mechanism for establishing rates was posted-price tariffs and were allocated on a first-come-first-served basis or those that were ordered first, were served first (Wilson and Dahl 2005). Under this mechanism, each origin/destination combination was assigned a tariff rate and railroads were highly regulated by the government and tariffs rarely changed. With the first-come-first-served allocation mechanism, shippers applied for cars as needed, but there was no mechanism to ensure timely car placement. This created issues during periods of high shipping demand since cars were allocated to those that applied first, rather than those that valued service the most. Also, there were no mechanisms in place that forward contracted freight service.

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

The Staggers Rail Act (SRA) in 1980 provided deregulation necessary for railroads to have more flexibility in establishing rates. Initially, carriers and shippers utilized confidential contracts, which were the precursor to service guarantees (Hanson 1989 and Wilson 2005). These contracts allowed railroads to make forward service guarantees in various forms to grain shippers. This led to the Certificate of Transportation (COT) program created by BNSF (BN at the time) in 1988 which had some important features including forward contracting, auction allocation system, guaranteeing placement, and transferability (Wilson and Dahl 2005). The ability to transfer service to another shipper led to the secondary market that exists today (Wilson and Dahl 2011). Under the COT program, forward shipping guarantees were offered that provided bilateral penalties for each party upon default of agreed terms. Although BNSF was the first to adopt such a strategy, other major Class I railroads such as Canadian Pacific, Union Pacific, CSX, and others followed with similar auction-based, and car guarantee programs (Wilson, Priewe, and Dahl 1998).

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

The other major feature of the COT program is the transferability of these instruments. These instruments are not specific to a particular origin, destination, or shipper, which allows the owner of these contracts to transfer the instrument to another shipper. If a shipper owns a COT and does not need all of the trains ordered, the contract gives them the right to sell the trip to another shipper. This transferability feature is what led to the creation of the secondary market. This impetus for this feature is discussed in more detail in a later section.

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

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

The current mechanism for each of the major carriers is described in the subsections below.

Evolution of Early Rail Car Pricing and Allocation Systems

Prior to discussing current programs, this sections briefly shows the early programs. These were based on the early BNSF programs that evolved from 1988 through the early 1990s and were previously summarized by Wilson and Dahl (2005). This program was a "public contract" issued by the carrier to the shipper. Features of that program are shown in Table 4.1 and include forward car offerings to shippers for a portion of their fleet, prepayment fees used as cancellation penalties, and guarantees provided by the railroad for prescribed delivery windows. These are described in detail below.

Table 4.1. Features of the Certificate of Transport Program (COTs).

Features	Description
Allocation of cars by corridor/period	Based on 5-year moving average of car loadings for individual grains and current demand projections.
Percent of fleet allocated	Generally, up to 40%.
Forward positions	Shipping periods defined up to 6 months forward
Window of car placement	Period of guaranteed car placement. Initially defined and traded in monthly increments; subsequently split into First-half (FH) and Last-Half (LH) positions; and redefined again to 10-day increments.
Auctioning mechanisms	Sealed bid auctions with announced minimum bids, are conducted weekly to allocate among bidders.
Bid value	The bid is for a differential (premium or discount) relative to the public tariff for the designated movement and grain.
Units	Bids are for unit trains.
Allocation of winning bids	Bids at or above the minimum acceptable bid will be accepted unless the offer is over-subscribed (number of acceptable bids exceeds the corridor allocation) or a situation arises where bids cannot be differentiated.
Service guarantee provision	Orders go into penalty on the 16th day after want date for the full among of $400/car. The order will maintain its priority.
Prepayment/cancellation fee	$300/car plus COT premium with no interest paid to the customer.
Negotiability/ transferability	Allowed to facilitate emergence of informal "secondary market" and internal transfer mechanisms.

Source: Authors' files and from periodic tariff filings (e.g., BNSF Railway, Tariff No. 4091).

These systems were not without problems and controversy. The initial systems were challenged in a lengthy legal proceeding. The ICC decided in favor of the BN, indicating that "allocation by price is efficient because service is provided to those who value it most" (Interstate Commerce Commission, p. 459) and that COTs-type mechanism should "enhance long-run efficiency by giving incentives to maintain an optimally sized grain car fleet." Following that decision, most other railroads introduced similar mechanisms. The CP/Soo introduced the PERX (Protected Equipment Rate Exchange) program on its wheat lines. The Union Pacific (UP) had previously adopted its ACOS system (Advanced Car Order System) under which a portion of railcars was allocated based on historical shipments. This was subsequently replaced with a comprehensive car allocation system, including "Vouchers" for guaranteed forward shipments. Similar mechanisms have also been introduced by the CSX and Illinois Central. Auction mechanisms were used for allocation for each of these.

Service was defined for a forward period, for a geographical region and/or grain (referred as corridors), guarantees were provided by the carrier if late and penalties are imposed on the shipper if canceled. Other features included the window of guaranteed delivery, options for ordering, switching of origins and destinations and transferability of the instruments.

In the BNSF system there have been at least nine major changes since its inception. The initial programs had highly specific geographic and grain corridors (e.g., Northern wheat west, corn south) for which separate auctions applied. Over time, these have been aggregated so there are fewer corridors. Now, there are not geographic corridors, but, there are several commodity/train configuration segments. The reason for this was in part due to the sparse number of bidders in some corridors/grains which impacted auction participation. The impact of aggregating corridors was effectively to increase the number of independent bidders in each auction.

Second is the fee for switching corridors. Initially this was established at $250/car to discourage switching. However, over time this proved to be onerous and reduced liquidity, and thus was reduced to $75/car. These have since been abandoned. Third, is the transferability of the instrument. Transferability gives the shipper greater flexibility and has allowed numerous subsidiary trading mechanisms to emerge. These include fairly active secondary markets for these instruments. These are operated internally by shippers, as well as through cash grain brokers, and bundling of these instruments as part of a procurement strategy. In addition, transferability reduces risk to the shipper and as a result enhances its value. This was particularly noteworthy in the CP PERX program which initially did not allow transferability. However, due to a crop shortfall in one of the early years, there was the prospect of massive default and this induced the carrier to allow transferability. The impact of transferability is valued and analyzed in a later section.

Another mechanism design feature is the window for guaranteed delivery. The BNSF system initially guaranteed placement within a 15-day window, to correspond with typical export contracts. However, shippers wanted narrower windows. In response, in the late 1990s the window was narrowed to a 10-day period. Other carriers' windows for car placement vary.

Another feature of these mechanisms is the bilateral penalties. If shippers cancel their order, they forfeit their prepayment. Over time the prepayment has declined initially from a value equivalent to the full tariff value ($1500-3000/car) to $300/car. The carriers guarantee of their car placements would be within the delivery window, and if in default would pay a penalty of $400/car. Finally, each of these was designed as a sealed bid auction. Multiple bids for the top K^{th} winning bidders were accepted and, bidders pay their bid.

This evolution has important implications for both carriers and grain shippers. Development of these mechanisms requires railroads to make decisions about mechanism design which affects bidding competition. Ultimately, an important element of competition among carriers is captured in these service options. For shippers, effective use of these mechanisms requires integration between grain merchandising and logistics. Shippers also must assess effects of market and competitor variables when developing strategies for bidding.

A summary of the early mechanisms and their features are summarized in Table 4.2.

Table 4.2. Comparison of Short-Term Guarantee Contracts (early 1990s).

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 at $400/car	$50/car up to $250 max/car	$50/car up to $400 max/car
Shipper pre-pay/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

Source: Authors files, and as reported in Lee, J (1999), Applying Option Theory To Guaranteed Rail Mechanisms.

These are in addition to other mechanisms, at that time, commonly referred as Long-Term Guarantee Contracts. These included what were referred as BNSF-SWAP, CPRS/Soo GEEP and UP Guaranteed Freight Pool.

BNSF Car Pricing and Allocation System (Current)[14]

The BNSF business model from shipping ag products is highlighted for a few reasons. First, they are usually the largest carrier of ag products, and therefore represent the largest share of shippers within the industry. Also, their allocation mechanisms facilitate a transparent secondary market, and the bids are therefore a good reflection of market conditions.

There are some terms and definitions regarding these mechanisms that should be specified (BNSF 4090-A rulebook):

- Monthly Grain Single: A COT order of one (1) covered hopper car, purchased for one (1) Shipping Period for one (1) month.
- Monthly Grain Unit: A COT order for twenty-four (24) covered hopper cars, purchased for one (1) Shipping Period for one (1) month.
- Yearlong Grain Single: A COT order of one (1) covered hopper car, purchased for one (1) Shipping Period per month for twelve (12) consecutive months as offered.
- Yearlong Grain Unit: A group of twenty-four (24) covered hopper cars, purchased for one (1) Shipping Period per month for twelve (12), twenty-four (24) or thirty-six (36) consecutive months as offered by BNSF.

[14] This section was reviewed and provided comments by Susan Stockstill at the BNSF.

- Domestic Efficiency Train (DET): A COT order of 110 covered hopper railcars, purchased for a single Shipping Period, loaded at a single location at one time. A DET may be separated enroute to arrive at multiple destinations.
- Yearlong DET: A COT order of 110 covered hopper cars, purchased for one (1) shipping period per month for twelve (12) consecutive months as offered by BNSF, loaded at a single location at one time. A Yearlong DET may be separated enroute to arrive at multiple destinations.
- Direct DET: 110 car trains that meet the conditions contained in BNSF 4022 series, Item 13505, including a 24-hour loading period, destined to a single destination
- Shuttle: a full complement of covered hopper equipment (100-120 cars) with dedicated locomotives in dedicated service for a specific period of time, which moves from a single origin facility to a single destination facility."

BNSF currently offers four car ordering programs to their customers; lottery cars, Certificates of Transport (COTs), Pulse COTs and the shuttle program. Table 4.3 lists the details of each of these programs, and the relevant terms are discussed further below. The secondary market mechanisms are also listed for comparison. The BNSF allows its cars to be traded on the secondary market, though they do not participate directly. All rules within the secondary market are privately negotiated between buyer and seller, and regulation and arbitration is provided by the National Grain and Feed Association (2017).

Table 4.3. BNSF Car Ordering Programs (bnsf.com).

Feature	Non COT Units and Singles (Lottery Cars)	Certificate of Transport (COTS)	Pulse COTs	Shuttle Program	Secondary Market
Pricing	-Tariff Lottery program Single car: ≤15 cars Units: 24-48 cars -General Tariff program -No prepayment	-Auction system. Can be for Singles, Units, or Domestic Efficiency Trains (110 cars) -Prepayment of $200/car plus premium, as a performance bond. $200 is then subtracted from total freight bill. Prepayment is $40/car for yearlong singles and yearlong units	-Price is tariff only. -No prepayment	-Weekly auctions	-Buyers and sellers post bids/asks through a third party broker. Bid/ask can be positive or negative. Effective tariff is the rate at time of shipment
Allocation through time	-Single trip commitments	-Can be either monthly (one shipment) or 12 or more monthly consecutive commitments.	-BNSF publishes daily offers for single car, one-time trips in a specified future delivery period	-Usually yearlong commitments	-Daily bid/ask sheets published and distributed by broker. Service is usually for one trip only
Allocation to Shippers	-Lotteries held each of the first 3 full weeks of each month	-Weekly auctions: -Monday – DET's, Yearlong DETs -Tuesday–Monthly Units, Direct DETs -Wed. –Yearlong Units, -Thursday – Monthly Singles, Yearlong Singles	-First come, first served basis	-Weekly auctions each Wednesday – variable depending on market conditions	-Buyer (seller) indicates acceptance of offer (bid) through broker.
Window for Delivery	-Three 10-day periods of each month in the future	-Three 10-day periods/month in the future	-Three 10-day periods of each month in the future	-First placement is a 10-day period of the given month, after which placement is dictated by velocity	-Can be any period, usually 10-15 day window
Specification of Want Date	-Roughly 30 days after lottery, -Customer specifies window -BNSF decides specific date	-Up to 30 days prior to shipping period and not less than 10 days prior to 1sr day of shipping period. Request any date within shipping period	-Up to 30 days prior to shipping period and not less than 10 days prior to 1st day of shipping period. Request any date within shipping period.	-First shuttle order must be placed at least 10 days in advance of startup period	-Indicated at time of bid/offer

Table. 4.3. BNSF Car Ordering Programs (continued).

Feature	Non COT Units and Singles (Lottery Cars)	Certificate of Transport (COTS)	Pulse COTs	Shuttle Program	Secondary Market
Cancellation	-$100/car unless order remains unfilled by end of placement period -General tariff cars cancelled 30 days after last day of placement period	-$200/car/trip ($160 cancellation + $40 pre-pay forfeiture) for Yearlong Grain Units and Yearlong Grain Singles	-$250/car if cancelled between car order placement and last day of shipping period -$200/car for cars that are not given a specified want date prior to shipping period	-$200/car per shipment period -If a shuttle is cancelled, all remaining trips on the shuttle train are cancelled	-Negotiable between primary owner and buyer
Transfer Among Shippers	-No	-Through secondary market	-Yes, but not organized by BNSF. Shippers may arrange transfers among themselves	-Through secondary market	-Resell in secondary market
Transfer. Among Origins	-Yes, upon BNSF approval	- N/A	- N/A	-Yes: but $1,000 per train per trip IF specified after train leaves prior destination	-No
Loading Incentive	-No	-No	-No	-Origin Efficiency Payment -Release <15 hours: $100/car -Release <10 hours: $150/car	-Yes, same as primary owner. OEP payment goes to the loading facility
Demurrage	-$150/car/day after 24 hours for loading; $75/car/day after 48 hours for unloading, debit/credit system	-$150/car/day after 24 hours for loading; $75/car/day after 48 hours for unloading; $600/hour/train for units after 24 hours	-Standard demurrage $150/car/day after 24 hours for loading; $75/car/day after 48 hours for unloading.	-After 24 hours, $600/hour/train After 48 hours, $1,000/hour/train	-Standard demurrage

Table 4.3. BNSF Car Ordering Programs (continued).

Feature	Non COT Units and Singles (Lottery Cars)	Certificate of Transport (COTS)	Pulse COTs	Shuttle Program	Secondary Market
Guarantee	-None	-If order placed more than 10 days prior to start date. If placed 1-9 days before, cars are honored but not guaranteed placement. -If guaranteed cars are 15 days late after want date, BNSF pays max. $200/car to shipper (Non-Delivery Payment, cars still honored), or shipper can cancel.	-If order placed more than 10 days prior to start date. If placed 1-9 days before, cars are honored but not guaranteed placement. -If guaranteed cars are 15 days late after want date, BNSF pays max. $200/car to shipper (Non-Delivery Payment, cars still honored), or shipper can cancel.	-No: but if < 5 trips/month per 61-day period, shipper can cancel remaining incomplete trips without charge at BNSF discretion	-Yes. If disputes or late cars cannot be settled between parties, NGFA handles arbitration
Contract Specs.	-Date and time -Name of party -Name of person receiving request -Kind and size of cars wanted -Number of cars wanted -Date wanted -Commodity to be loaded -Destination and route	-Car number(s) -Origin -Consignor -Destination -Consignee -Route -Commodity -Other terms	-Car number(s) -Origin -Consignor -Destination -Consignee -Route -Commodity -Other terms	-Car number(s) -Origin -Consignor -Destination -Consignee -Route -Commodity -Other terms	-Date of contract -Quantity -Kind of grade of grain -Price or pricing method -Type of inspection -Type of weights -Applicable trade rules -Transportation specs -Payment terms -Other terms

Throughout the marketing year, BNSF is in communication with grain handlers in regarding demand and upgrades and tweaks are made to the programs in order to ensure that the mechanisms are mutually beneficial for the carrier and the needs of the shippers. The programs evaluated in this study are current as of January 2019.

Although the exact definition of a shuttle train varies from carrier to carrier, the idea behind the BNSF program is that a shipper bids on 100-120 car service that is forward contracted. When BNSF holds an auction for a certain number of trains, shippers place bids that are interpreted as premiums to secure trains. This premium does not include the tariff rate that is paid each time a shipment is made.

For example, if a shipper places a winning bid of $20,000, they make a one-time payment to BNSF of the full $20,000.[15] The actual per-trip shipping costs (tariff) are paid at the time of shipment. The exact schedule of auctions fluctuates based on BNSF's inventory of railcars and the demand in the market. The duration of these contracts is usually one year. This means that shippers must forecast their estimated shipping demand for the upcoming year and bid accordingly. The rate in effect on the date the shuttle is waybilled applies.

Union Pacific Rail[16]

The Grain Car Allocation System (GCAS) was developed to facilitate allocation across four segments and methods. These include: Shuttle trains (72%), Guaranteed Freight (17%), Vouchers (5%) and General Distribution (6%) where the number in ( ) indicates the approximate share of cars in recent periods in each segment.[17] There are three mechanisms for allocating cars including Car Supply Vouchers, Guaranteed Freight and General Distribution. Each are described below.

Shuttles[18]

The dominant segment is for shuttle trains which are similar to the BNSF program in a several respects.

A Grain Train Shuttle is a dedicated set of 75 or 110 covered hopper cars for loading of whole grains that move as a unit (train) from one origin to one destination. The Shuttle Operator and Union Pacific enter into a contract to move this train on a continuous basis for a specific

[15] There is no pre-payment on shuttles like there is on DETs, singles or monthly COTs. For shuttles the customer only pays the bid.

[16] These features were taken from information contained at https://www.up.com/customers/ag-prod/gcas/index.htm, and titled "Grain Car Allocation System Additional Description."

[17] Some of this was taken from Union Pacific 2017.

[18] There is some confusion in the documentation between "Shuttles" and "Vouchers." The ppt treats these as separate; but the www document describes them as "Car supply vouchers." Discussion with traders clarified the distinction and that is what is reflected in the text.

time, generally one year. The Shuttle Operator is provided an incentive for their commitment and there are incentives to the loading/unloading facilities for fast loading/unloading.[19]

Important features are:

- Allocated by weekly auction (similar to that described below for vouchers).
- Commitments are for one year;
- Shipper absorbs the performance risk based on velocity.
- Transferable
- Secondary market exists
- Unit/shuttle train terms;
    - Continuously cycle next load or trip
    - 15 hours for loading and unloading
    - Incentives paid for load/unload/trip
- Cancelation penalty if contract is terminated early

The auction mechanism for grain shuttles seem to be administered the same/concurrent as the auction for voucher cars (below).

Car Supply Vouchers

Vouchers are used to allocate cars for whole grains for specific shipping periods. These are administered as:

- Allocated by weekly auction.
    - Bids are submitted for 1) first-half and last-half of the shipping month.
    - Winning bidders are notified the following business day. ; .
- UP allows a mechanism 'proxy' whereby the UP can revise your bid on the shipper's behalf.
- Regional allocation: There are three regions defined and a specific number of cars for each voucher is allocated for each region;
- Vouchers are specified as 100 car unit trains but can be ordered as 75, 100 or 110.
- Prepayment: Shipper makes a payment of the bid, plus a $300/car deposit. The deposit is deducted from the freight bill upon shipment.
- Cancellation: If cars are not ordered by the 5th calendar day of the shipping period, the shipment is cancelled, and the shipper forfeits the premium and deposit. There is a shortfall penalty of $250/car.
- Penalties for cancellation due to late placement

[19] https://www.up.com/customers/ag-prod/shuttle/index.htm

    - UP penalty paid to customer: If UP is late, the UP pays shipper $50/car/day up to $400/car;
- Transferability is allowed at $35/car;[20]
- Secondary freight market: There are three brokers listed including Tradewest, Joiner and Malsam.
- Train features
    - Unit and manifest
    - Continuously cycle
    - Trans are 100 car unit but can be ordered as 75. 100 or 110
    - Contract for dedicated unit trains shuttle operator
    - 15 loading and unloading hours (flexibility for trains >110 cars)
    - Efficiency: power status
    - *Velocity*: Averages 3.5 turns per month

General Distribution

- As available based on supply
- No commitment from UP or customer
- No guarantees by the UP
- Shipper can order 1 car per order for the number of cars for their spot; Once cars are placed; another order can be made.
- Offers are about 7-14 days in advance of car availability.

Guaranteed Freight

- Operated as a freight pool;
- UP guarantees a monthly supply of cars for loading; and the customer guarantees to load for each. A volume commitment is required;
- Transfers allowed at $25/car
- Secondary market exists
- Late placement by the UP: if late, shippers can cancel the order and receive a $250/car penalty from the UP.
- Volume commitment required
- Half-month commitment   FH and LH
- Penalties

[20] GSAC rules: Item 70-M (Grain Car Allocation System Rules).

- Shipper penalty for customer failure (not fulfilling load commitment)
- Rail penalty if UP fails to provide equipment according to commitment

- Train features
  - Unit or manifest
  - Velocity 1.3 to 1.4 turns per month

CP Rail

Canadian Pacific's (2016) Products & Services include a Dedicated Train Program (DTP), Auctioned Flex Train Products, Auctioned 25-Car Blocks, and an Open Distribution weekly order deck.[21] [22] The dominant program is that for Dedicated Trains. Over 75% of CP's freight moves in Dedicated Trains (including Dedicated Auction Trains) in a given crop year.

The CP programs are summarized below. [23]

Overview

In general, these involve

1) An auction allocation system
2) One-year commitment, beginning in August or September
3) Transferability is allowed
4) Secondary markets: The secondary market is not very liquid, and less public than others (e.g., BNSF and UP) and operates mostly through private trading firms. Values are thought to be roughly ½ of those for the BNSF secondary market prices. Since the market is not very public, the CP and presumably other shippers typically do not know values for the secondary market.
5) Guarantee/commitment: any number of trips > 2 don't need to be utilized
6) Cancellation: Single trips can be canceled for $300/car;
7) Shuttle features: Trains must be loaded/unloaded in 24 hours. Split trains (i.e., blocks of 25 cars) are allowed during April-July.

Below are details of each program in 2016/17.[24]

[21] https://www.cpr.ca/en/our-markets/grain

[22] The CP is planning a few tweaks to the 2019 products and services.

[23] CP recently announced their 'shuttle' program shipped 147 cars. See https://www.world-grain.com/articles/12418-paterson-grain-utilizes-cps-hep-train-to-ship-grain?id=12418-paterson-grain-utilizes-cps-hep-train-to-ship-grain&e=mjones@ndmill.com&utm_source=World+Grain+Daily&utm_medium=Newsletter&oly_enc_id=5902G4509389C8Z

[24] Taken from CP Rail: *Grain Products and Services 2016/17 Customer Fly Sheet*.

Auction Process

- Selection criteria to be based on the total value of the bid per FTP or 25-car block (highest wins).
- Bids must be on a train (100 cars per train) or 25-car block basis and customers may bid on multiple FTP's or 25-car blocks.
- Customers must place a positive bid for either a train or 25-car block.
- Equal bids will be allowed to rebid to determine the winner.
- All bids must be in USD, and include the following: program owner, number of FTP's or 25-car blocks, and bid amount.
- Customers are advised within 48 hours of the auction closing time if their bid is successful. Results of primary bidding are available to grain shippers and they are informed by an email bulletin with the results after each auction.

An example of communication of the results is below:

CP

Customer Station Bulletin

Canadian Pacific Dedicated Auction Train Program Results for Canadian and US Grain

February 04, 2019

Thank you to all participants in the final of three Dedicated Auction Train (DAT) auctions for Canadian and US Grain.

The high/low successful bids in the February 1, 2019 auction for the April-July 2019 period were $20,000 and $1,000 (US$ per DAT set for the period). All THREE (3) Dedicated Auction Train (DAT) sets were awarded.

- CP reserves the right to accept or deny any bids; or cancel the program at any time; or to amend the terms prior to the auction.
- Submitting a bid does not constitute a contractual agreement between the bidder and CP.
- CP will invoice, and customers must pay bids before the first FTP block is loaded.
- CP retains control of the number of cars available for each auction period as markets fluctuate.
- Auction results are distributed through a Customer Station notification.

Dedicated Train Program (DTP) [25]

- Over 75% of CP's freight moves in Dedicated Trains (including dedicated auction trains);
- The DTP is a contractual agreement between CP and customers designed to provide train-load capable origins with dedicated train capacity to run in continuous train service;
- Scope:
  - Eligible customers include asset owners of train-load origin elevators or signed Agents of asset owners of trainload origin elevators;
  - The DTP is provided for a one-year term and is eligible to be run between pre-qualified origins and destinations;
  - A list of eligible origins and destinations is available;
  - CP assigns a dedicated train to a customer for their exclusive use;
  - The DTP offers flexibility to shift trains between customers, origins, and corridors/destinations.
  - CP will review requests for multiple spots in a week and provide approval subject to corridor capability and operational considerations.
  - CP may supply empty trains from any origin in order to reduce empty cross haul miles.
  - Train features
    - DTP eligibility requires loading in 24 hrs. of arrival at origin and unloading in 24 hrs. of arrival at destination. Shippers must nominate their next origin loading elevator prior to unloading at approved destinations.
    - Between March-July, DT holders may opt to break up sets into 25-car blocks as follows:
    - For DTs split into 25-car blocks, train multi-car block incentives will not apply.
    - All cars must be loaded at origin and unloaded at destination in accordance with demurrage rules.
    - DT sets spin continuously; shippers for export trains can have an expectation that they receive 2 spots per month, however it is not tied to window of placement.
  - Origins (New in 2016): Canadian origins to a single U.S. or Eastern Canada destination. And, US origins to a single U.S. destination.
  - The number of DTs being requested should be communicated to CP by May 20, 2016.

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[25] The CP targets two trips/month for those with annual Dedicated Train commitments. The number of trips and timing of placement are not guaranteed and depends upon the previous corridor the shipper choses. For example, the US-PNW corridor target is about 2/month but in more fluid periods can be greater than that providing additional capacity. Trips to Duluth-Superior are faster than the PNW.

The current option to explode 'DT' after April 1st reduces trip capability to 1/mo. Finally, the 100-car train auction gets 1 trip/month for the respective period.

Grain Auction Program

- Auctions are offered for three 4-month periods (Aug-Nov, Dec-Mar, and Apr-July). The auction dates for these in 2016 were: June 1 for Aug-Nov, October 3 for Dec-Mar, February 1 for Apr-July.
- The auction includes unit trains, and, in the U.S., 25-car blocks are offered. Car supply for auction is announced one week prior to auction date.

Auction Trainload Rules

- Auction FTPs must be cycled for a minimum of one loaded movement per month; however
  - FTP trains can be billed as 25-car blocks for less than train destinations.
  - Eligible less than train destinations must be able to accept 25 car blocks in one switch.
  - When FTP is billed as 25-car blocks, all blocks within the FTP must go in the same direction East, West or South.

Auction 25-Car Block Rules

- Blocks cannot be combined and must be billed as 25-car blocks. Tariff rates will apply.
- Eligible corridors are U.S. to U.S., and Mexico
- CP Tariffs 1 through 10 will apply.
- Shipper penalty: If customer is unable to use the block for at least one cycle in each calendar month of the agreed to program, a charge of $7,500 for each block will be applied to the customer. Successful bidders can expect 1 cycle per month.

CP Auction Guarantee

- There is a 14-day window of placement for auction trains
- If CP is unable to supply car(s) 14 days after want date, the customer has two options. One is to cancel the car order, and receive $275 per car penalty plus bid refund, or, retain the car order, waive penalty fees, and receive bid refund.

Open Distribution (OD)

- Weekly allocation of cars based on requests entered into RMS.
- CP retains the ability to allocate cars based on corridor capacities.
- DT holders may not order trains (100+ cars for one origin-destination pair) from Open Distribution.
- Maximum Open Distribution orders are: 56 cars per order in Canada, 50 cars per order in the U.S.
- Cars may be ordered up to 4 weeks in advance of want date for 1 spot per week.

Differences in US vs Canada Distribution

The Dedicated Train Program (DTP) product is similar in Canada and the United States. In Canada the DTP primarily go to Vancouver (VC) and Thunder Bay (TB) and the contract holders generally allocate the supply to their origins and destinations they control. The cycles to this destination generally average 10 days as CP either serves the Vancouver and Thunder Bay elevators or is interchanged with CN near the end destination.

In the United States the cycle time is variable depending on the destination they select. The contract holders usually do not control the origin or destination and another railway is involved in the move. Cycles can range from 10 to 15 to 30 days.

CSX

It is important that a large portion of grain car capacity on the CSX are under contracts, typically with receivers. This contrasts radically from the western carriers which had largely abandoned these types of contracts. This is important as the CSX has an auction program described below, but that seems to be largely for residual capacity or demand.

This CSX program for grain car allocation is called the *bid*CSX Grain Car Auction Program.[26] This program was developed to provide a priority mechanism for allocating cars among shippers and in the process increase the likelihood of receiving cars at their facility. [27]

Features include:

- This is a voluntary program whereby customers may participate on a month-to-month basis through a link on ShipCSX.
- Bidding:
  1) Shippers can bid a minimum of 5 cars and a maximum of 50 cars or the car spot capacity. No corporation can buy more than 150 cars/week.
  2) The car placement period is a 4-week cycle preceded by a 3-day bidding period/;
  3) Minimum bid is $100/car
  4) If there are identical bids, the bidder who bid first would win;
  5) Minimum bids are for 10 cars a week to a single location.
  6) Minimum bid amounts are determined each month prior to the start of the auction.
  7) Cars are allocated to the highest bidders. If there are identical bids, then the bid received earliest will win.

[26] Taken from https://www.csx.com/index.cfm/customers/resources/tools/shipcsx-com/car-order/ and from https://www.csx.com/index.cfm/customers/commodities/agricultural-products/

[27] For more program information, refer to the Terms & Conditions for Jumbo-Covered Hoppers (PDF)

- Bidding and placement period: A placement period is defined as a 4-week period that CSX would provide cars. The bidding period is a 3-day period. Shippers can only bid on cars for the placement period that follows the bid-period.
- Prepayment: Winning bidders transfer the total bid amount to the CSX;
- Transferability: Auction winners cannot transfer their priority rights;
- Guarantee. CSXT does not guarantee car supply. However, they will guarantee money back for cars not placed within each week of the placement period;
- Shipper cancellation: If a shipper cancels, the bid amount will be forfeited;
- The Car Auction Program is initially limited to jumbo-covered hoppers for single car grain.

NS

The car allocation program on the Norfolk Southern also differs from that of the western carriers; and has similarities to that of the CSX describe above. The priority is for allocating cars to receivers and with the use of private cars.

Despite that a system is specified for allocating cars, [28] it is thought by the trade that this is fairly limiting in application in that a significant share of cars are handled through contracts largely controlled by receivers. Notable features of the program include:

Private contracts: The vast majority of unit train/shuttle movements are shipped under private contracts.

Car allocation: Use of the online car ordering/distribution system TEAMS. Customer input the number of cars required, and the system allocates cars based on availability and other parameters.

How far forward: There is not a specific cutoff period. Customers can order cars several weeks ahead of the intended shipping period.

Penalties for cancellation: Customers can cancel up until the empty car reaches the serving yard. Cancellation after that point is subject to a $450/car charge.

Penalty paid by NS if late: None

Use of Auction: NS does not use an auction system.

[28] Taken from: http://www.nscorp.com/content/nscorp/en/shipping-tools/equipment-guide.html And, Norfolk Southern *Quick Reference Guide: Empty Car Request Widget*.

CN

CN Rail operates a separate program for grain shipments from western Canada, versus that in the United States. The system for western Canada is subject to extensive controls through the rail rate and service regulatory regime in Canada. As a result, the mechanism for allocating cars within Western Canada are complex and not discussed here.[29]

The system for car allocation differs in the United States. The CN has developed a "US Covered Hopper Fleet Integration Program" which is described here. This program is a mechanism for the CN to secure privately owned cars for shipment on their system. Its purposes are to improve efficiency, reduce switching, improve transit times and reduce congestion. For shippers, the benefit is a guarantee for service and having CN manage the private firm's fleet of cars.

Features of that program are:

Shipper supplied cars:	Shippers provide cars to the CN Rail which operates a pool of cars;
Region:	Regions are specified to include origins in the Midwest and south east, for domestic and export shipments;
Shipping period:	Shippers can bid cars into the fleet for either 1, 2, or 3 years;
Quantity Limits:	CN will allow up to 2000 cars to be bid into their fleet;
Bidding:	Shippers bid to put their cars in the program. Successful bidders put their cars into the Fleet Integration program. The lowest bids are accepted up to the program maximum. Maximum bids apply at $350/car;
Cancellation:	If the shipper withdraws their cars prematurely, there is a penalty of $475/car. Also, if the shipper has insufficient orders, they will be charged $100/car;
Rail performance:	The CN provides 2.0 spots per month for each car in the program. If the CN is late, there is a non-performance fee of $100 car.

Comparisons

The rail car allocation mechanisms for grain varies across carriers. In some cases, there are similarities, and others there are drastic differences. There is a difference between western and eastern carriers, largely due to that the latter make greater use of receiver contracts which serves the purpose of allocation. Each of the western carriers have some form of auction, and the instruments are transferable. However, transparency and liquidity varies across carriers. The durations are similar but the window for placement varies. In addition, the treatment of penalties for shippers for cancelation and penalties on carriers for late placement varies.

[29] These are described in detail at https://www.cn.ca/en/your-industry/grain/

Importantly, the BNSF and UP have programs which transfer the risk of car velocity on to the shipper, which differs from the original programs. This also varies across mechanisms. These are compared and summarized in Table 4.4.

Table 4.4. Comparison of Features in Current Rail Mechanisms for Allocating Shuttles Across Carriers.

Feature	BNSF	UP	CP	CN	CSX	NS
Allocation	Auction	Auction	Auction	Fleet Integration	3-day bid period	na
Car owner (predominant)	RR	RR	RR	Private cars to CN Fleet	Private	Private
Transferable	Yes	Yes at $35/c	Yes	Yes	No	Na
Secondary market	Yes	Yes	Yes	Not in practice	No	NA
Shipment size	Shuttle	Shuttle	Shuttle	Shuttle	Min 10 car/week	Na
How far forward	Year long	One-year	One-year	1, 2, 3-year terms	4-week cycle	
Window for Placement	10 days	15 days	15		4-weeks	
Allocation by region	No	No	No	No	No	
Transparency of Primary	Yes	Yes	Yes	No		
Transparency of Secondary	Yes	Yes	No	Na	Na	
Prepayment	Bid	Bid +$300/c			Bid	
Shipper Cancellation	$200/c subj to provisions	Yes	Bid + $300/c	$100/car		
Rail Guarantee	No	Yes $50/car/day up to $400 max	>14 days late Rail pays $275/c if cancelled	If 10+ days late, $100/c	No	
Quantity	Subject to rail velocity	Subject to rail velocity	2 trips/month; greater vel is shipper option	2 spots/month		
Transfer among origins	Yes	Yes	Yes		No	
Other programs	Non-COT unit and singles; COTs, Pulse COTS	Guaranteed freight, Vouchers, General distribution	Grain auction program;	W. Canada is separate;		
Share or rail grain traffic		72%	75%	50%		

Notes: 1) this is a summary and details as available are on previous pages; 2) only the mechanism use for Shuttle train allocation are shown; 3) blanks means the treatment of the feature are not apparent from the public documents; 4) and, other related features of importance include 1) application of demurrage; 2) origin and/or destination loading/unloading incentive mechanisms; 3) shipping periods e.g., week, first-half/second half month, and FP/MP/LP.

Primary vs. Secondary Rail Car Markets

Development of rail pricing and allocation mechanism has resulted in a number of what a appears to be complex transaction mechanisms now confronting the grain marketing industry. Most important is what we refer to as the primary transaction, and the secondary market and there are important differences between market mechanisms.

Primary Market

The primary market, although with some variation across carriers, is the initial allocation of trains in which shippers bid for rights to utilize a specified number of cars for a certain time period forward. This takes the form of a k^{th} priced sealed bid auction (Wilson and Dahl, 2005)[30]. Railroads offer trains for forward shipping, shippers bid, and the winners of each car offering are allocated contracts for service which specify elements such as forward order period, rate level (tariff), and number of cars per month (Wilson and Dahl 2005).

An important feature of the primary transaction mechanism is their transferability, which is the foundation for the secondary market. Indeed, the secondary market can only exist due to that the railroads allow this transferability. Transferability gives the owner of the contract the right to sell trains to another shipper that is quoted as a premium or discount on the tariff rate. This is important to shippers due to the fact that there is large variability in shipping demand month-to-month due to intra-seasonal supply and demand levels (Wilson and Dahl 2011 and 2005). Variability in shipper demand creates problems if an elevator has a locked-in, constant supply of railcars to fill and ship each month, since there would be months when the shipper would want to ship more or less than their allocation of trains allows. The primary owner may choose to sell one or more trips to another shipper, while still retaining the rights to that train afterwards. This mechanism, combined with the primary market, efficiently provides shippers railcar placement, and the option to transfer these trains as a means to mitigate risk.

An example of the communications from the BNSF and UP regarding shuttle auctions are shown in Figures 4.1 to 4.3. In both cases, the winning bid values are shown, as well as number of bids received or offered.

[30] Wilson and Dahl (2005) developed a game theory bidding model of these mechanisms to evaluate critical factors impacting bid values.

BNSF Railway Shuttle Offer 08/23/2017

BNSF offers COTs under provisions of Tariff BNSF-4090-series for Shuttle COT. For each Shuttle Train Bid, the Customer Must specify the Beginning Period.

OFFER	MTH	PERIOD	COTs	MIN PRICE
YLS0005547	Sep	FP	1(110 CARS)	$0
YLS0005584	Sep	MP	1(110 CARS)	$0

Acceptances or higher whole dollar bids accepted until 3:00PM CT at COT Bids. Shuttles offered are 1 year with no trip incentive.

BNSF Railway Shuttle Results 08/23/2017

OFFER NUMBER	MTH	PERIOD	TOTAL BIDS	TOTAL COTs AWARDED	RANGE OF SUCCESSFUL BIDS
YLS0005547	Sep	FP	2	1	$51,000
YLS0005584	Sep	MP	2	1	$8,254

For additional auction detail, please click BNSF COTs and select the history tab.

Figure 4.1. BNSF Shuttle Auction Offer and Results, August 23, 2017.

UPRR - Tender for August 05, 2019 - Auction Closed

Lot Number	Placement Period	Unit Type	Units Offered	Winning Bid(s)
Region 1 - Arkansas, Illinois, Louisiana , Missouri, New Mexico, Oklahoma, Texas, Wisconsin (including Duluth, Mn)				
52506	LH August,2019	1	30	$10
52508	FH September,2019	1	10	*NO BID*
52509	LH September,2019	1	10	*NO BID*
52516	FH October,2019	1	50	*NO BID*
52517	LH October,2019	1	50	*NO BID*
Region 2 - Colorado, Iowa, Kansas, Minnesota, Nebraska, Wyoming (including Kansas City And St Joseph, Mo)				
52510	FH September,2019	1	175	$10
52511	LH September,2019	1	175	$10
52512	LH September,2019	100	1	*NO BID*
52518	FH October,2019	1	400	$10
52519	FH October,2019	100	2	*NO BID*
52520	LH October,2019	1	400	$10
52521	LH October,2019	100	2	*NO BID*
Region 3 - Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, Washington				
52513	FH September,2019	1	10	$10
52514	LH September,2019	1	10	*NO BID*
52522	FH October,2019	1	50	*NO BID*
52523	LH October,2019	1	50	*NO BID*
Shuttle Trains				
52507	Sep, 2019 Start, One Year	100	6	*NO BID*
52515	Oct, 2019 Start, One Year	100	5	*NO BID*
Shuttle Trains 6 Month				
No lots available to bid on at this time.				
Weekly Vouchers				
No lots available to bid on at this time.				

Figure 4.2. UP Shuttle Auction Offer and Results for August 5 and 12, 2019.

UPRR - Tender for August 12, 2019 - Auction Closed

Lot Number	Placement Period	Unit Type	Units Offered	Winning Bid(s)
Region 1 - Arkansas, Illinois, Louisiana , Missouri, New Mexico, Oklahoma, Texas, Wisconsin (including Duluth, Mn)				
52525	FH September,2019	1	10	*NO BID*
52526	LH September,2019	1	10	*NO BID*
52533	FH October,2019	1	25	*NO BID*
52534	LH October,2019	1	25	*NO BID*
Region 2 - Colorado, Iowa, Kansas, Minnesota, Nebraska, Wyoming (including Kansas City And St Joseph, Mo)				
52527	FH September,2019	1	150	*NO BID*
52528	LH September,2019	1	150	*NO BID*
52529	LH September,2019	100	1	*NO BID*
52535	FH October,2019	1	300	$10
52536	FH October,2019	100	2	*NO BID*
52537	LH October,2019	1	300	$10
52538	LH October,2019	100	2	*NO BID*
Region 3 - Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, Washington				
52530	FH September,2019	1	10	*NO BID*
52531	LH September,2019	1	10	$10
52539	FH October,2019	1	25	$10
52540	LH October,2019	1	25	$10
Shuttle Trains				
52524	Sep, 2019 Start, One Year	100	6	*NO BID*
52532	Oct, 2019 Start, One Year	100	5	*NO BID*
Shuttle Trains 6 Month				
No lots available to bid on at this time.				
Weekly Vouchers				

Figure 4.2. (continued) UP Shuttle Auction Offer and Results for August 5 and 12, 2019.

UP: Grain Car Allocation System - Bid Detail

Bid(s) for Lot 52432

Region: System

Placement Period: Aug, 2019 Start, One Year - Shuttles

Unit Type: 100 **Units Offered:** 3

Units Wanted	Bid(s)	Current Bid Time (Central Time)	Max Bid Time (Central Time)	Bid Type
1	$0	07/01/2019 01:59:14 PM	07/01/2019 01:59:14 PM	User
1	$0	07/01/2019 01:56:51 PM	07/01/2019 01:56:51 PM	User

UP: Grain Car Allocation System - Bid Detail

Bid(s) for Lot 52441

Region: System

Placement Period: Sep, 2019 Start, One Year - Shuttles

Unit Type: 100 **Units Offered:** 7

Units Wanted	Bid(s)	Current Bid Time (Central Time)	Max Bid Time (Central Time)	Bid Type
1	$0	07/01/2019 01:57:17 PM	07/01/2019 01:57:17 PM	User

Figure 4.3. Detailed Bid Results for UP Primary auction, July 1, 2019.

Other Features: Velocity and Transferability

There are two important features of these programs, particularly for the BNSF and UP Shuttle systems, though to a lesser extent for the other carriers. These are the role of velocity and transferability.

The shuttle owner receives a certain number of trips per month, which depends on velocity (as illustrated in above). Railroad performance may vary due to factors such as heavy traffic, weather, etc. Velocity is critical for logistical management because it is risky, and it impacts the number of trains received per month. The figures above show the behavior of velocity, its mean, distribution and correlation relative to other market variables

Velocity in this system is very important as illustrated in the models below. The actual cars received, which we refer to as car supply depends on the number of trains bought, velocity, in addition to the number of cars per train which is the carrier's option between 100 and 110 cars. Or, the actual cars derived as:

$C_a = V * T_o * 110$

where, C_a = actual cars, V=Velocity and T_o= Trains purchased (ordered).

As an example, if a shipper sells the quantity equivalent of 2.7 trains and owns primary contracts; and if they receive 2.4 trips per month, then the shipper either has to cancel sale of grain, or, buy trains in the secondary market. If the shippers receive 3 trains/month, then, the shipper would have too many cars; and would have to either sell additional grain to use the cars, buy additional grain, or, sell the surplus trains in the secondary market.

This relationship is illustrated below. It converts velocity/month, and trains bought, to bushels. If the expected velocity is 3 trips/month, and the shipper bought 2 trains, that would infer a likely shipment and sale of 2.475 million bushels. If the velocity were less, they would have less car supply and may have oversold their position, and, vice versa. It is for these reasons that car ordering is now a very important strategic variable. The dimensions of this is explored in the sections below.

Table 4.5. Impact of Train Velocity on Quantity That Can Be Shipped.

Velocity	Trains bought			Trains bought		
Trips/month	1	2	3	1	2	3
	Car/month			Bushels/month		
2.7	2.7	5.4	8.1	1,113,750	2,227,500	3,341,520
2.8	2.8	5.6	8.4	1,155,000	2,310,000	3,465,000
2.9	2.9	5.8	8.7	1,196,250	2,392,500	3,588,750
3	3	6	9	1,237,500	2,475,000	3,712,500
3.1	3.1	6.2	9.3	1,278,750	2,557,500	3,836,250
3.2	3.2	6.4	9.6	1,320,000	2,640,000	3,960,000
3.3	3.3	6.6	9.9	1,361,250	2,722,500	4,083,750

The other feature of this mechanism is that the instrument is transferable. This can also be interpreted as an option given to the owner when they do not need the train. If a shuttle contract owner finds that they do not need all of the cars coming to them in a given month, they essentially have three options. They can either cancel the cars for $200/car/remaining trip, sell them into the secondary market, or source additional grain in order to use the cars, in what we refer to as a “forced” shipment. There is also the option of letting the cars sit idle, but this incurs significant demurrage costs, and is not considered a viable alternative for this study.

Since it is not possible to cancel just one or two trips, or essentially pause the shuttle, timing plays a large role in deciding whether to cancel cars or sell into the secondary market (industry source). If secondary market values are at a discount, the shuttle owner who does not need all of the trains must decide whether to pay the cancellation fees and forfeit the rest of the trips, or to sell the trains for a loss and retain ownership. If there are still many months left on the shuttle contract, the owner may be willing to sell cars at a loss (less than -$200/car) in the short term in order to retain ownership in hopes that shipping demand and/or secondary market prices rally in the distant months. If there is only one month left on the shuttle, or only a couple of trips, there is no incentive for the owner to sell the remaining trips for less than $200 below tariff, when they could just cancel them for $200/car/remaining trip. The cancellation economics behind a shuttle contract are dynamic and involve many variables. The only time a shuttle owner may cancel remaining incomplete trips without charge if they receive less than five trips in 61-day period, but this is at the discretion of BNSF and does not happen very often.

Secondary Market

The secondary market has some key differences in comparison to the primary market which are important. These differences are not the same across all carriers. Those that apply to carriers which have dominant secondary markets are highlighted.

There are several forms of inter-firm transactions that are sometimes commonly referred as the secondary market. One of these is through 3rd party cash brokers. One of the dominate brokers is Tradewest. At one time, there were many more (up to 11 different ones), but over time there has been consolidation in this function. Bids and offers are published through brokers. To our understanding, now there are three cash brokerages that facilitate trade in secondary rail cars, including Tradewest, Malsam and JW Nut (Littlerock) that trades Union Pacific instruments. [31] There are also a system of Rules and Arbitration that govern these mechanisms at NGFA (2017).

These offers are published daily and come in a variety of forms. An example is shown in Figure 4.4 which is from Tradewest in August 2017. Several observations are important in interpreting these values: 1) though this is for the BNSF instruments, there are similar offers for UP ACOS system; 2) both a bid and offer are shown: bids would be from potential buyers, and offers would be from potential sellers; 3) bids and offers are made for multiple periods forward; 4) taken together the inter-month difference in values may take the form of a carrying charge market, or inverse; and 5) different temporal packages are offered demarked as combinations of FP, MP and LP for the 3 ten day periods of each shipping month.

[31] UP lists to following brokers handling their freight: James Joiner, Malsam Company and Tradewest.

BNSF RAILWAY

** BNSF 110 CAR SHUTTLE CAR MARKET RECAP **

*(FP = FIRST PERIOD – MP MIDDLE PERIOD – LP = LAST PERIOD)

** BEFORE BIDDING ON RETURN TRIPS, PLEASE CHECK YOUR LOADING ORIGIN WITH THE RR FOR THEIR APPROVAL; RAILROAD LOAD ORIGIN REJECTION FOR PURCHASED SHUTTLE TRIP/S WILL BE THE BUYER'S RESPONSIBILITY UNLESS STIPULATED OTHERWISE.

** BNSF 110 CAR SHUTTLES **

SELLER's CALL

	BID (+ POSSIBLE PUSH)	ASK (- POSSIBLE GIVE)
SPOT EMPTY	-	TARIFF*
RETURN TRIP	-	-
LP AUG	-	TARIFF*
FP SEP	-$200*+	-$100*
SEP 5-15	-$125(MEX OPTION)+	TARIFF*
MP SEP	-$100*	-$25*
LP SEP	$400*	$800*
SEPT 25-OCT 5	$700*	$1250*
FP OCT	$1000*	-
MP OCT	-	-
LP OCT	-	-
*PKG (1/3's) OCT, 17	$1300*(SPLIT or 1/3's)	$1600*(SPLIT)
FP NOV	$200*	-
FH NOV	$100*	-
MP NOV	-	-
LP NOV	-	-

Figure 4.4. Tradewest Secondary Market Values, August 2017.

Tradewest lists several notes that govern shipping under this mechanism. These are:

*** BEFORE BIDDING ON RETURN TRIPS, PLEASE CHECK YOUR LOADING ORIGIN WITH THE RR FOR THEIR APPROVAL; RAILROAD LOAD ORIGIN REJECTION FOR PURCHASED SHUTTLE TRIP/S WILL BE THE BUYER'S RESPONSIBILITY UNLESS STIPULATED OTHERWISE.*

Paper Terms:

a.) Trip incentive, if any for the account of the seller.

b.) There is no fuel surcharge protection.

c.) Weekend load for account of buyer if available on the trip provided.

d.) Buyer to bill the train and receive the EDI payment.

e.) Seller's call, five (5) day pre-advise on shuttle placement.

f.) No Mexico or Mobile destination/s without seller's consent.

g.) Existing tariff rate at time of shipment.

h.) Seller to make shuttle trip contract application/s against this contract per NGFA rules.++

Similarly, there are secondary market values for the UP-shuttle program. Those as reported in Tradewest are shown in Table 4.6 as an example. The Tradewest Brokerage service also offers brokerage for the UP voucher and shuttle trains.

Below are shown the results of the daily bids/offers on Tradewest for these products.

Table 4.6 UP Rail 2nd Market Values from Tradewest Aug 2 2017

UP 110 CAR SHUTTLE SELLER's OPTION	BID	ASK
SPOT (EMPTY)	-	-
RETURN TRIP	-	-
AUG 7-11	-$100*	-
FH AUG	-$100*	-
LH AUG	-$125*	-$50*
FH SEP	-	-
SPLIT SEP	-$100*	TARIFF*
LH SEP	-	-
LP SEP	TARIFF*	-
SEP 25-30	$150*	-
SEP 25-OCT 5	$150*+	-
FP OCT	$250*+	$450*
FH OCT	-	-
SPLIT OCT	$50*+	$650*-
LH OCT	-	-
FH NOV	-	-
SPLIT NOV	-	$200*
LH NOV	-	-
FH DEC	-	-
SPLIT DEC	-	-
LH DEC	-	-
*PKG, FP OND, 17	TARIFF*(INDICATION)	-
*PKG, SPLIT OND, 17	-$100*+	$250*-
FH JAN	-	-
SPLIT JAN	-	-
LH OCT	-	-

Footnotes referring to the UP-shuttle terms provided in Tradewest:

UP 110 CAR SHUTTLE FREIGHT TERMS: UP Shuttle Car Rules for execution of this contract to apply at time of shipment.

Placement to apply for all UP approved origins.

-Trip incentive for Seller's account.

-No fuel surcharge protection.

-Buyer to bill train.

-Existing tariff rate at time of shipment.

-Seller's call, 5-day pre-advice on shuttle placement.

-No Mexico, Windsor, CO, Cedar Rapids, Columbus, NE or Clinton, IA destination without seller's consent.

-Seller to make shuttle trip contract applications per NGFA rules.

Any contractual trade dispute related to a breach of contract performance that has become non-reconcilable through direct dialog or negotiation relating to this contract by either or both party/s named as buyer or seller, shall agree to submit their case to the NGFA for binding arbitration.

***Cars quantities are settled between principals by the number of cars on the Bill of Lading.*

Rule 6. Advice of Schedules (A) Application of Shuttle Freight: (1) The Seller shall furnish the identifying number(s) and identity of the shuttle trip owner to the Buyer for the unit/freight by 12 noon, Central Time. The Buyer shall notify the Seller of acceptance or rejection of application by 2:00 p.m., Central Time. In the case of rejection, the last Buyer shall also notify the shuttle trip owner by 2:00 p.m. Central Time. acceptance shall be defined as transfer of shuttle trip ownership or naming of a loading origin. Application may not be given on Saturdays, Sundays and legal holidays, unless otherwise agreed. (2) First day of pre-advice is defined as day of accepted application. For pre-advice, a day is defined as a calendar day, including weekends and holidays.

Any contractual trade dispute related to a breach of contract performance that has become non-reconcilable through direct dialog or negotiation relating to this contract by either or both party/s named as buyer or seller, shall agree to submit their case to the NGFA for binding arbitration.

The other form of inter-firm transactions are direct offers from grain companies to shippers or customers. In this case, individual grain companies would accumulate varying positions in rail cars and trains through their freight trading department (discussed below), and from this would offer trains to other shippers. This may be part of a procurement strategy in which offers to purchase grain are bundled with offers to provide freight. An example of this is shown in Figure 4.5 from CHS. The alternative would be to use the mechanism to offer cars to 3rd parties that may not be needed by the principal.

A couple observations are important about these freight offers. First, most larger grain companies with centralized freight trading have similar systems and may use them in different ways. Second, not all of these offers are circulated broadly or beyond their targeted customers. Hence, they are not symmetrically transparent. Third, though these are offers, that does not mean they are transaction values. Instead, the transaction values may indeed differ from the offer-value. Fourth, though these values follow those from the brokerage markets very directly, it is clear their offers are not identical. Indeed, casual observation suggests that 1) there are differences, though not substantial between company freight offers, and those in the brokerage market; and 2) offers do vary across carrier instruments, as illustrated below.

CHS

GRAIN MARKETING
COVERED HOPPER EQUIPMENT OFFERS

Date: 21-Jul-16

Railcar Placements:

BNSF: Placing cars on time to about 5 days late depending upon location/corridor.

UP: Placing cars on time to about 5 days late depending upon location/corridor.

BNSF Offers:	Return	Aug			Sep			Oct			Nov			Dec			Jan-2017			Feb			Mar			Apr or May		
	Trips**	F10	M10	L10	F10	M10	L10	F10	M10	L10	F10	M10	L10	F10	M10	L10	F10	M10	L10	F10	M10	L10	F10	M10	L10	F10	M10	L10
COT Small Units		Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call
Shuttles	Call	650	600	550	600	800	Call	Call	Call	Call	Call	700	350	160	120	40	0	0	0	(20)	(20)	(20)	(40)	(40)	(40)	(175)	(175)	(175)

UP Offers:	Return	Aug		Sep			Oct			Nov			Dec		Jan-2017		Feb		Mar		Apr or May	
	Trips**	FH	LH	FH	M10	L10	FH	M10	L10	FH	M10	L10	FH	L10	FH	L10	FH	L10	FH	L10	FH	L10
G'teed Freight		Call	Call	Call		Call	Call		Call	Call		Call	Call	Call	Call	Call	Call	Call	Call	Call	Call	Call
Shuttles	Call	250	150	150	150	500	Call	Call	Call	300		(50)	(50)	(50)	(75)	(75)	(75)	(75)	(75)	(75)	(200)	(200)

Figure 4.5. CHS Railcar CHS Offers.

While the primary market is a sealed bid auction, the secondary market is largely a bid-offer mechanism, which could be interpreted as a form of a double-auction. All bids and offers are quoted as a premium or discount in relation to tariff. For example, if a shipper bought secondary cars for $100/car/trip, they must pay $100/car/trip to the seller, and the tariff rate to BNSF. Bids and offers are usually for one trip only, but can be for multiple forward trips as well, usually out to a year. The offer could specify two trains per month for the next five months at a certain price. The bid or offer also lists a specific window for delivery. These windows are usually ten days, and are either first, second, or third period of each month. If it lists a fifteen-day period, it is for either the first or last half of the month. If a buyer of secondary market service decides that they do not need the cars, they can either resell in the secondary market, or cancel for a fee. The secondary buyer usually does not have free reign over the cars, though, and resale and cancellation must be negotiated with the seller.

The specified time window is guaranteed by the original seller. This a fundamental difference from the primary market, where this guarantee does not exist. As described above, in a primary transaction, the shipper receives the actual TPM, or trips per month, which varies with rail performance. Thus, if the expected value (average) of rail velocity is 2.75, that would be the number of trains expected to be shipped under the primary instrument. However, the actual number could vary depending on rail performance, as reflected in velocity.

This differs in a secondary market transaction. If a seller is unable to get cars to the secondary buyer's location within the window listed in the contract, the seller is considered in breach of contract. Under this situation, the buyer has the option to either accept the late cars and resume business as usual or require that they receive cars from another source. The buyer could either buy cars elsewhere and force the original secondary seller to pay any price differentials, or have the seller furnish cars from another train that they control. Either way, the solution to late cars is usually negotiated between the buyer and seller. If a resolution cannot be reached, the case is handled by the NGFA. [32]

Finally, there is an important relationship between secondary market values, and basis movements. As an example, RJO (in market comments 2/13/2019) indicated how the 2nd market is thought to lead the basis, which leads the futures value increases. Specifically:

> *It's always about transportation, and as it relates to transportation, lots of moving parts. Fun to observe.*
>
> *BNSF shuttle equipment for Feb 2019 reportedly bid PLUS $1400 v PLUS $2100 offer; prompted nearby track US PNW shuttle corn to trade 137H. Yikes.*

Freight Trading

The separation between primary and secondary markets is not always as distinguished as suggested above. To discern the commercial application, we interviewed several industry participants involved in these transactions.

While a few small grain companies buy primary certificates, a majority of the current primary contracts are owned by larger shippers. Rather than each individual elevator buying shuttles from the railroad, a grain company who owns many elevators buys a large pool of shuttles that is managed from central freight desk. A shuttle train almost never sticks with one elevator, but rather sticks with one grain company or operator and trips are allocated between elevators as needed. As long as the train is notified before it reaches a destination, the next origin can be any location at the choice of the contract owner.

The freight desk manages shuttles that a grain company owns, and works with country elevators, both owned and not-owned, to sell shuttle trains for either single-trip or multiple-trip commitments. Due to the operations of the "freight desk," the line between primary and

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[32] In fact, these provisions are similar to mechanisms that exist in cash grain contracting when there is concern of seller performance. E.g…., MGEX rule 1003.00. SALES "FOR SHIPMENT": DEFAULTS. Indicates,

> In case the Seller defaults on a Sale "For Shipment," the Buyer, upon delivering a written or telegraphic notice to the Seller, shall have the right to (a) declare the unshipped portion of the contract canceled, or (b) to buy in the open market for account of the Seller a property equal in quantity to the unshipped portion and equal in quality to that contracted for or (c) to require settlement by the Seller of the unshipped portion at the market value; and, in any case, the Seller shall reimburse the Buyer for any proved direct loss sustained on account of failure to make shipment within contract time.
>
> Available at http://www.mgex.com/documents/Rulebook_048.pdf

secondary markets is not always clear. Some freight managers consider the primary market as strictly transactions between them and the railroad. Some freight managers who work with a regular book of country elevators (some owned by the company and some not) consider transactions between them and the country elevators as primary market transactions. If the freight manager sells a train to a non-regular customer, they may consider this to be a secondary market transaction. The elevator that buys the train usually has the option to either resell or cancel the trip. However, this is at the discretion of the freight desk operator.

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

Although the exact definitions of primary and secondary transactions are not standardized in practice, in the interest of clarity for purpose of this study we make a distinction. The primary market refers to transactions between carrier and the owner of the shuttle contract. The freight desk operator has basically 3 ways to make trades of trains in secondary transactions. These include: 1) some shuttles are sold on a trip-by-trip basis to other companies; 2) some shuttles are utilized by individual company owned elevators; and 3) some shuttles are forward contracted to other companies for a set quantity, delivery period and duration. The exact composition of these alternative varies across companies and through time.

Rail Pricing and Service Mechanisms: Canada

The Canadian railroads experienced numerous problems in the post-Western Grain Transportation Act (WGTA) period. Under the previous regulatory scheme (WGTA), cars were allocated through the Grain Transport Authority (an industry/committee process), through a labyrinth of rules, and were largely based on historical shipments.

This was abandoned in 1996 and replaced by an industry consensus group, CAPG (Car Allocation Policy Group) using similar procedures, until a longer-term strategy is agreed upon. Since then, two commissions of inquiry (Estey, 1998; Kroeger, 1999) proposed various forms of liberalizing these procedures but the mechanisms adopted essentially gave greater control to the primary shipper (Canadian Wheat Board, 2000). Due in part to the inability to reconcile various proposals for car allocation, each of the Canadian National (CN) and Canadian Pacific (CP) railroads explored use of varying versions of bidding processes for allocating a portion of their grain car fleet in late 2000 and early 2001.

These mechanisms as applied by the CN and CP rely on allocation based on immediate past historical shipments. This is administered in varying ways across railroads. In recent years, a priority mechanism has been implemented for shippers that have invested in special high-throughput facilities.

It is important that underlying car allocation system in western Canada are that rates for those shipments are based on a formula and does not facilitate using rate differentials as applied in the U.S. system. Further, there were several complaints by shipper's overuse of these mechanisms which were lost by the railways, and since largely abandoned.

These experiences combined with the underlying regulations stifled development of these mechanism. Instead, rail performance evolved to be disciplined through a system of revenue targets, and penalties applied to carriers for under-performance. This was implemented following the 2013/14 rail car shortage that occurred in the United Sates, but, similarly in Canada.[33]

More recently, railways in Canada became subjected to a 'maximum revenue entitlements' (or MRE) for moving western Canadian grain.[34] Concepts related to this date back to 2000 and have been revised and reconfirmed since then. Each year, the CTA determines how much revenue CN and CP can legally earn from moving western Canadian grain along federally regulated transportation routes. The MREs for each railway are calculated using a complex formula considering the volume of grain moved, the distance that grain is transported, and the cost of moving grain based on factors that include the price of labor, fuel, materials and capital. If revenue exceeds the MRE, the carriers are imposed a penalty which is payable to the WGRF.

Money directed to the WGRF would be used to pay for agricultural research that benefits prairie farmers. As a recent example, the Canadian National Railway and Canadian Pacific Railway were ordered to pay nearly $2.7 million to the Western Grains Research Foundation after exceeding their maximum revenue entitlements for moving western Canadian grain (Cross 2019).

These earlier developments were re-evaluated in 2018. At that time the Government of Canada past the "Transportation Modernization Act" (Donley, 2018). This included two important features to discipline carriers. First, it requires railways to report during the summer their abilities to move that year's grain crop, and to publish a contingency plan by October 1 for managing shipments during bad weather. Second, these included financial penalties for railways that fail to deliver the number of rail cars promised on time.

Summary

There are many different sources of risk facing grain shippers, and each provides a unique challenge. Of these, certain sources of risk are easier to mitigate than others. Grain prices can be mostly hedged with futures, and grain quantity can be partially mitigated with the use of forward contracts. Risk in rail shipment of grain is more difficult to manage since there is no derivative market for hedging. Users of primary shuttle instruments typically establish low premiums, but the quantity of rail cars received is subject to rail performance. Users of secondary rail shuttles are guaranteed placement within a window of time, but they are subject to price risk and normally greater premiums.

[33] A recent summary of these issues and problems are contained in AgriWeek, Grain Rail Service Deteriorates Once Again, April 8, 2019.

[34] https://www.otc-cta.gc.ca/eng/western-grain-maximum-revenue-entitlement-program

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

Data Behavior

In the empirical analysis and description of mechanisms below, it will be important to have a perspective on the behavior of selected data. For that purpose, several figures are shown below for illustration. These include figures on basis values, rail preference and secondary market values.

Data for these series are from multiple sources. The PNW Basis data were extracted from weekly reports published by *TradeWest*. Report dates are from either the Thursday or Friday of each week. The value equals the nearby basis bid for Soybeans going to the PNW Terminal. The Jamestown ND basis is weekly data from *DTN ProphetX* and from the Gavilon elevator located in Stutsman County, ND. The spread between this is simply "PNW-Jamestown Spread" and derived by subtracting the origin basis (Basis Jamestown ND) from the destination basis (Basis PNW). The secondary car market is defined as DCV (daily car value) and reported in $/car and extracted from the reports published by *Trade West* on a weekly basis. It is equal to the average of the Bid-Ask spread for rail cars in the nearby month. Values can be expressed as First-Part, Mid-Part, Last-Part (If divided into thirds of a month); or as First-Half, Last-Half (if divided into half's).[35] A "red star" indicates a "no bid" on the date of extraction.

Data	Source	Assembled By
Basis: PNW	Trade West Brokerage Co. Thomson Reuters Eikon	Bruce Dahl
Daily Car Value (DCV)	Trade West Brokerage Co. Thomson Reuters Eikon	Bruce Dahl
Soybean Futures Spread	Data Transmission Network (DTN) ProphetX	Jesse Klebe
Tariff Rate	BNSF www tariff rates	William Wilson
Velocity	Trade West Brokerage Co.	Bruce Dahl

[35] We have the data for a longer period (i.e. 2004 to current) but only show that from 2012 to current, as weekly

Figures 4.6-4.8 show the basis for soybean at Jamestown, PNW and both Jamestown and PNW. Typically, the Jamestown basis is about -100c/b. However, there is substantial variability. In early 2013 the basis was volatile and spiked to greater than normal values; and, in mid-2014 the basis spiked to lower than normal values, but for a very short time. Again, in mid-late 2018 the basis fell, and there were periods of no bids, due in part to the impact of the Chinese tariff. The basis at the PNW was similar though a bit inverted. Typically, that basis is about +100c/b. However, in periods prior to 2013/14, it was higher than normal, and spiked to a sharp peak in later 2014. Since then, it has returned to normal, but in mid-late 2018 it was less than normal, again, due to the impact of the China tariff.

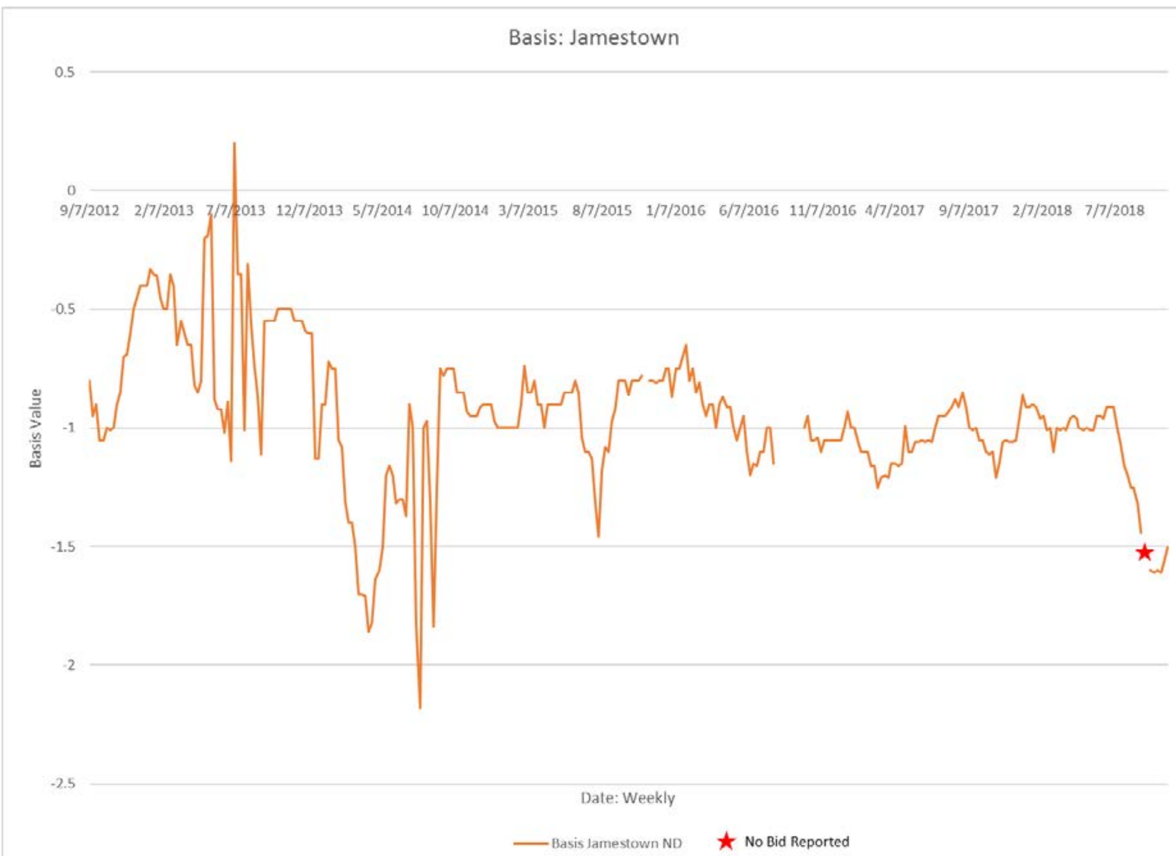


Figure 4.6. Basis at Jamestown ND for Soybean.

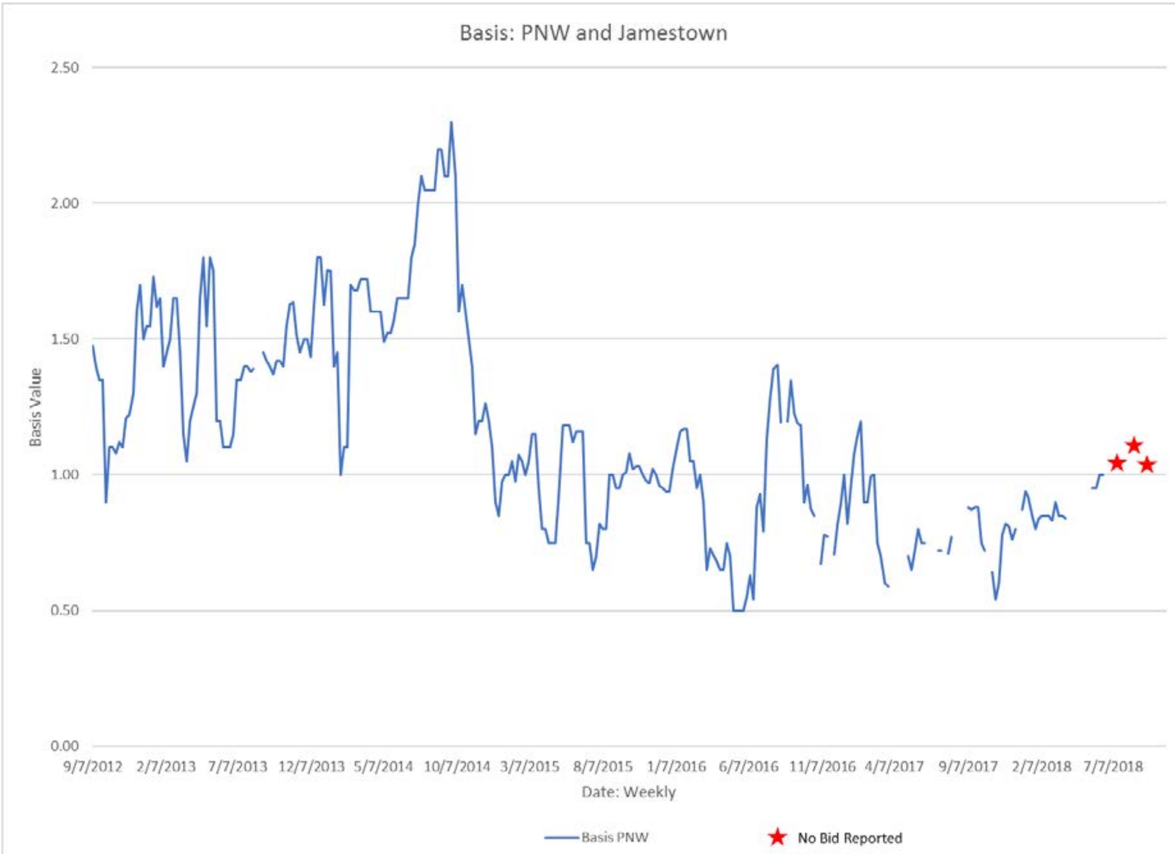


Figure 4.7. Basis at PNW (Portland) for Soybean.

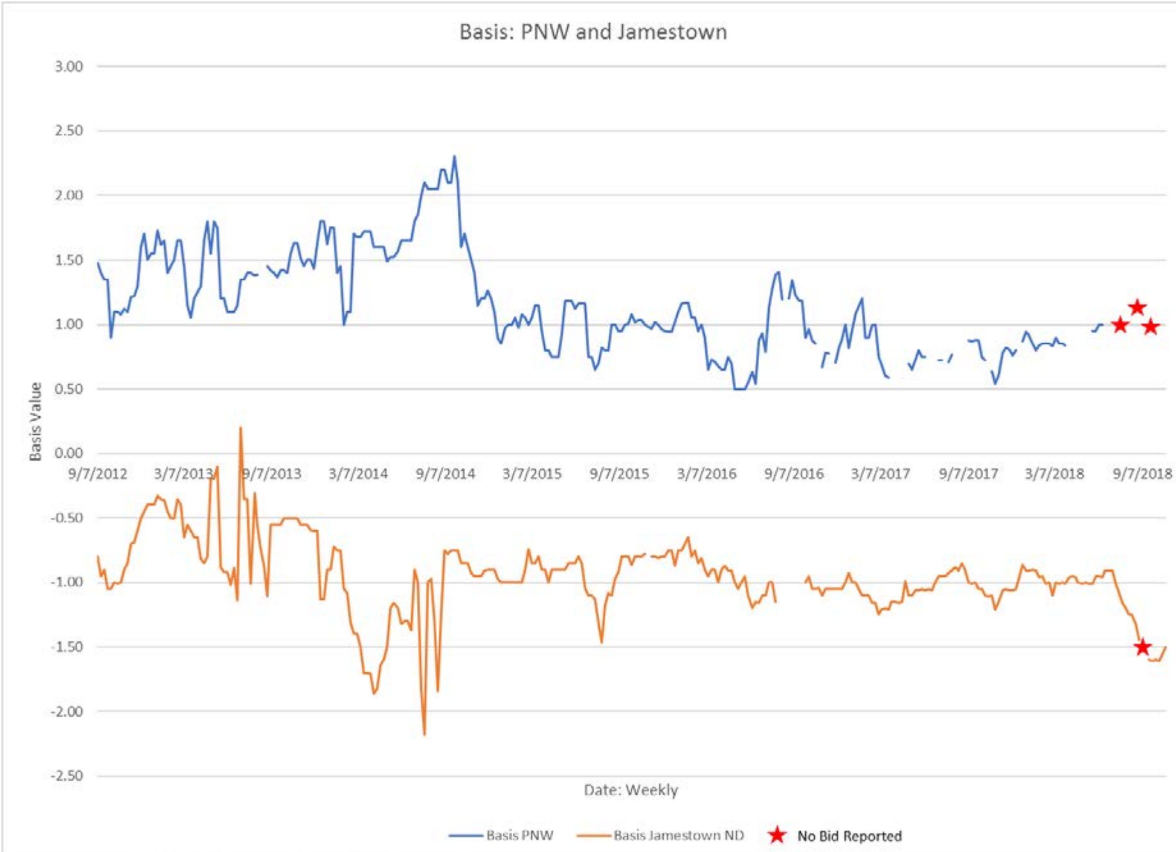


Figure 4.8. Comparison of Basis at PNW and Jamestown ND for Soybean.

Figures 4.9-4.11 shows the DCV and rail velocity respectively. Secondary rail-car markets are quite volatile. The average over this period was $546/car. There are extended periods of near nil to negative values, and also, periodic spikes upward to in this data $4000, or $5000/car. Velocity has also been volatile. It is typically between 2.5 and 3.0, but there are periods of extremely good performance, and poorer performance. The DCV and velocity are somewhat correlated as illustrated in Figure 4.11.

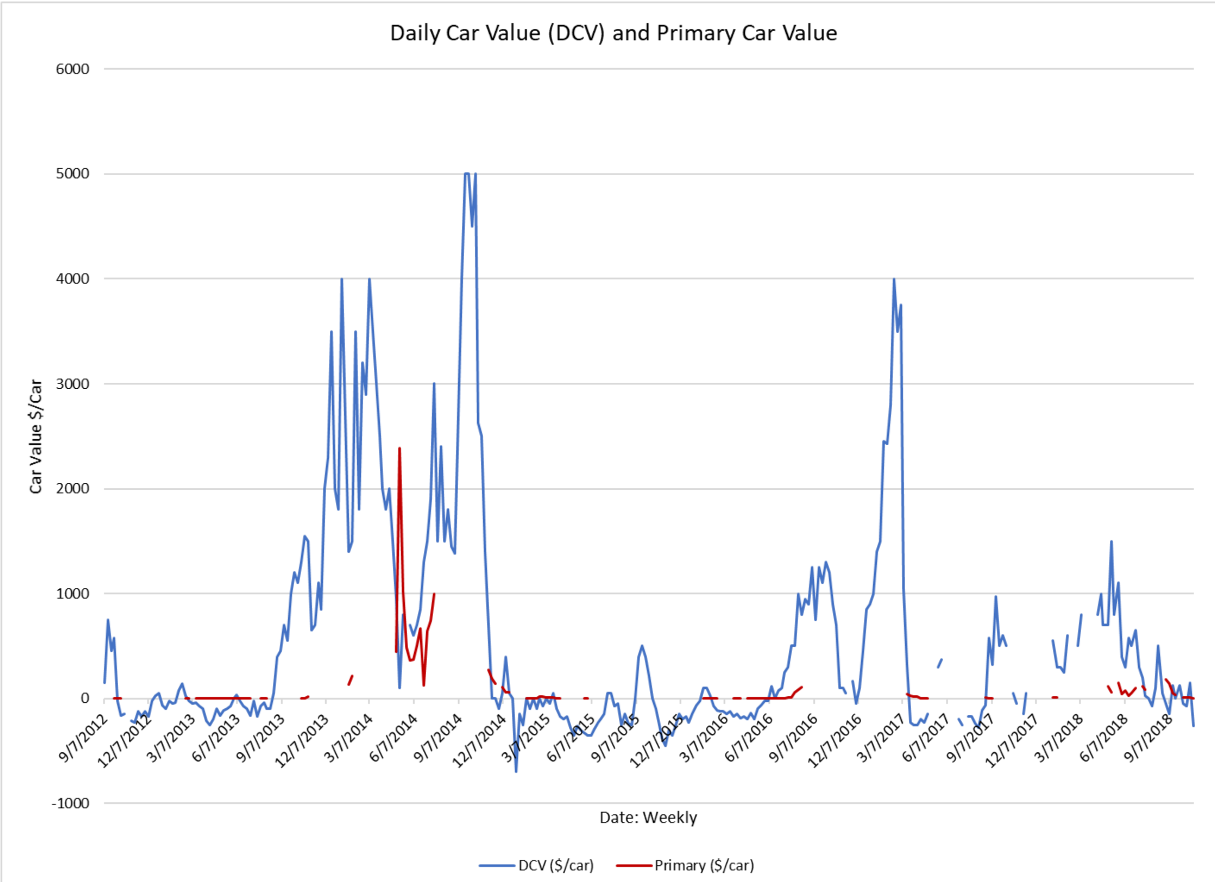


Figure 4.9. Secondary Market Values for Nearby Shipment (DCV), and Primary Auction Results, in $/car.

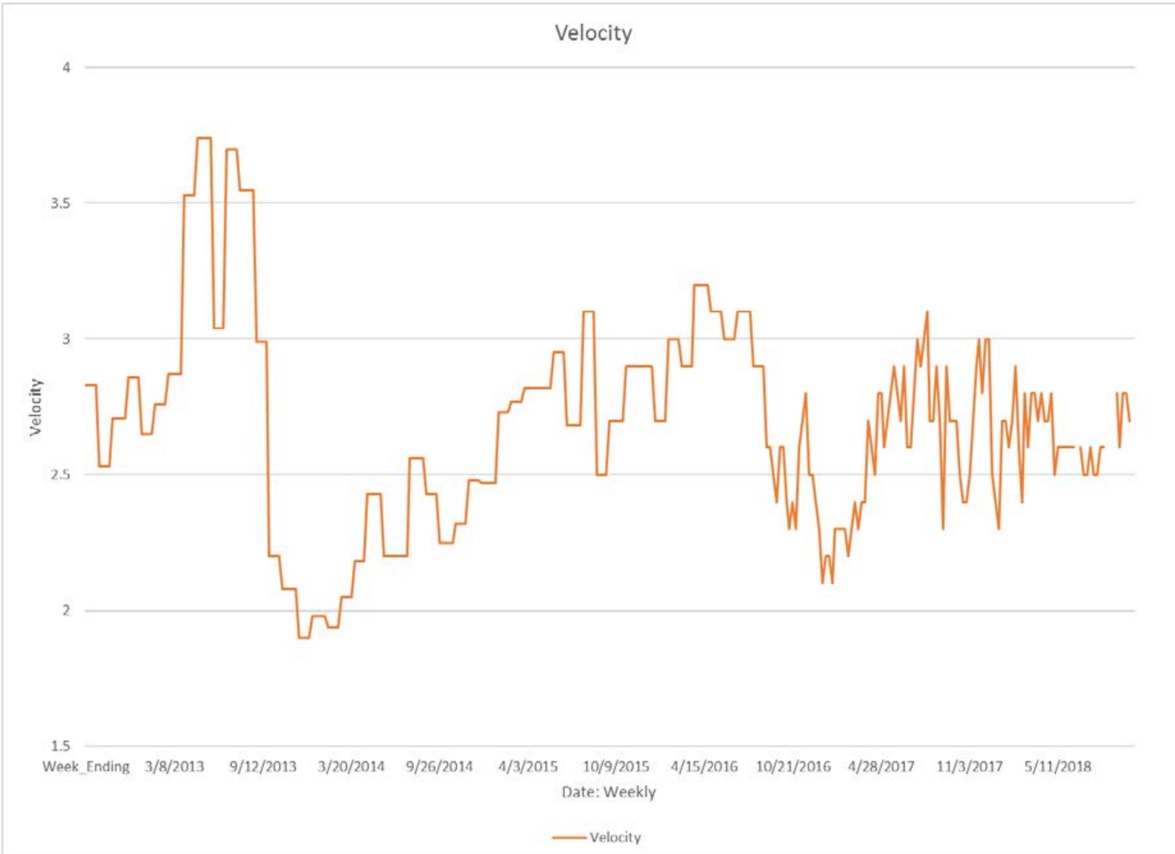


Figure 4.10. Rail Car Velocity (BNSF) in Trips/Month.

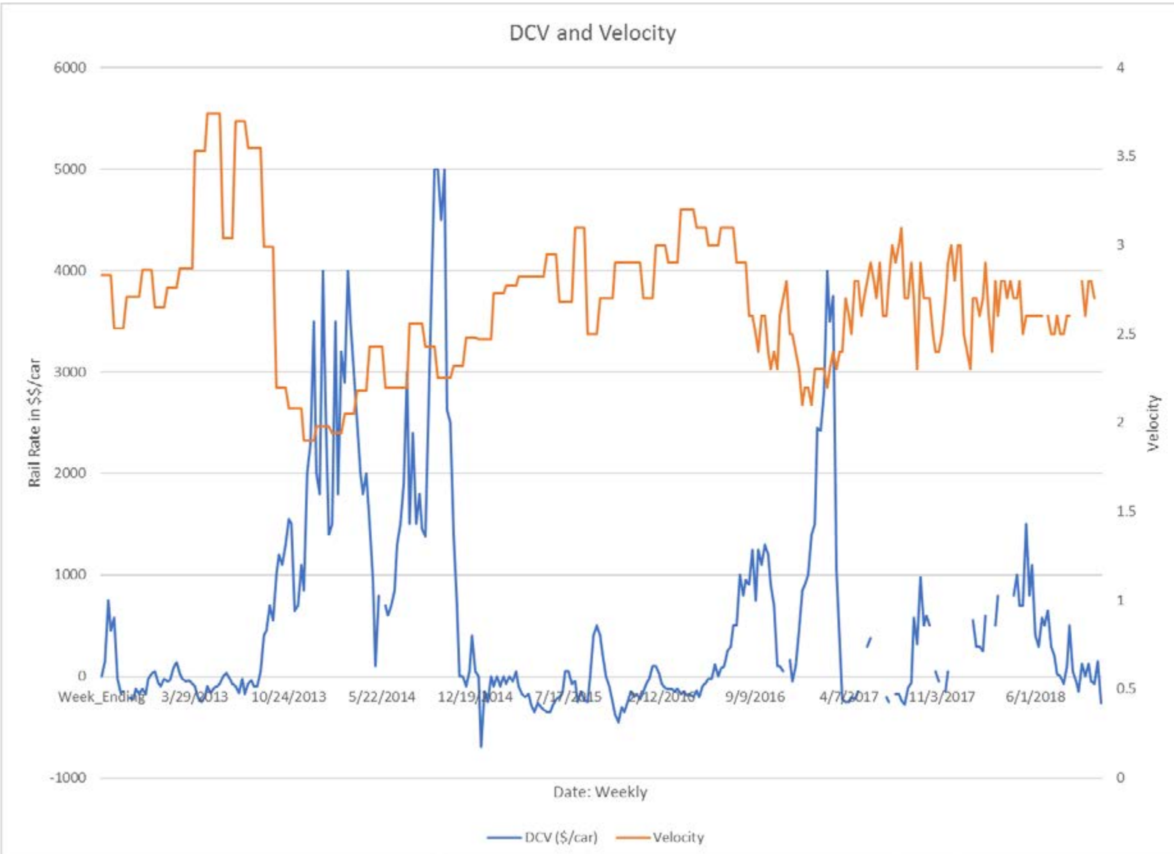


Figure 4.11. Comparison of DCV and Rail Car Velocity.

Finally, Figures 4.12-4.13 show the relation between basis, the DCV and velocity.

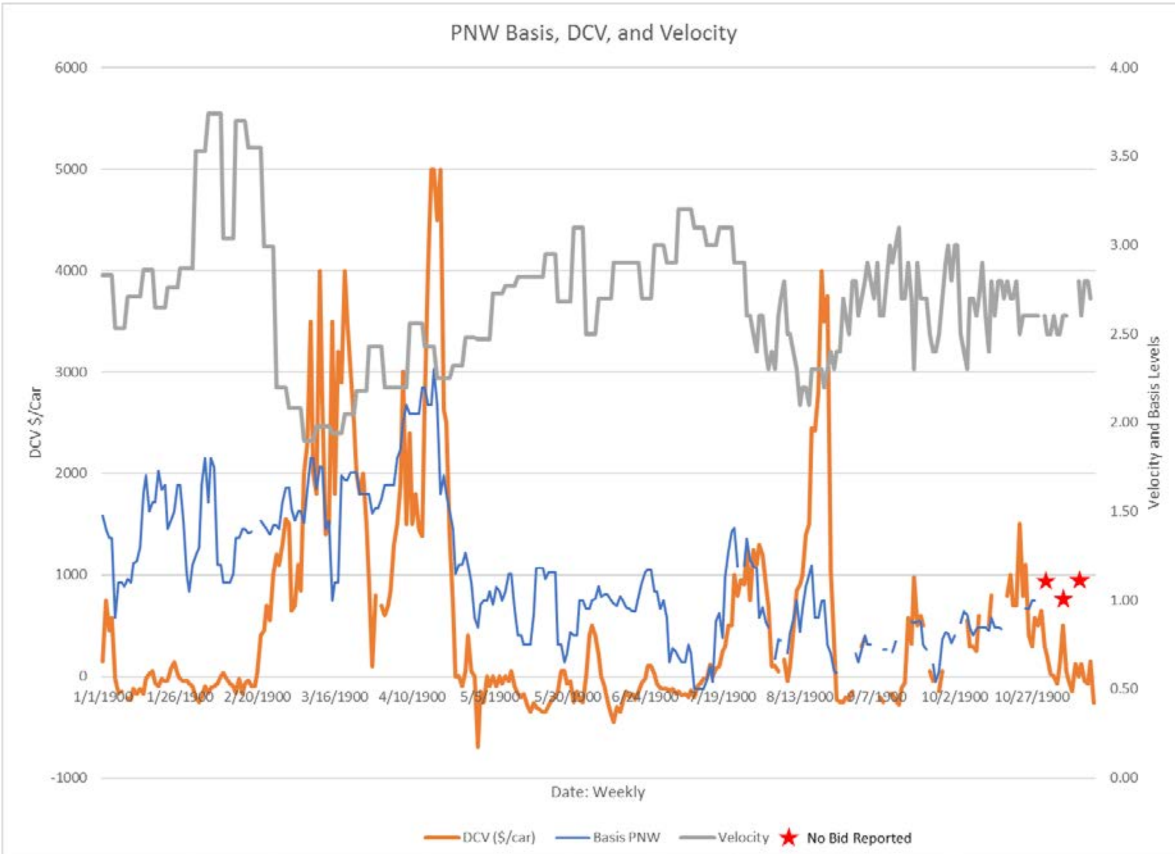


Figure 4.12. Comparison of DCV, Basis at the PNW, and Velocity.

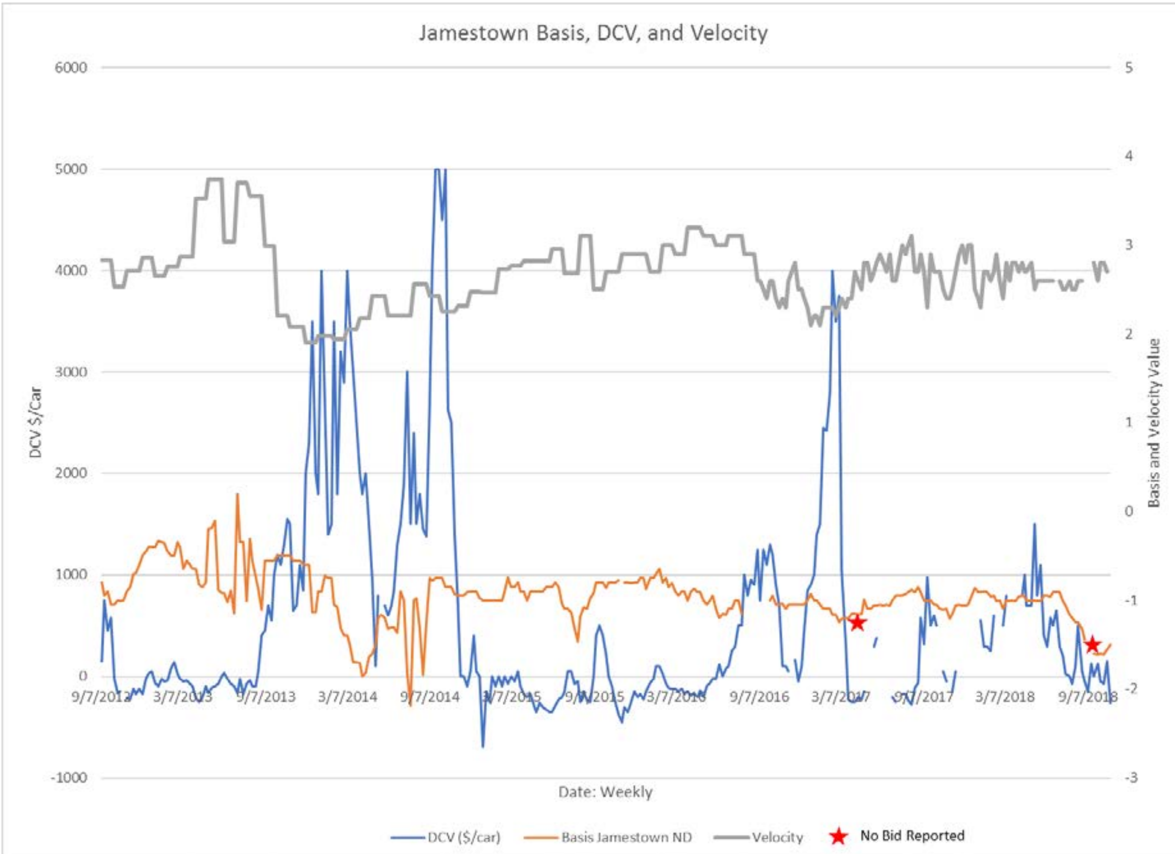


Figure 4.13. Comparison of DCV, Basis at the PNW, and Velocity.

Distributions and correlations among these values are summarized in Table 4.7 and 4.8. There is an obvious skew in the distribution of the PNW basis, the DCV and velocity. Distributions for other variables are more normal. It is also of interest that some of these variables are correlated. These include 1) the relatively weak correlation between the PNW and Jamestown basis; 2) the strong correlation between futures prices, and the PNW basis, but lesser on the Jamestown basis; 3) the DCV has a relatively strong positive impact on the PNW basis, and lesser and inverse impact on the Jamestown basis; 4) velocity has a strong inverse impact on the DCV; among others.

Table 4.7. Distributions of Selected Variables.

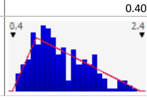
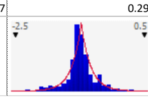
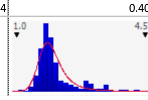
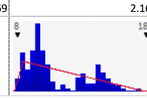
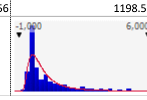
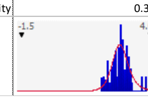
Name	Basis PNW	Basis Jamestown ND	PNW-Jamestown Spread	Nearby Soybean Futures	DCV ($/car)	Primary ($/car)	Velocity
Range	Bruce_Data!C446:C767	Bruce_Data!D446:D767	Bruce_Data!E446:E767	Bruce_Data!F446:F767	Bruce_Data!G446:G767	Bruce_Data!H446:H767	Bruce_Data!I446:I767
Best Fit (Ranked by AIC)	RiskTriang(0.45144,0.80000,2.3	RiskLaplace(-0.96000,0.29242)	RiskLogLogistic(1.07810,0.8975	RiskTriang(8.0770,8.7100,17.56	RiskPearson5(3.3809,3353.3,Ris	RiskLevy(-0.041841,0.13734)	RiskLogLogistic(-1.0488,3.7102,
Function	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?
AIC	227.5722	76.591	217.5423	1290.1312	4722.5796	930.7092	285.2762
Minimum	0.4514	-Infinity	1.0781	8.077	-862.251	-0.0418	-1.0488
Maximum	2.3288	+Infinity	+Infinity	17.5651	+Infinity	+Infinity	+Infinity
Mean	1.1934	-0.96	2.0447	11.4507	546.195	+Infinity	2.6812
Mode	0.8	-0.96	1.8983	8.71	-96.8042	0.00394	2.6374
Median	1.1309	-0.96	1.9757	11.0837	235.7537	0.26	2.6614
Std. Deviation	0.4077	0.2924	0.4069	2.1656	1198.5736	+Infinity	0.3874
Graph							

Table 4.8. Correlations Among Selected Variables.

Correlation	Basis PNW	Basis Jamestown ND	PNW-Jamestown Spread	Nearby Soybean Futures	DCV ($/car)	Primary ($/car)	Velocity
Basis PNW	1.000						
Basis Jamestown ND	0.311	1.000					
PNW-Jamestown Spread	0.777	-0.219	1.000				
Nearby Soybean Futures	0.514	0.090	0.490	1.000			
DCV ($/car)	0.442	-0.221	0.582	0.255	1.000		
Primary ($/car)	0.463	-0.369	0.629	0.150	0.578	1.000	
Velocity	-0.282	0.281	-0.464	-0.086	-0.642	-0.679	1.000

STUDIES ON RAIL SHIPPING MECHANISMS AND BASIS

As part of this study, we conducted several specific studies on the iteration and relation between rail pricing mechanism and basis values. There has been extensive earlier studies on this topic. The analysis in this section use those studies as a point of departure and expands on them analytically. For each, we present only the salient issues, overview of the method and results. Details on models, data, estimation are available in a stand-alone research report.

Secondary (2nd) Rail Car Values in Grain Transportation and Basis Values[36]

In commodity trading, the importance of logistical performance has escalated in recent years. Logistical performance is an important factor in interfirm competition that impacts domestic as well as international spatial and temporal competition. Due to the existence of multiple shipping mechanisms, the relationship between basis values and performance measures including rail velocity is important.

The impact of shipping costs is frequently ignored in market analysis. However, since the deregulation of modal rates there is greater volatility in shipping costs, heterogeneity among shippers that could prospectively impact inter-spatial price differentials. Since the deregulation of railroads in 1980, alternative mechanisms for car allocation and pricing have emerged that impact inter-firm relationships and firm strategy. Important features of these mechanisms are bidding, transferability and velocity, among others.

The impact of these facilitated development of what is commonly referred as a secondary market for rail cars. While loosely referred as the secondary market, it is a complicated mechanism, is related to underlying commodity market values, and has important impacts on firm strategy. The impact of this regime on commodity trading is drastic including a dichotomy among shippers that may utilize the primary market mechanisms in which there is quantity risk; or shippers utilizing the secondary market in which there is no quantity risk, but there is price risk and typically a premium relative to the primary market; or, some shippers using both mechanisms. There has been dramatic volatility in the secondary market having adverse impacts on some shippers, whereas others have benefited from these instruments,

[36] This section is taken from a forthcoming research report by Wilson, W. and P. Lakkakula, 2019. Secondary (2nd) Rail Car Values in Grain Transportation and Basis Values, Department of Agribusiness and Applied Economics, North Dakota State University.

whether they are long or short primary or secondary market instruments, and, impacting basis values.

The rail and basis markets now are structurally interdependent. Other studies have treated that secondary rail markets are exogenous and impact origin basis values in varying ways. However, it is quite clear the secondary market while impacting the basis, the basis also impacts the secondary market. Simply, increasing the basis value, increases value of guaranteed shipments; and, increasing the secondary market value, increases the basis. See derivation on pp. 11-13.

The purpose of this analysis is to estimate the determinants of and relationship between the export basis for soybean at the Pacific Northwest (PNW), and rail car values in the secondary market. We develop econometric models to explore these relationships, and test hypotheses about simultaneity. The results are robust and indicate these values are impacted by numerous variables. Of notable importance is that they are determined simultaneously and are heavily impacted by velocity of rail shipments which is variable. This study provides clarity of the functional specification among these relations. Second, it tests for and demonstrates that these values are determined simultaneously which is important and in contrast to previous literature.

Historical velocity of BNSF shuttles is shown in Figure 5.1. Velocity is measured in trips per month, and, varies from as low as less than 2 trips/month, to more than 3.5 trips/month.

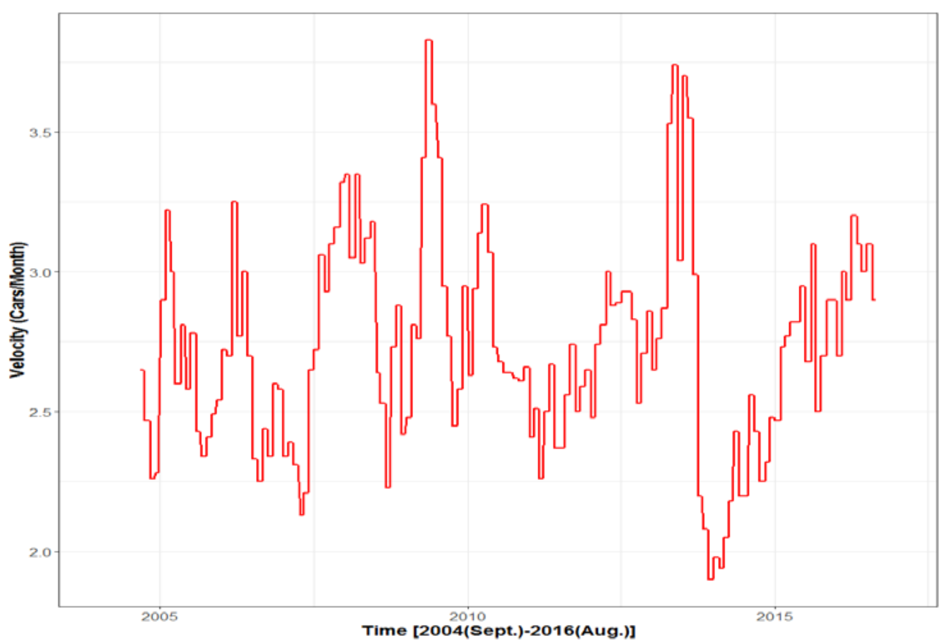


Figure 5.1. Velocity, 2004 to 2016.

Figures 5.2 and 5.3 show daily car values and the historical basis at PNW during the 2004—2016 period. The secondary market values (DCV for daily car value) suggests that these are highly seasonal, and over this period seems to have 5 spikes, and numerous discounted periods. The PNW basis is for soybean and is subject to the analysis in this study.

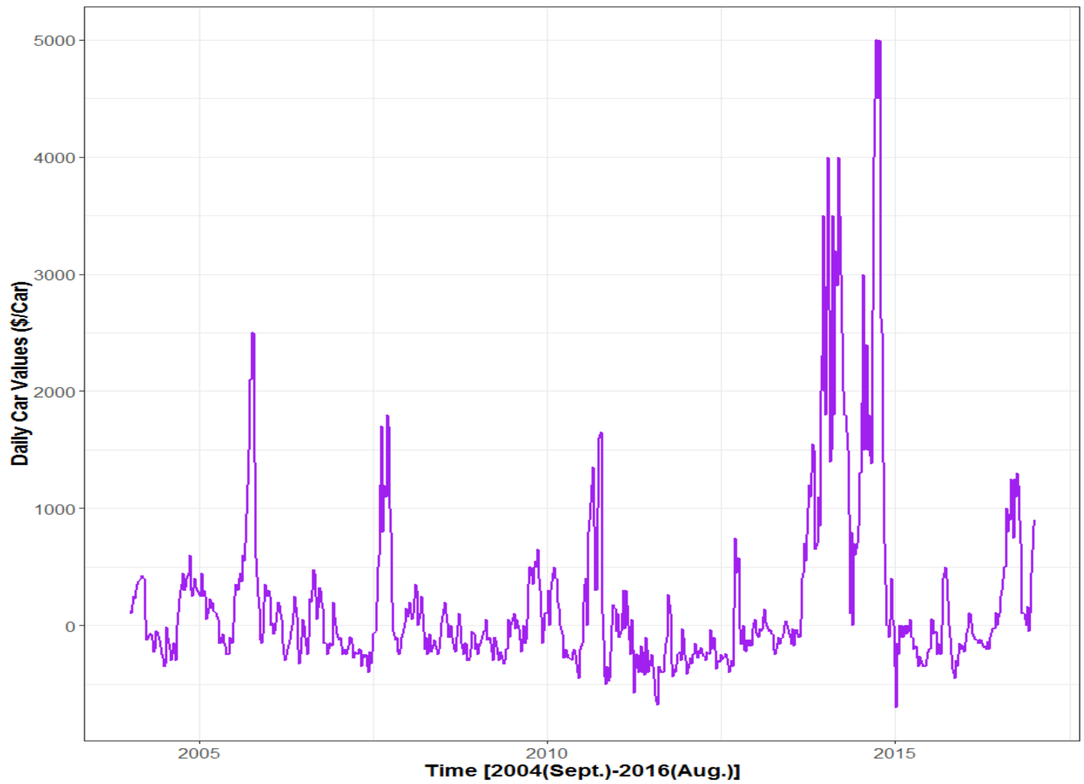


Figure 5.2. Daily Car Values, 2004 to 2016.

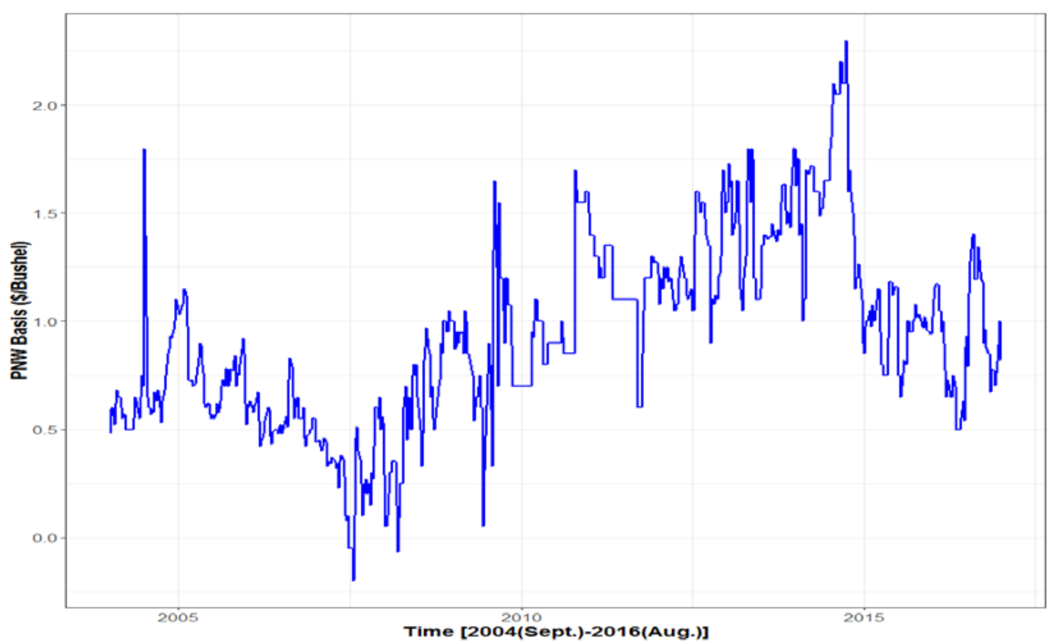


Figure 5.3. PNW Basis Values, 2004 to 2016.

Data

The focus of this analysis is on the PNW (Pacific Northwest) export soybean market, which is one of the fastest growing markets in the United States. The PNW is also the dominant destination for soybean shipments from the states in Upper Midwest. This study uses weekly data between January 2, 2004 and December 30, 2016. Summary of data consisting of different variables of interest are shown in Table 5.1. Basis data were compiled from several sources. We obtained the data from the United States Department of Agriculture's (USDA) Agricultural Marketing Service Portal (USDA-AMS, 2018), DTN Prophet Market Information system, including destination basis values (USDA-AMS Portal [https://www.ams.usda.gov/] and Trade West Brokerage Co. [private cash grain broker]) and futures (DTN Prophet Market Information System [https://www.dtn.com/industries/financial-analytics/commodity-trading/dtn-prophetx-commodity-trading/].

Table 5.1. Descriptive Statistics of Different Variables of Interest.

Variable	N	Mean	Std. Dev.	Min.	Max.
Daily Car Values ($/Car)	668	213	779	–700	5,000
PNW Basis ($/Bu.)	668	0.96	0.43	–0.20	2.30
Velocity (Cars/Month)	617	2.73	0.37	1.90	3.83
Farm Delivery Percent (%)	617	8.35	6.89	1.00	37.00
Futures Spread (c/Bu.)	668	3.61	24.15	–19.50	155.75
Gulf Port Due in 10 Days	666	57	13	18	97
Ratio of Stocks to Storage Capacity (No Units)	668	0.75	0.06	0.63	0.79
PNW in Portland ($/Bu.)	663	11.28	4.85	0	27

Other data include farmer deliveries of soybeans in North Dakota, which were retrieved from the USDA's National Agricultural Statistical Service database (USDA-NASS, 2018). Farmer deliveries represent the percentage of crop year sales that farmers made each month within a given area. Data on railcar velocity in trips per month were from the Burlington Northern and Santa Fe (BNSF). Additionally, we supplemented the data shown above with more detailed soybean export inspections (USDA-AMS, 2018), outstanding soybean export sales (USDA-FAS, 2018), rail car performance (BNSF), the ratio of grain stocks to storage by state (ProExporter). Data on ships in port and ships to arrive were from USDA AMS (USDA-AMS, 2018). The ratio of grain stocks relative to storage data were obtained from (ProExporter) by state and year.

Empirical Framework

The general specification is specified in this section and the following shows the econometric details. A two-equation model was specified as:

$$B_t^{pnw} = f\left(B_{t-1}^{pnw}, DCV_t, FAR_t^{del}, FS_t, R_t, SDum_M\right) + e_{1t} \tag{5.1}$$

$$DCV_t = f\left(DCV_{t-1}, Vel_t, SHIP_{Gulf}, SHIP_{pnw}, B_t^{pnw}, SDum_M\right) + e_{2t} \tag{5.2}$$

where B_t^{pnw} is the basis at the PNW; B_{t-1}^{pnw} is one period lag of Basis at PNW; DCV_t is the rail car value in the secondary market; DCV_{t-1} is one period lag of the rail car value in the secondary market; FAR_t^{del} is the share of farmer sales in North Dakota by month, FS_t; is the futures market spread; R_t is the ratio of stocks to storage capacity; Vel_t is rail car velocity; $SDum_M$ is monthly seasonal dummies; $SHIP_{Gulf}$ and $SHIP_{pnw}$ are ships in port at the US Gulf (expected in 10 days) and PNW, respectively. Finally, e_{1t} and e_{2t} are disturbance terms of PNW Basis and daily car values equations, respectively.

In order to study the determinants of daily car values and PNW Basis, we specify the following regressions. We run two regressions, first with PNW Basis as the dependent variable and then with daily car values (DCV) as the dependent variable. The general specification of the model is:

$$Y_{it} = \alpha_{i1} + \sum_{k=1}^{11} \delta_k + Y_{i,t-1} + \sum_{j=1}^{4} \beta_j X_{it} + \varepsilon_{it} \tag{5.3}$$

where Y_{it} is PNW Basis ($i = 1$) in the first regression and DCV ($i = 2$) in the second regression, and $Y_{i,t-1}$ is the respective one period lagged dependent variable, α_{i1} is one of the excluded seasonal monthly dummies, δ_k represents the remaining eleven monthly seasonal dummies. X_{it} is the list of independent variables which in the PNW Basis equation includes daily car values, farmer delivery percent, futures spread, and the ratio of stocks to storage capacity. The independent variables in the DCV equation include velocity, ships due at Gulf Port in 10 days, PNW Basis, ships in Portland and finally ε_{it} is a disturbance term with mean zero. Once we find the best model specification for each of the regressions, we perform a series of tests such as collinearity, heteroskedasticity, and serial correlation.

We included lagged dependent variables in each of the PNW Basis and DCV equations as the current value (t) is dependent on the value from the previous period ($t - 1$). Originally, we analyzed the appropriate lag structure by including an additional lag of up to five lags for each equation. However, the period one lag, that is, $(t - 1)$ captured most of the variation in the dependent variable and all other lags did not impact the explanatory power of the model. Therefore, we retained only one lagged dependent variable in the estimation of our models. We included monthly seasonal dummies in each regression equations.

We estimate equation (3) twice, first with PNW Basis and then with daily car values as the dependent variables using Ordinary Least Squares (OLS). We tested for the presence of autocorrelation and heteroskedasticity in the OLS models. Similarly, we used residual plot analysis as well as the Breusch-Pagan (BP) test to test for the presence of heteroskedasticity in both the OLS models. And, to account for autocorrelation and heteroskedasticity, we used the heteroskedasticity and autocorrelation consistent (HAC) standard errors.

We also tested for simultaneity to determine whether daily car values and PNW Basis, are simultaneous. If the dependent variables are simultaneous, then the estimates obtained from the OLS model are no longer consistent. The solution to simultaneity problem is to treat both DCV and PNW Basis equations as simultaneous equations and use the two stage least squares, instrumental variable or full information maximum likelihood estimation procedures.

We use full information maximum likelihood estimation (FIML) as it is an asymptotically efficient estimator for simultaneous models in case of both linear and non-linear models (White, 1982; Gourieroux et al., 1984). An essential feature of the FIML estimator is that it considers the model as a system in contrast to OLS estimation where each equation is independent of the other.

Results

Using the Akaike Information Criteria (AIC), and Bayesian Information Criteria (BIC), we found the specifications presented in equations (5.1 and 5.2) to be the best model specifications with respective set of independent variables in the estimation of PNW Basis and daily car values. The results of simultaneity indicated daily car values and the PNW Basis variables are determined simultaneously.

Results are shown in Table 5.2, which presents the OLS estimation results of individual specifications of PNW Basis and daily car values in columns (1), and (2), respectively. Columns (3) and (4) presents the parametric results of Full Information Maximum Likelihood (FIML) estimation. Results of both the models are similar in signs but one important difference is that the effect of PNW Basis on daily car values is quite different in FIML model.

Table 5.2. Estimation Results.

	OLS Estimation		FIML Estimation	
	PNW Basis	DCV	PNW Basis	DCV
	(1)	(2)	(3)	(4)
PNW Basis. Lag 1	0.889*** (*0.026*)	–	0.882*** (*0.018*)	–
DCV	0.000 (*0.000*)	–	0.000** (*0.000*)	–
Farmer Delivery Percent	–0.002 (*0.002*)	–	–0.003* (*0.001*)	–
Futures 1 Spread	0.001*** (*0.000*)	–	0.001*** (*0.000*)	–
Ratio of Stocks to Storage Capacity	0.315*** (*0.111*)	–	0.313*** (*0.119*)	–
DCV. Lag 1	–	0.859*** (*0.045*)	–	0.852*** (*0.020*)
Velocity	–	–78.402** (*39.271*)	–	–87.986** (*39.456*)
Gulf Port Due in 10 Days	–	3.911** (*1.773*)	–	3.970*** (*1.403*)
PNW Basis	–	85.800 (*46.642*)	–	112.087*** (*40.074*)
PNW in Portland	–	3.925 (*3.722*)	–	3.478 (*3.408*)
Monthly Seasonal Dummies	Yes	Yes	Yes	Yes
Observations	617	610	610	610
R-Square Value	0.908	0.857	0.908	0.846

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

We interpret the coefficients from the FIML model results only. First, when daily car values are increased there is a slight but a positive impact on the PNW Basis. The coefficients of lagged dependent variables in each of the PNW Basis and daily car values equations are important. The coefficients of lagged dependent variables are interpreted in two ways. First, in case of PNW Basis, the coefficient of lagged PNW Basis implies that if PNW Basis in the previous period had been a dollar greater per bushel, PNW Basis this period would have been $0.88 or 88 cents greater. Similarly, in case of DCV, the coefficient of lagged DCV implies that, if DCV in the previous period had been a dollar greater per car, DCV this period would have been $0.85 or 85 cents greater. Second, the coefficients of lagged dependent variables are subtracted from one to obtain the speed of adjustment parameter. For example, the speed of adjustment parameters for PNW Basis and DCV are 0.12 (obtained from 1-0.88) and 0.15 (derived as 1-0.85), respectively. The speed of adjustment in case of PNW Basis implies that 0.12 of the difference between desired and actual PNW Basis is eliminated in one period. Similarly, the speed of adjustment in the case of DCV indicates that 0.15 of the difference between desired and actual DCV is eliminated in one period. These results are important from a trader perspective. Overall, the results indicate that there is a lag in the adjustment process as opposed to adjusting instantaneously. In this case, some of the effect of a change occurs within one period, yet, it is still partial implying there can be trading opportunities.

The impacts of the exogenous variable are important. One of the most important variables is velocity on the DCV. An increase in velocity has a negative effect on daily car values, which decreases by approximately $88 per car. This is to be expected. If velocity decreases, shippers with pre-arranged forward sales, need to acquire trains in the secondary market and to do so have the effect in increasing basis. Similarly, if velocity increases, shippers would have surplus cars relative to planned demands, and they sell their surplus cars in the secondary market.

In addition, the PNW basis has a significant impact on the DCV. The PNW Basis has a positive effect on the daily car values. For example, if the PNW Basis increases by a dollar per bushel of soybeans, then the daily car values increase by $112 per car. In contrast, the PNW Basis in Portland has an insignificant effect on daily car values. Simply, if the basis increases, it increases the value of guaranteed trains that can be shipped in a specific period, and, vice versa. Thus, increases in the basis are partly captured in the value of the DCV.

Other variables impacting DCV include ships in port (PNW) and ships expected to arrive at the US Gulf. Both of these are significant and have a positive impact on the DCV. An additional ship or enroute to ports have the impact of increasing DCV by about $4 per car. The parameter estimates for both of these variables are statistically different from zero at 0.01 level of significance.

There are several variables in the PNW Basis equation besides the partial adjustment and seasonal effects that are important. An increase in one percent of farm delivery percent leads to a decrease in 0.3 cents in PNW Basis. The coefficient of farm delivery is statistically different from zero at 0.10 level of significance.

For every additional unit of stock to storage capacity ratio, the PNW Basis increases by 31.3 cents. The parameter estimate of the ratio of stock to storage capacity is statistically and significantly different from zero at 0.01 level. Lastly, the impact of DCV on the PNW Basis is positive and significant, albeit its impact is small. For example, a dollar increase per car of DCV may increase 0.004 cent per bushel of PNW Basis.

These results are of interest. First, inclusion of rail cars late in this equation were not significant, indicating this variable did not impact the basis. However, DCV is significant. This means that it is really the DCV, which is impacted by rail car velocity, which drives the effect of rail performance on basis values.

Finally, we present the Figures 5.4 and 5.5 to show the comparative performance of OLS and FIML model results. The figures clearly show that the FIML model's fitted values of both DCV and PNW Basis (more legible in PNW Basis figure) are better fitted with the actual values of the respective variables.

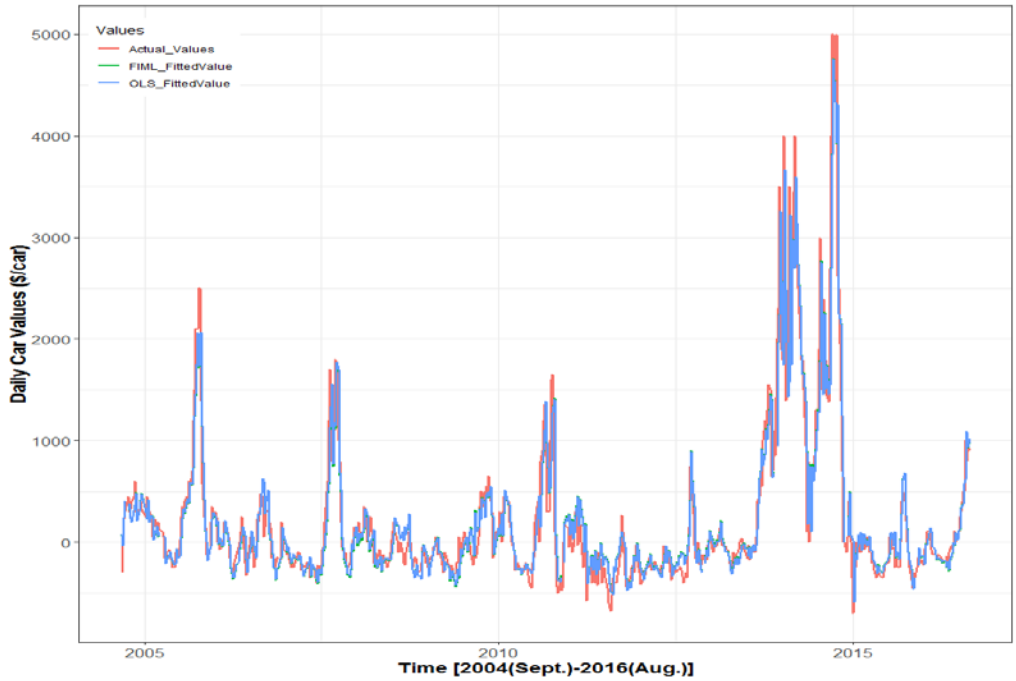


Figure 5.4. Daily Car Values, OLS and FIML Model's Fitted Values—Actual Values.

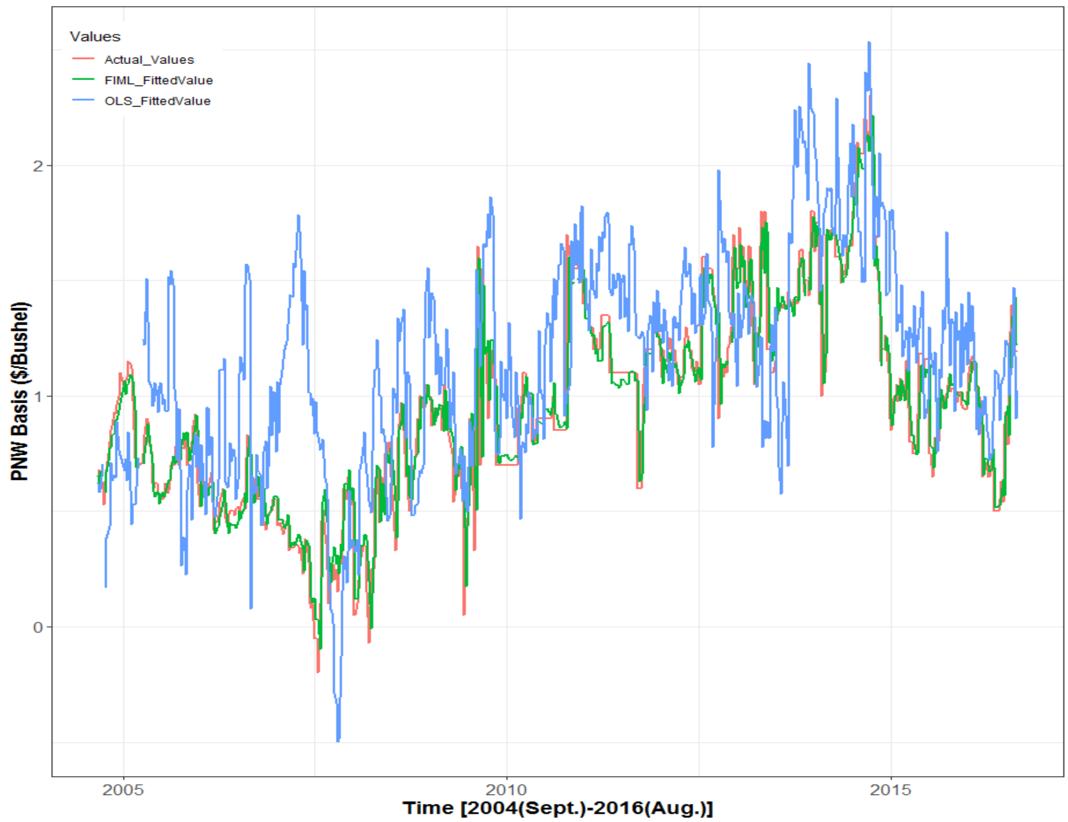


Figure 5.5. PNW Basis Values---Fitted Values of OLS and FIML Models and Actual PNW.

Summary

The purpose of this study is to estimate the determinants of and relationship between export basis for soybean at the Pacific Northwest and rail car values in the secondary (2nd) market. The secondary rail market value has significant impact on the marketing system and on basis values. The results indicated that these relationships are determined simultaneously. This is very important as it suggests that the market for freight and that for the commodity basis are integrated. The results also indicated there is significant seasonality in each market, and a partial adjustment process for each. Specifically, the adjustment to changes in exogenous variables spanned one period prior.

Several exogenous factors are important. Velocity is one of the most important variables impacting these relationships. This is a measure of rail performance and has an inverse impact on secondary market values, which had a positive impact on the basis. Importantly, higher values of rail car velocity, lowers the secondary market value, and therefore the basis. Second, the basis has a positive impact on the secondary rail car market value. A higher basis reflects greater demands for nearby deliveries, and the secondary rail market is one of the means of meeting these demands, without which shippers would accrue penalties, demurrage and other costs of not conforming to temporal demands for shipments. The secondary rail market value also impacts the basis equation. Other exogenous variables are important including ships in port or ships to arrive in the equation for secondary car market values; and, farmer deliveries, intermonth spreads in futures contracts, and the ratio of stocks-storage in the basis equation.

These results have implications for commodity trading firms, as well as analysts of the commodity marketing system. First, these results indicate that the market for freight and commodity basis are interdependent and econometrically simultaneously determined. Thus, for traders and commodity analysis trying to understand the temporal behavior of the basis, it is important to consider the integration of the freight market and that of the commodity market. Second, for commodity trading firms, it is important to integrate trading and freight functions. Third, the partial adjustment process, and the inherent seasonality of these functions indicate clear opportunities for trading.

The impact of rail performance on basis values has been an important area of research, particularly due to alleged earlier rail car shortages. These results provide a number of implications for this topic one of which is the direction and logic of the impact. Other studies either assumed rail performance was the problem, or measured rail performance as 'cars late,' or, assumed basis was impacted by secondary market values which were assumed exogenous or independent. These results present the more appropriate specification and logic indicating 1) basis and secondary rail car values are determined simultaneously; and 2) velocity is the driving factor impacting secondary market values, and indirectly the basis. In fact, including a measure called railcars late in our model was not significant. A second implication relates to the simultaneity of these equations, and the transparency of the secondary rail market values. The fact that these are positively related should be viewed favorably. Indeed, increases in the basis reflects the value of grain in deliverable position. That this is reflected in the secondary market, which is transparent, provides positive information to market participants. A third implication not addressed in previous studies relates to the temporal and seasonal allocation of rail cars. These mechanisms were developed to serve as a car allocation mechanism, both across shippers, and through time. This is accomplished in a complicated way inclusive of the effects of primary and secondary market values, and their impacts on the basis.

Panel Data Analysis of Soybean Basis[37]

A companion study to the above seeks to replicate the model by Wilson and Dahl (2011). That study used panel data on basis values and shipping costs to determine the factors impacting inter-market basis differentials. Studies related to this problem and methodology include Jiang and Hayenga (1997); O'Brien (2009); Thompson, Eales, and Hauser (1990); Tilley and Campbell (1988). McNew and Griffith (2005) and Lewis, Kuethe, Manfredo, and Sanders (2010). O'Neil Commodity Consulting (2010). Wilson and Dahl (2011).

We use panel data consisting of 46 origin cities (in 9 states) over the 2004—2016 period and estimate the relationship between factors affecting the origin basis and destination basis. The OLS (pooled) model does not account for the heterogeneity across States (cross section

[37] This is a synopsis of a forthcoming research report by Lakkakula. P and Wilson, W. (*forthcoming)*. .

units) and Time (time units). For this reason, we used Panel-Simultaneous Equations Model in this study.

The origins and destination (PNW and US Gulf) were the same as in Wilson and Dahl (2011). The data consisted of origins in 9 states, and the period was 2004 to 2016 using weekly data. In total there were 688 time series observations and a total n=30,728 observations. The data were from: USDA Agricultural Marketing Service [AMS]—Soybean Export Inspections; Advance Trading LLC, Bloomington, IL; DTN ProphetX—Origin Basis Values; USDA Foreign Agricultural Service [FAS]; ProExporter—Rstubstore and Maritime Research Inc.—Ocean Ship Spread.

The summary of data variables are shown in Table 5.3 and in Figures 5.6 and 5.7.

Table 5.3. Descriptive Statistics of Different Variables.

Variable		Mean	Std. Dev.	Minimum	Maximum	NA's
Origin Basis	Overall	–36.47	56.63	–257.50	434.75	1816
(c/bu.)	Within		50.14	–184.61	485.23	1816
	Between		26.33	–41.04	55.42	1816
Dest. Basis	Overall	102.60	92.79	–35.00	592.00	419
(c/bu.)	Within		91.58	–151.88	513.50	419
	Between		14.97	–29.37	15.72	419
Ship Cost	Overall	100.20	46.36	12.00	302.20	6880
(c/bu.)	Within		30.26	–97.09	189.95	6880
	Between		35.12	–68.24	40.05	6880
Export Inspections	Overall	26.63	22.70	0.00	188.25	0
(million bu.)	Within		22.70	–26.63	161.62	0
	Between		0.00	0.00	0.00	0
Ocean Ship Spread	Overall	21.77	9.10	8.11	60.90	0
($/bu.)	Within		9.10	–13.66	39.13	0
	Between		0.00	0.00	0.00	0
Futures Nearby	Overall	1034.30	298.78	499.50	1756.5	0
(c/bu.)	Within		298.78	–534.80	722.20	0
	Between		0.00	0.00	0.00	0
Futures Spread	Overall	–3.61	24.14	–155.75	19.50	0
(c/bu.)	Within		24.14	–152.14	23.11	0
	Between		0.00	0.00	0.00	0
Ratio of Stocks to Storage	Overall	1.05	0.13	0.00	1.24	2003
(No units)	Within		0.06	–0.32	0.13	2003
	Between		0.11	–1.05	0.09	2003
BN Cars Late	Overall	24.68	34.98	0.00	169.76	46
('00 cars)	Within		34.98	–24.68	145.08	46
	Between		0.00	–0.00	–0.00	46

Notes: c/bu.: cents/bushel of soybeans; '00 Cars: hundred cars.

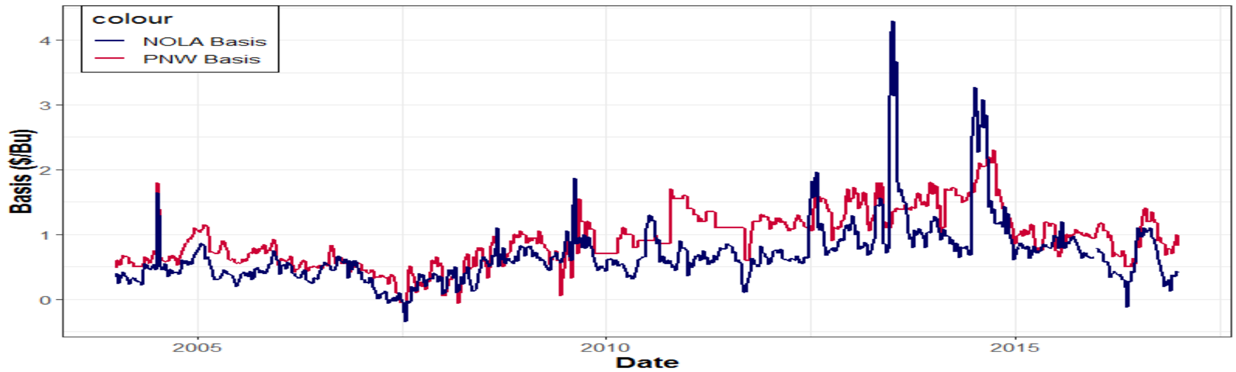


Figure 5.6. Soybean Basis at PNW and US Gulf (NOLA), 2004-2016.

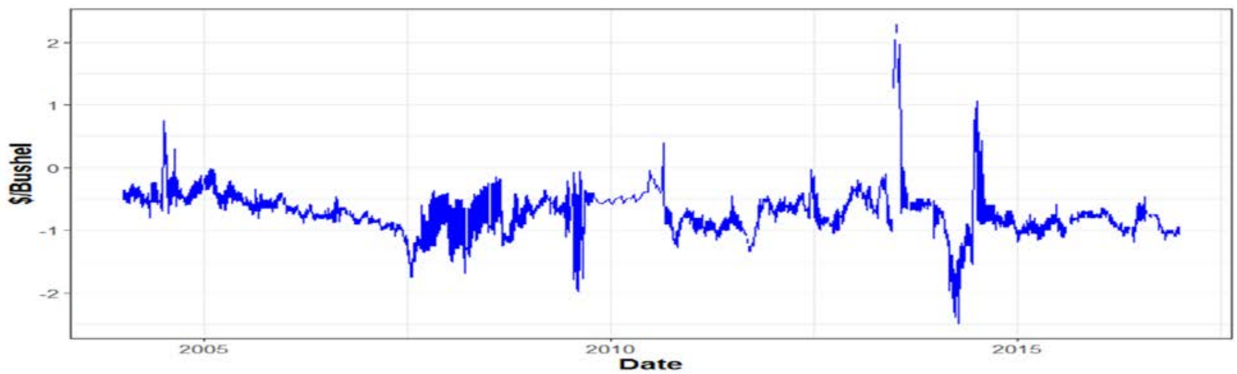


Figure 5.7. Origin Basis, in North Dakota, 2004-2016.

Overall the summary statistics suggest that origin and destination basis exhibit more within variation while the shipping cost and the ratio to stock to storage exhibit more between variation. In order to capture more within variation in the origin and destination basis, we included several interaction effects between the independent variables in addition to their individual effects on the dependent variables.

The model was estimated using panel techniques to account for fixed effects (origin cities) and the models were estimated for soybean. We also explored and estimated other panel models, including individual equations (running origin and destination basis separately) fixed effects and random effects. Using Hausman test we concluded that fixed effects is the preferred model. We then estimated the Panel Simultaneous Equations Model (P-SEM) accounting for the fixed effects.

The model was specified as:

$$B_{it}^{O} = \beta_{10} + \beta_{11}.RSC_{it} + \beta_{12}.OSP_{it} + \beta_{13}.EI_{it} + \beta_{14}.BNCL_{ij} + \beta_{15}.RSST_{it} + \beta_{16}.FNB_{it} + \beta_{17}.FS_{it} + \beta_{18}.B_{it}^{D} + \beta_{19}(EI_{it} * B_{it}^{D}) + \varepsilon_{1t} \quad (5.4)$$

$$B_{it}^{D} = \beta_{20} + \beta_{21}.RSC_{it} + \beta_{22}.OSP_{it} + \beta_{23}.EI_{it} + \beta_{24}.BNCL + \beta_{25}.RSST_{it} + \beta_{26}.FNB + \beta_{27}.FS_{it} + \beta_{28}.B_{it}^{O} + \beta_{29}.T + \beta_{210}.\left(EI_{it} * B_{it}^{O}\right) + \beta_{211}.(EI_{it} * RSC_{it}) + \varepsilon_{2t} \quad (5.5)$$

where B_{it}^{O} = origin basis at the city *i* and time *t*; B_{it}^{D} = destination basis at the city *i* and time *t*; RSC_{it}= shipping cost from city *i* and time *t*; OSP_{it}= ocean ship spread; EI_{it}= export inspections (hereafter exports); $BNCL_{ij}$= BN cars late; $RSST_{it}$= ratio of stocks to storage; FNB_{it}= futures nearby; FS_{it}= futures spread; T= trend; ε_{1t} and ε_{2t} = error terms of origin and destination basis equations, respectively. β_{ij}= coefficient estimates. When $i = 1$ they are the coefficients of origin basis, while $i = 2$ represents the coefficients of destination basis.

The results are shown in Table 5.4. As expected, shipping cost have negative effect on origin basis and a positive effect on the destination basis. The origin and destination basis are positively related, but this relationship is also complicated. If exports are zero, a dollar increase in shipping costs increases the destination basis by about 82 cents, and lowers the origin basis by about 19c/b.[38]

[38] If the exports are non-zero, the relationship becomes complicated as a result of the interaction effects in each of the origin and destination basis equations.

Table 5.4. Simultaneous Equations Fixed Effects Model Results of Panel Data.

	Origin Basis (1)	Destination Basis (2)
Ship Cost	–0.191*** (*0.009*)	0.825***(0.024)
Ocean Ship Spread	–0.296*** (*0.028*)	–1.595***(0.067)
Export Inspections	0.324*** (*0.017*)	0.044 (0.053)
BN Cars Late	–0.158*** (*0.007*)	0.287***(0.014)
Ratio of Stocks to Storage Capacity	–52.62*** (3.*863*)	153.59***(8.014)
Futures Nearby	–0.041***(0.001)	0.168*** (*0.002*)
Futures Spread	–1.070***(0.011)	1.068*** (0.027)
Destination Basis	0.324***(0.004)	–
Dest. Basis::Export Inspections	–0.003***(000)	–
Origin Basis	–	1.244***(0.014)
Origin Basis:: Export Inspections	–	–0.008***(0.000)
Ship Cost:: Export Inspections	–	–0.005***(0.000)
Trend	–	–3.724***(0.197)
Observations	30,728	30,728

Notes: ***p < 0.01; "::"=interaction effect.

Late car placement (BN Cars late coefficient) is negatively associated with the origin basis and positively with the destination basis given all other variables are constant. For example, for every 1000 late cars the origin basis decreases by 1.6 cents per bushel while the destination basis increases by 2.9 cents per bushel of soybeans. These results indicate that while late car placement impacts both the origin and destination basis, it has a greater positive impact on the destination basis. Thus, buyers are adversely affected by late car placements more than sellers.

Nearby futures have a negative effect on origin basis but positive effect on destination basis. Exports have significant positive effect on origin basis, but its coefficient is insignificant in case of destination basis without interaction effects. Several of the interaction effects are important in the model to maintain the correct sign of the individual exogenous variables.

There are several important implications from these results. First, the results show that the origin and destination basis are determined simultaneously. We infer the simultaneity between the origin and the destination basis based on the significance of the coefficients associated with each other in the P-SEM. This differs from some of the earlier studies which treat them separately, or independently. Thus, treating B_o and B_d as independent is inappropriate and would result in biased results. These results are intuitive. Trying to infer that one basis depends on the value and changes in another basis is not correct. Instead, they are determined simultaneously. For this reason, shipping cost is analogous to an incidence of a tax on buyers versus sellers, which inherently may depend on the supply and demand for underlying products. Overall, these results indicate that changes in rail shipping costs are shared by producers, and buyers, though the distribution between these varies through time and depends on the level of exports, among other factors.

Factors Influencing the Gulf and PNW Soybean Export Basis: An Exploratory Statistical Analysis[39]

As shown in the sections above, the export basis has an important influence on the origin basis. This section examines the impact of fundamental factors upon both the level (marketing year average) and seasonality (by marketing year) of Gulf and PNW nearby soybean basis values for the 2004/05 through 2015/16 marketing years. Explanatory variables include Brazilian basis values (FOB Paranagua), nearby futures spreads, rail transportation costs (tariff plus fuel surcharge), secondary railcar values (DCV), barge rates, ocean freight rates, number of ships in port (Gulf and PNW), and a number of additional supply / demand variables (too many to list here).

Since the number of explanatory variables (27) exceeds the number of observations (12 marketing years), this study utilizes an exploratory regression technique called partial least squares (PLS) which was originally developed by Herman Wold (1966) to determine the influence of the explanatory variables upon the marketing year average basis level. PLS is similar to principal components regression (PCR); however, it has the advantage of considering information in both the dependent and explanatory variables in constructing its regression components (latent variables). Regression coefficient t-statistics are used to test the statistical significance of each explanatory variable in the final PLS estimation.

To explain basis seasonality, additive seasonal indices for each marketing year are calculated by taking the difference between the monthly value and the marketing year average. The marketing years are then grouped into seasonal analogues by applying agglomerative hierarchal clustering (AHC) using Euclidian distance as the clustering metric (Ward 1963). The optimal number of clusters is determined for each location (Gulf and PNW) using minimum entropy. To determine which explanatory variables are most significant to each analog cluster, a value test (Lebart et al. 2000) for testing the differences in means between a subset and overall population was used with each analog comprising the subset.

Though analogue year analysis has been used extensively in other disciplines (including climate and meteorology, and other disciplines, it has been used less frequently in agricultural

[39] This section is a synopsis of a recent paper by David W. Bullock and William Wilson, *Factors Influencing the Gulf and PNW Soybean Export Basis: An Exploratory Statistical Analysis*, Agribusiness and Applied Economics Report No. 788, NDSU Department of Agribusiness and Applied Economics, May 2019 and, Journal of Agricultural and Resource Economics (forthcoming).

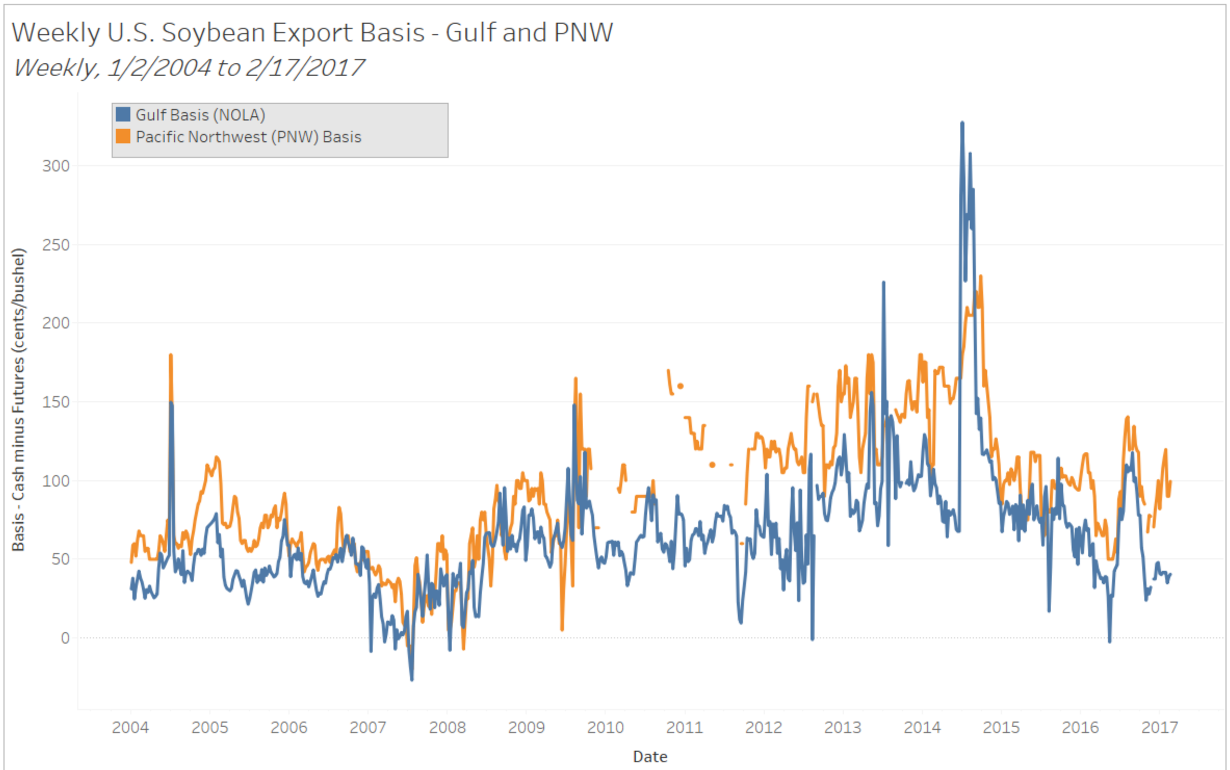
economics. Most of the research relating to analog seasonal analysis has focused on relating weather analogs to crop yields and production (Hansen, Potgieter and Tippett 2004; Menzie 2007; Johansson et al. 2015; Irwin and Good 2016).   Extension publications, such as Flaskerud and Johnson (2000), have published seasonal indices based upon crop fundamental analogs by grouping marketing years based upon a fundamental factor such as crop production. There have also been patents filed (Kolton, Gamboa and Chimenti 1996; Phillips et al. 2004) for systems using analog techniques to forecast commodity prices. Additionally, there have been recent studies examining the potential of analog techniques in the financial markets (Wanat, Śmiech and Papież 2016; Lahmiri, Uddin and Bekiros 2017).

Bullock (2004) applied a multivariate technique called *exploratory factor analysis* (EFA) to derive seasonal analogs for Minnesota hard red spring wheat prices and basis values (September and July futures) for the 1960/61 through 2003/04 marketing years. For price, a total of 8 unique analogs were derived with two unique outlier years (1973/74 and 1974/75). A total of 6 and 5 analogs were identified for the September and July basis values.

Data and Methodology

Dependent Variables

Weekly nearby basis data (CIF) from 1/2/2004 through 2/17/2017 for both the Gulf (NOLA) and Pacific Northwest (PNW) export markets was obtained from TradeWest Brokerage and are illustrated in Figure 5.8.   Missing values (64 total) were interpolated using the NIPALS (Wold 1973) procedure. The data was then converted into monthly and marketing year (September through August) averages to be used in the analyses to follow.



Source: TradeWest Brokerage. Based on CIF cash prices.

Figure 5.8. Weekly U.S. Soybean Export Basis—Gulf and PNW

Independent (Explanatory) Variables

A complete list of the potential explanatory variables, sources, and levels of aggregation is given in Table 5.5 below. All the variables are rolled up to a marketing year (MY) level for the analyses to follow.

Table 5.5. List of Explanatory Variables Used in the Analyses.

Category	Variable Name	Description	Source	Aggregation
International Demand (IntD)	*Basis-Brz*	Brazil Soybean Basis, Paranagua - CME Futures (US$/bu)	CME, Cepea	MY Average of Weekly Values
	SA-Prod	Total South American (Argentina-Brazil-Paraguay) Soybean Production (mmt)	USDA - WASDE	MY Reported Values
	China-Import	China Total Soybean Imports (mmt)	USDA - WASDE	MY Reported Values
	World-SU	World Soybean Ending Stocks-Use Ratio (%)	USDA - WASDE	MY Reported Values
Domestic Demand (DomD)	*Futures-NB*	Nearby CBOT Soybean Futures Price (c/bu)	CME, DTN ProphetX	MY Average of Weekly Values
	FutSprd1	2nd NB Futures - NB Soybean Futures Price (c/bu)	CME, DTN ProphetX	MY Average of Weekly Values
	FutSprd2	3rd NB Futures - 2nd NB Soybean Futures Price (c/bu)	CME, DTN ProphetX	MY Average of Weekly Values
	SU-Ratio	U.S. Soybeans Ending Stocks-Use Ratio (%)	USDA - WASDE	MY Reported Values
	MealP	U.S. Domestic Soybean Meal Price ($/ton)	USDA - WASDE	MY Reported Values
	OilP	U.S. Domestic Soybean Oil Price (c/lb)	USDA - WASDE	MY Reported Values
	Crush	U.S. Domestic Soybean Crush as % of Total Supply	USDA - WASDE	MY Reported Values
Transportation Costs (Trans)	*Rail-Gulf*	Total Rail Cost, Shuttle Trains (Tariff plus Fuel Surcharge) - Freemont, NE to Texas Gulf ($/car)	BNSF Railroad	MY Average of Weekly Values
	Rail-Sprd	PNW versus Gulf Rail Cost Spread, Shuttle Trains - Freemont, NE ($/car)	BNSF Railroad	MY Average of Weekly Values
	Barge-Spot	Spot Barge Rate - St. Louis to Gulf ($/ton)	USDA - AMS	MY Average of Weekly Values
	Barge-3M	3-month Forward Barge Rate - St. Louis to Gulf ($/ton)	USDA - AMS	MY Average of Weekly Values
	Ocean-PNW	Ocean Freight Rate from PNW to Japan ($/mt)	USDA-AMS	MY Average of Weekly Values
	Ocean-Sprd	Ocean Freight Spread to Japan - Gulf versus PNW ($/mt)	USDA-AMS	MY Average of Weekly Values
Logistic Conditions (Logistic)	*Cars-Late*	Average BN Railcars Placed Late (# of cars)	BNSF Railroad	MY Average of Weekly Values
	DCV	Daily Secondary Market Car Values for Shuttle Trains ($/car)	TradeWest Brokerage	MY Average of Weekly Values
	FarmDel-Q1	Cumulative farmer delivery % through Q1 of MY	USDA - NASS	Cumulative Sum of Monthly
	FarmDel-Q2	Cumulative farmer delivery % through Q2 of MY	USDA - NASS	Cumulative Sum of Monthly
	FarmDel-Q3	Cumulative farmer delivery % through Q3 of MY	USDA - NASS	Cumulative Sum of Monthly
Level of Export Activity (ExpActivity)	*Gulf-InPort*	Average Number of Ships in Gulf Ports (ships)	USDA - AMS	MY Average of Weekly Values
	PNW-InPort	Average Number of Ships in PNW Ports (ships)	USDA - AMS	MY Average of Weekly Values
	Export-Gulf	FGIS Export Inspections at Gulf Ports (1000 bushels)	USDA - FGIS	MY Average of Weekly Values
	Export-PNW	FGIS Export Inspections at PNW Ports (1000 bushels)	USDA - FGIS	MY Average of Weekly Values
	Export-Out	U.S. Soybean Export Sales - Outstanding Balance (1000 bushels)	USDA - FAS	MY Average of Weekly Values

Methodology

In this analysis we used PLS. Details of the methodology and analytical approach are provided in Bullock and Wilson (2019 and forthcoming).

Since the number of explanatory variables (27) exceeds the number of observations (12 marketing years), this study utilizes an exploratory regression technique called partial least squares (PLS) which was originally developed by Herman Wold (1966) to determine the influence of the explanatory variables upon the marketing year average basis level. PLS is similar to principal components regression (PCR); however, it has the advantage of considering information in both the dependent and explanatory variables in constructing its regression components (latent variables). A useful output of the PLS procedure is an index called the variable importance in projection (VIP) where values greater than one are considered important in making the projection (Wold et al. 1993, pp. 523-550). The VIP values can be effectively used to pare down the number of explanatory variables that are fitted in the final round of PLS estimation. Regression coefficient t-statistics are used to test the statistical significance of each explanatory variable in the final PLS estimation.

Results

Statistical Characterization of the Market Year Average Basis for Gulf and PNW

Examination of the marketing year average basis levels for both the Gulf and PNW markets indicated a noticeable shift higher in the mean MY basis level beginning with the 2008/09 marketing year for both markets. Therefore, for the analysis of the marketing year averages, the explanatory dataset was augmented with a dummy variable (*Prior to 2008?*) which is equal to one if prior to 2008/09 and a linear trend (*Trend*) variable. The reasons for these shifts are due in part to the radical change and increase in volatility in all commodity markets following the 2008/09 crop year, and the growing trend in U.S. soybean exports, particularly to China.

For the mean basis level, the values from 2004/05 through 2007/08 were 38 and 55 cents per bushel respectively for the Gulf and PNW respectively. For 2008/09 through 2015/16, the average basis levels were 80 and 114 cents per bushel respectively. A two-sample t-test with the null hypothesis of no difference between the means versus the alternate hypothesis that the mean in the first period was less than the latter was applied. The t-test rejected the null hypothesis in favor of the alternative hypothesis at the 99% confidence level for both the Gulf and PNW markets.

Further, the volatility of the basis has escalated over time. The standard deviation of the basis (derived using monthly data) for the period prior to 2008/09 was 10 and 19 cents per bushel respectively for the Gulf and PNW. For the period following, these values increased to 24 and 272 cents per bushel for the Gulf and PNW respectively. Application of Fisher's F-test to the basis variance (Ha: first period variance is less than latter period), however, indicated that only the Gulf basis was significantly lower (at 90% confidence level) while the PNW was not significant at the 90 percent level or higher.

The MY average basis values for the Gulf and PNW are highly correlated (93.0%) over the 12 market year observations; therefore, they were both included in the Y matrix for the PLS-R estimation. For the analysis to follow, a two-part procedure was used. First, the PLS-R model was applied to the full explanatory dataset. Those variables whose variable importance in projection (VIP) indices are greater than one was retained in the dataset for the final estimation while those with values less than one were removed. The second part applied PLS-R to the reduced dataset for the final estimation of the regression coefficients and interpretation of significance.

The VIP Index scores on the explanatory variables are shown (in descending order) in Figure 5.9. The retained variables for the final stage of PLS-R modeling are shaded in red. The results indicate that the Brazilian export basis (*Basis-Brz*) is the most important variable in projecting both the Gulf and PNW basis levels. Following in importance are the nearby futures spreads (*FutSprd1* and *FutSprd2*), the domestic soybean meal price (*MealP*), and the total rail shipping costs from Freemont, NE to the Gulf (*Rail-Gulf*) which includes both the tariff and the fuel surcharge. Less than half (13 out of 29) of the variables had a VIP score greater than one and were retained for the final regression estimation procedure.

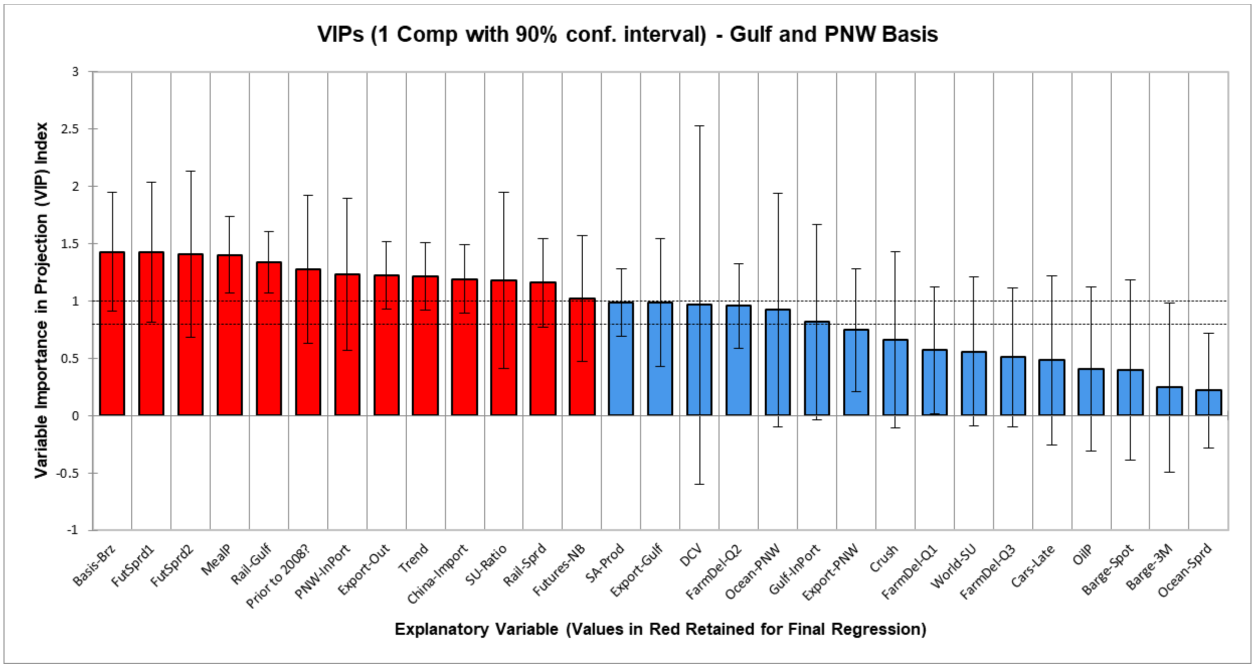


Figure 5.9. VIPs: Gulf and PNW Basis

The second round of PLS-R estimation regressed the Y matrix of MY average basis values upon the one retained latent variable component derived from optimizing the covariance between the Y matrix and the VIP reduced explanatory variable set (X matrix). This resulted in a quality index (Q^2) statistic of 0.7198 which indicates a substantial improvement in the out-of-sample predictability of the model (6.43% gain in Q^2 from the full to the reduced variable set). The in-sample R^2Y equaled 0.798 which indicates the latent variable accounts for almost 80% of the variability in the Y matrix.

Table 5.6 shows the PLS-R regression equation for the Gulf marketing year average basis level. The regression fit had an R^2 coefficient of 0.7989 with a root mean squared error (RMSE) of 12.3 cents per bushel (both in-sample). The non-standardized and standardized coefficient estimates are both presented with the coefficients ordered by the absolute value of the standardized coefficient estimates.

Table 5.6. PLS-R Regression Results for Gulf Market Year Average Basis Level.

Variable	Coefficient	Standardized Coefficient	Std. deviation	Lower bound (90%)	Upper bound (90%)	T-Statistic	Significance	
Intercept	-1.4753	N/A	14.7704	-28.0012	25.0506	-0.0999	0.9222	
Basis-Brz	0.0722	0.0920	0.0243	0.0286	0.1159	2.9729	0.0127	**
FutSprd1	-0.1804	-0.0917	0.0695	-0.3053	-0.0555	-2.5944	0.0249	**
FutSprd2	-0.1668	-0.0905	0.0715	-0.2952	-0.0383	-2.3310	0.0398	**
MealP	0.0256	0.0902	0.0063	0.0142	0.0370	4.0370	0.0020	***
Rail-Gulf	0.0042	0.0862	0.0008	0.0029	0.0056	5.6118	0.0002	***
Prior to 2008?	-4.7869	-0.0822	0.9871	-6.5596	-3.0143	-4.8497	0.0005	***
PNW-InPort	0.8422	0.0792	0.3737	0.1710	1.5134	2.2535	0.0456	**
Export-Out	0.0240	0.0789	0.0054	0.0143	0.0337	4.4286	0.0010	***
Trend	0.6231	0.0783	0.0994	0.4446	0.8015	6.2695	0.0001	***
China-Import	0.1122	0.0766	0.0207	0.0749	0.1494	5.4080	0.0002	***
SU-Ratio	-0.4607	-0.0758	0.1698	-0.7656	-0.1559	-2.7140	0.0201	**
Rail-Sprd	0.0094	0.0745	0.0026	0.0048	0.0141	3.6269	0.0040	***
Futures-NB	0.0063	0.0656	0.0017	0.0032	0.0094	3.6482	0.0038	***

The results indicated that all of the explanatory variable coefficients are statistically significant at the 95% level or greater. The Brazilian MY average export basis value (*Basis-Brz*) has the greatest overall impact upon the Gulf average basis value. The sign of the coefficient is positive which indicates that maintaining international competitive parity with Brazil is the most important factor in setting the Gulf export basis value.

The nearby futures carry spreads (*FutSprd1* and *FutSprd2*) are next in terms of statistical importance with negative signs for both coefficients with both significant. Strong negative carry in the intermonth futures spreads is an indication of strong current demand for soybeans when compared to demand in the deferred months. In order to draw stocks of soybeans into the export channel to meet the higher current demand, a higher basis level is necessary in order to maintain market competitiveness for the current supply of soybeans.

The domestic soybean meal price (*MealP*) is fourth in importance and has a positive coefficient value. The sign is as expected since higher soymeal prices would indicate increased domestic crush demand for soybeans. The export basis levels would have to adjust higher in order to maintain competitive parity with the domestic crush demand.

The top four explanatory variables (*Basis-Brz, FutSprd1, FutSprd2,* and *MealP*) are all reflective of competitive demand pressures that are applied to the Gulf export market; therefore, this supports the hypothesis that the primary role of the Gulf export basis level is to effectively meet competitive pressures, both from abroad (*Basis-Brz*) and domestically (*FutSprd1, FutSprd2,* and *MealP*).

The only logistical cost factors that remain in the reduced explanatory variable set are the costs of rail transportation (sum of tariff and fuel surcharge) from Freemont, NE to the Gulf (*Rail-Gulf*) and the additional cost to the PNW (*Rail-Sprd*). Both of these costs are significant. The cost to the Gulf (*Rail-Gulf*) has a higher standardized coefficient value and t-statistic when compared to the additional cost to the PNW (*Rail-Sprd*). The positive sign on the rail cost to the Gulf is expected since the Gulf export basis must adjust higher in order to maintain competitiveness with the domestic market. However, the positive sign on the additional cost to the PNW is not expected as the logic would follow that Gulf basis levels would not have to increase as much to maintain competitive parity with the PNW. The only potential explanation would be that the more important rail cost is the total cost to the PNW (equals *Rail-Gulf* + *Rail-Sprd*) rather than to the Gulf, where barge shipments are also a major part of the logistics. There is also evidence that export activity out of the PNW is more important to overall basis levels in both locations as the average number of ships in port at the PNW (*PNW-InPort*) is in the reduced explanatory variable set while the average number of ships in port at the Gulf (*Gulf-InPort*) did not make the initial cut.

Both the early period dummy variable (*Prior to 2008?*) and the market year trend (*Trend*) variables were highly significant (99% confidence level) and had the anticipated signs (negative for period dummy and positive for trend). The average number of ships in port at the PNW (*PNW-InPort*) was significant at the 95% level and had the expected positive sign reflecting a larger volume of export activity at the PNW. The absence of the similar Gulf measure indicates that activity in the PNW is more important as an influence upon overall basis values at both locations and reflective of the emerging primacy of the PNW market with the emergence of China as a major exporter of soybeans.

The average level of export demand outstanding (*Export-Out*) is highly significant (99% level) and the positive sign of the coefficient is as expected since higher anticipated export demand should be reflected in higher export basis values in order to move stocks into position to meet anticipated demand. The volume of total soybean imports by China (*China-Import*) is highly significant (99% confidence level) and the positive sign is as expected since China is the number one source of export demand for U.S. soybeans over the past decade. Even though some of this demand moves through the PNW export market, the increase in overall export demand also has a positive effect upon the Gulf demand and basis level also.

The domestic soybean ending stocks-use ratio (*SU-Ratio*) made the initial cut while the global stocks-use ratio (*World-SU*) did not. The coefficient estimate is significant at the 95% level and the negative sign of the coefficient is as expected. A higher domestic stocks-use ratio indicates that demand is low relative to existing supply; therefore, the export basis level can decline and still maintain competitive parity with the domestic market demand. Also, the significant (99%) and positive sign with the MY average nearby futures price level indicates that basis levels generally adjusts in the same direction as the overall level of demand for soybeans relative to supply.

Table 5.7 shows the PLS-R regression results with the PNW marketing year average basis as the dependent variable. The regression fit had an R^2 coefficient of 0.80 with an RMSE of 160 cents per bushel.

Table 5.7. PLS-R Regression Results for PNW Market Year Average Basis Level.

Variable	Coefficient	Standardized Coefficient	Std. deviation	Lower bound (90%)	Upper bound (90%)	T-Statistic	Significance	
Intercept	6.7783	N/A	14.8033	-19.8067	33.3632	0.4579	0.6559	
Basis-Brz	0.0934	0.0919	0.0306	0.0385	0.1482	3.0558	0.0109	**
FutSprd1	-0.2331	-0.0916	0.0838	-0.3836	-0.0827	-2.7830	0.0178	**
FutSprd2	-0.2155	-0.0904	0.0854	-0.3689	-0.0621	-2.5229	0.0283	**
MealP	0.0331	0.0901	0.0068	0.0209	0.0453	4.8700	0.0005	***
Rail-Gulf	0.0055	0.0861	0.0008	0.0040	0.0069	6.8680	0.0000	***
Prior to 2008?	-6.1860	-0.0821	1.5748	-9.0140	-3.3579	-3.9282	0.0024	***
PNW-InPort	1.0883	0.0791	0.4536	0.2738	1.9029	2.3995	0.0353	**
Export-Out	0.0310	0.0788	0.0062	0.0198	0.0422	4.9644	0.0004	***
Trend	0.8052	0.0782	0.1205	0.5888	1.0215	6.6824	0.0000	***
China-Import	0.1450	0.0766	0.0264	0.0976	0.1923	5.4979	0.0002	***
SU-Ratio	-0.5954	-0.0757	0.2305	-1.0094	-0.1814	-2.5829	0.0255	**
Rail-Sprd	0.0122	0.0745	0.0025	0.0076	0.0167	4.8195	0.0005	***
Futures-NB	0.0081	0.0655	0.0020	0.0044	0.0118	3.9777	0.0022	***

Given the very high level of Pearson correlation (93%) between the MY average basis values for both the Gulf and PNW, the regression results for the PNW are nearly identical to the Gulf with a few exceptions. First, the intercept for the PNW equation is 6.7783 while for the Gulf it is -1.4753 indicating an average fixed premium of a little over 8 ¼ cents per bushel over the 12-year study period. However, the high standard deviations for both coefficients indicate that the difference is not statistically significant.

Second, the coefficient estimates for the PNW equation have a higher magnitude in value but match the signs of the Gulf equation, indicating a slightly higher impact for each variable. However, this difference in impact can almost be completely attributed to a higher variability in the PNW basis as the standardized coefficients are nearly identical between the two estimates. When examining the loadings of the two export basis vectors upon the one retained latent variable, the Gulf (0.7989) had a higher loading when compared to the PNW (0.7971). However, from an out-of-sample forecasting perspective, using the Jackknife-LOO cross-validation procedure, the PNW had a slightly higher quality (Q^2) index value of 0.7263 when compared to the Gulf (0.7134).

The coefficient standard errors and t-statistics for the PLS-R estimation procedure are estimated directly from the cross-validation procedure; therefore, the coefficient estimated for the PNW have slightly higher (in absolute value) t-statistics when compared to the Gulf.

From these results, the following observations can be made. First and foremost, factors influencing the overall marketing year average level of the export basis are primarily identical between the Gulf and PNW in terms of importance ranking, statistical significance, and level of impact. The primary factors influencing the average basis level are competition from Brazil (*Basis-Brz*) and the domestic market (*FutSprd1*, *FutSprd2*, and *MealP*). Export basis must adjust in order to maintain competitive parity with both markets in order to assure international competitiveness and an adequate amount of stocks in exportable position to meet international demand, particularly from China.

Second, the rise of the Chinese export demand has increased the relative importance of the PNW market over time despite the fact that the percentage of exports moving through the PNW is still less than the volume moving through the Gulf. Activity directly related to the volume of exports out of the PNW (*PNW-InPort*) has more influence upon the MY average basis levels at both the Gulf and PNW when compared to a similar measure of activity (*Gulf-InPort*) out of the Gulf.

Third, internal logistical costs are of secondary importance and are primarily limited to rail costs (tariff and fuel surcharge). The export basis level must move in positive correlation with these costs in order to maintain parity with domestic demand and assure adequate export market flows and supplies.

Seasonal Analog Derivation

Application of the AHC clustering procedure to the additive seasonal indices (by marketing year) for the Gulf soybean basis resulted in five distinct seasonal analog groupings that are shown in Table 5.8. Generally, a cluster that only contains one observation is considered as a potential 'outlier' observation. The 2013/14 marketing year, with its extreme fluctuation in the monthly basis levels, was assigned to a singular analog (G5).

Table 5.8. Summary of AHC Seasonal Analog Groupings for Gulf Basis.

Analog	G1	G2	G3	G4	G5
Objects	3	2	3	3	1
Sum of weights	3	2	3	3	1
Within-class variance	1223.42	1954.39	2044.86	1409.71	0.00
Minimum distance to centroid	25.12	31.26	30.54	26.49	0.00
Average distance to centroid	28.23	31.26	36.54	30.52	0.00
Maximum distance to centroid	34.36	31.26	43.39	33.36	0.00
	MY2004	MY2006	MY2007	MY2008	MY2013
	MY2005	MY2014	MY2010	MY2009	
	MY2011		MY2012	MY2015	

Figure 5.10 shows a plot of the average seasonal indices for each of the five Gulf seasonal analogs. Analog G1 shows a typical pattern with a relative stable basis level throughout the marketing year with a slight seasonal increase from September through January and a decline through March followed by a slight increase from June through August. Analog G2 shows a general weakening (decline) in the basis level throughout the marketing year. Analog G3 has a relative stable pattern from September through June with a slight increase in the basis level in the final two months of the marketing year. Analogs G4 and G5 are similar in that they show a general weakening of the basis through April with a strengthening through the end of the marketing year. The main difference is that G5 (outlier) shows much more volatile swings in the basis when compared to G4.

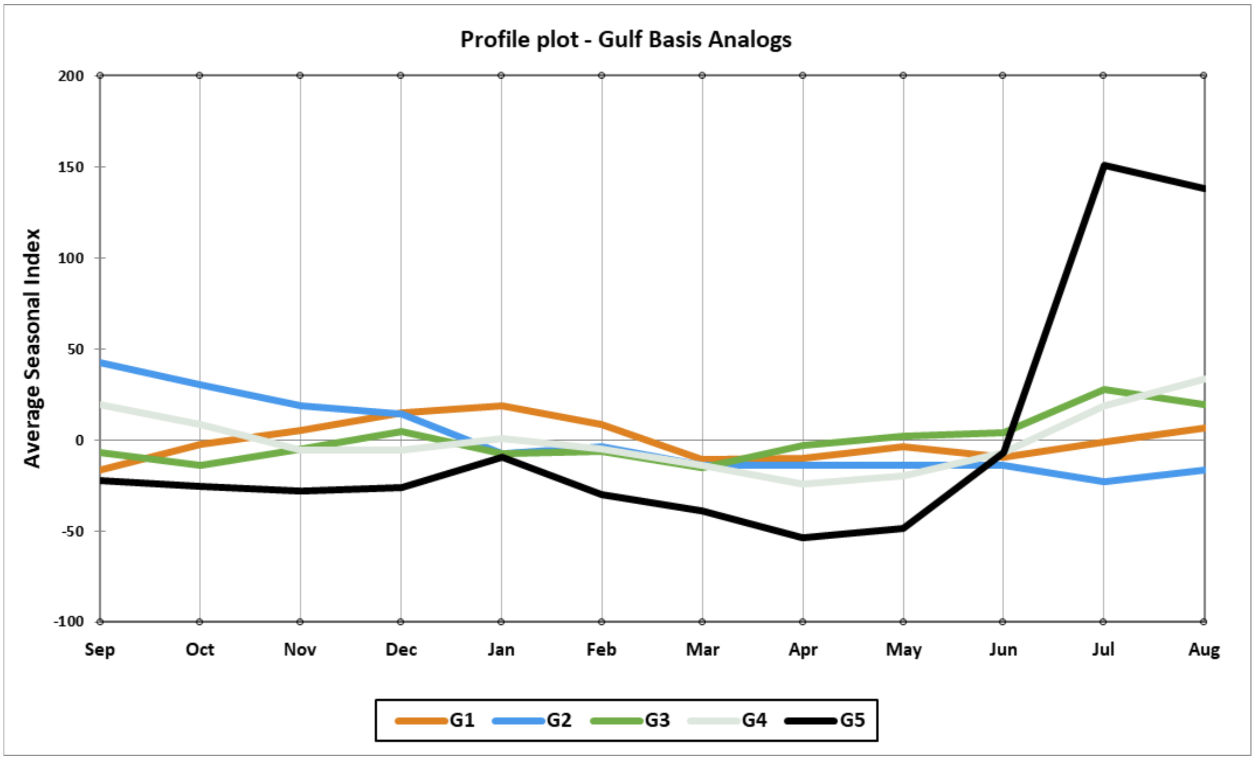


Figure 5.10. Profile Plot: Gulf Basis Analogs

The AHC clustering procedure applied to the PNW basis data resulted in four distinct seasonal analogs in the PNW basis (compared to the five for the Gulf) with one single observation analog (P4) composed of the 2014/15 marketing year. Table 5.9 provides a summary of the AHC analog groupings for the PNW basis. Analog P1 contains 5 of the marketing years with 3 each in P2 and P3. Analog P4 contains the single 2014/15 marketing year.

Table 5.9. Summary of AHC Seasonal Analog Groupings for PNW Basis.

Analog	P1	P2	P3	P4
Objects	5	3	3	1
Sum of weights	5	3	3	1
Within-class variance	2777.65	1675.66	2926.84	0.00
Minimum distance to centroid	36.89	26.07	42.19	0.00
Average distance to centroid	46.71	32.93	44.11	0.00
Maximum distance to centroid	56.21	40.01	47.32	0.00
	MY2004	MY2005	MY2007	MY2014
	MY2008	MY2006	MY2011	
	MY2010	MY2009	MY2013	
	MY2012			
	MY2015			

The profiles of the four PNW seasonal analogs are shown in Figure 5.10. Analog P1 is similar to G1 in that it shows a strengthening basis through the first four months of the marketing year (through January) with a weakening through June and a strengthening pattern through the final two months of the marketing year. Analog P2 is also similar to G2 in that it shows a general weakening of the basis throughout the marketing year with a slight uptick in the final month. Analog P3, however, does not correspond with any of the Gulf patterns, showing a substantial strengthening through the first three months followed by a relatively stable pattern before strengthening in the final three months. Analog G4, as with P5, shows a highly variable pattern; however, it has a sharp weakening in the first two months with an uneven weakening pattern through the end of the marketing year.

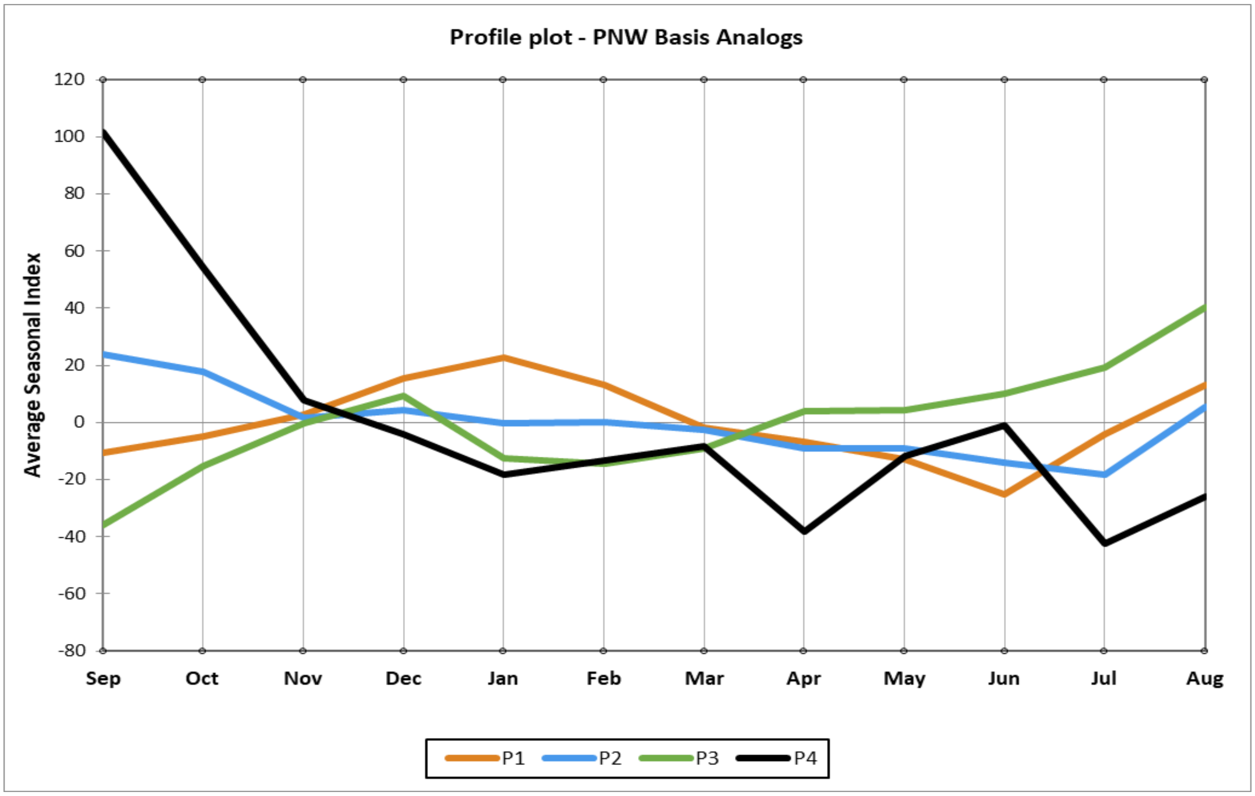


Figure 5.11. Profile Plot: PNW Basis Analogs

Statistical Characterization of the Basis Seasonal Analogs for Gulf and PNW

The Lebart z-scores for the Gulf and PNW basis analogs are shown in Table 5.10. The sign of the z-score indicates whether the analog mean was less than (negative) or greater than (positive) the overall mean value for the explanatory variable. The test is two-tailed; therefore, those z-scores exceeding 1.64 in absolute value are significant at the 90 percent confidence level. Those absolute scores exceeding 1.96 are significant at the 95 percent level and those exceeding 2.56 are significant at the 99 percent level.

Table 5.10. Lebart (1990) Variable Characterization Test Z-Scores (2-tailed) Shaded by Sign and Significance.

	Gulf Analogs					PNW Analogs			
Variable	**G1**	**G2**	**G3**	**G4**	**G5**	**P1**	**P2**	**P3**	**P4**
Futures-NB	-1.3221	-0.9670	**1.9841**	-0.4625	0.9914	0.1741	**-1.8721**	**1.8139**	-0.2193
FutSprd1	0.8537	1.0025	-0.3557	-0.1158	**-1.9506**	-0.7959	1.4171	-0.6797	0.2643
FutSprd2	0.7560	1.1533	-0.5989	0.3091	***-2.2855***	-0.3084	1.4799	-1.4333	0.4771
Basis-Brz	-0.5218	-0.5276	-1.0617	1.0609	1.5300	0.3499	-0.8446	0.0592	0.6063
Rail-Gulf	-1.4324	-0.1886	0.6948	0.1008	1.2520	0.0805	**-1.7061**	1.0604	0.8679
Rail-Sprd	-1.6278	0.6239	0.7154	-0.5322	1.4220	-1.0496	-1.2067	1.5090	1.3987
Barge-Spot	-0.6086	0.4473	1.0774	-1.5984	1.1665	-1.3040	-0.0137	0.8774	0.9729
Barge-3M	-1.3548	0.8063	1.1246	-1.0208	0.8728	**-1.6655**	0.2029	1.1082	0.9167
Ocean-PNW	-0.3136	-0.0204	1.4044	-0.8681	-0.3214	-1.2805	0.5331	1.4837	-0.8757
Ocean-Sprd	-0.6890	-1.0079	**1.9094**	-0.4298	0.1204	-0.6827	-0.6685	**1.8968**	-0.7067
Gulf-InPort	***-2.3784***	0.1052	-0.1419	1.2221	**1.8919**	-0.2917	-0.3449	0.2382	0.6874
PNW-InPort	-1.2923	-0.7809	0.5807	0.0593	***2.0750***	0.2083	-1.2355	0.7561	0.3794
Cars-Late	0.2039	0.4848	-0.2392	**-1.7558**	***2.1525***	-1.4814	-0.0275	1.0196	1.0879
DCV	-0.5291	0.1458	-0.8116	-0.7282	***3.0448***	-1.2155	-0.2386	1.2172	0.6350
Export-Gulf	-1.4294	0.5159	-0.5318	1.1246	0.6153	0.6755	-1.3337	-0.5237	**1.7052**
Export-PNW	**-1.7890**	0.5412	-0.2804	1.3517	0.3946	-0.0662	-1.2701	0.2667	**1.6900**
Export-Out	**-1.8365**	0.2369	0.4077	0.3779	1.3268	0.0012	-1.4439	0.5798	1.3516
FarmDel-Q1	-1.6246	1.4614	1.5198	-1.4150	0.4105	-0.9666	-0.7861	0.4717	***2.2169***
FarmDel-Q2	-0.9311	0.6869	1.0198	-1.4632	1.2273	-1.1553	-0.4877	1.0198	1.2273
FarmDel-Q3	-0.2351	0.4943	-0.1008	-0.7724	1.0698	-1.0127	-0.3694	1.2426	0.4385
Crush	1.2143	-1.2426	0.8878	-0.6648	-0.5763	-0.3471	0.2540	1.0485	-1.4214
SU-Ratio	1.0078	1.4966	-0.6127	-1.0564	-0.9820	-0.8911	***2.3223***	-1.0301	-0.4349
MealP	-1.5326	-0.6231	1.1011	-0.1038	**1.6790**	0.0832	**-1.9267**	1.5621	0.4230
OilP	-0.8512	-0.8653	***2.4217***	-0.8724	0.0732	-0.1028	-1.3321	**1.8039**	-0.5559
World-SU	-0.5925	**1.6760**	0.0257	-0.5242	-0.5506	-0.5224	1.6038	-1.4415	0.6776
SA-Prod	**-1.8621**	0.9109	0.2079	0.2660	0.9465	-0.1294	-0.8381	-0.1138	**1.7222**
China-Import	-1.3782	0.1778	-0.1309	0.7074	1.0163	0.1757	-1.5809	0.4606	1.4419

*Values in **bold** are significant at 90% confidence level, ***bold italics*** at 95% confidence level.

For the Gulf basis, the results indicate that analog G1 is mostly associated with marketing years with lower than average weekly ships in port at the Gulf location, lower than average South American soybean production, lower than average weekly outstanding exports, and lower than average weekly export inspections in the PNW. Analog G2 is characterized by years with a higher than average world soybean stocks-use ratio. Analog G3 is characterized by higher than average domestic soybean oil prices, higher than average nearby futures prices, and higher than average PNW ocean freight costs (relative to the Gulf). Analog G4 is characterized by lower than average weekly railcars placed late. Analog G5 is characterized by higher than average secondary railcar values, lower than average second nearby futures carry spreads, a higher than average weekly number of railcars placed late, a higher than average weekly number of ships in port at the PNW, a lower than average nearby futures carry spread, a higher than average weekly number of ships in port at the Gulf, and a higher than average domestic soybean meal price. All of these significant at the 90% confidence level or higher.

For the PNW basis, analog P1 is characterized by a lower than average weekly forward barge rate. Analog P2 is characterized by a higher than average domestic soybean stocks-use ratio, a lower than average domestic soybean meal price, a lower than average nearby futures price, and a lower than average weekly rail cost from Freemont, NE to the Gulf. Analog P3 is characterized by a higher than average weekly ocean freight cost for the PNW relative to the Gulf, a higher than average nearby soybean futures price, and a higher than average domestic soybean oil price. Analog P4 is characterized by a higher than average percentage of farmer deliveries in Q1, a higher than average South American soybean production, and higher than average export inspections out of both the Gulf and PNW. All of these significant at the 90% confidence level or higher.

For all of these seasonal analogs, unlike the average basis level results, the average Brazilian export basis was not statistically significant nor was the overall level of Chinese imports. However, it appears that logistical costs (barge and ocean rates in addition to rail costs) and conditions (cars placed late, secondary railcar market values, and pace of farmer marketing) play a more important role in determining the seasonality basis as opposed to its overall average level.

Summary and Conclusion

There is substantial variability in the basis for crops and oilseeds at the export market. While this has been an issue for some time, it appears the basis level and variability has increased over time. Other studies have mostly analyzed the basis of the futures delivery market, or at crop origins. But factors impacting the basis in these locations differ substantially from those impacting export basis values. In fact, some studies use the export basis as an explanatory value in the analysis of origin basis. The export basis is highly variable, both inter year and intra year and potentially explained by numerous factors including selected world supply and demand conditions, the rate of importing by major buyers, international competing basis values, as well as intramarket spreads and shipping costs. Export basis are also highly seasonal, but the seasonal behavior varies across marketing years. Commodity analysts refer to this as analogue years and variations in seasonal behavior is an important feature in understanding markets.

Results indicate that the marketing year average basis level for the Gulf and PNW markets is primarily influenced by international and domestic competition. The most significant variable impacting both the Gulf and PNW export basis values is the Brazilian export basis (as measured at the Port of Paranagua) which U.S. exports must compete in order to be competitive in the international export market (particularly to China).

The export basis levels are also significantly impacted by the growth in total soybean imports by China – even after adjusting for the upward trend in both variables. While the importance of China to the PNW market is well known and established, the results show that China is also of paramount importance to the Gulf export basis values with significant and positive coefficient values in both markets.

The results also indicate that the marketing year average export basis levels are more sensitive to rail transportation costs (tariff plus fuel surcharge) when compared to barge and ocean freight. Both variables had the expected signs (positive) which are reflective of the need of basis to reflect the higher transportation costs in order to encourage shipments to the export ports.

The clustering procedure identified a total of 5 and 4 distinct seasonal basis patterns for the Gulf and PNW respectively. In each market, there is a distinct outlier analog containing just one marketing year (2013/14 for Gulf, 2014/15 for the PNW) and these particular analogs were characterized by extreme seasonal swings in the basis.

The factors impacting seasonality were divergent between the two export markets (Gulf and PNW) but were primarily related to the level of export activity (i.e., average number of ships in port, volume of export inspections), pace of farmer marketing, and logistical status (i.e., number of railcars placed late, secondary railcar market values, barge and ocean freight rates) of the individual export markets.

The results indicated analogues were mostly related to variables characterizing the level of export activity, farmer marketing, and logistical situations. In particular, the singleton outlier analogs (G5 and P4) for both markets, which exhibited high basis variability, were dominated by the presence of logistical constraints (i.e., high number of late railcar placements, high secondary railcar values) in the face of very high levels of demand and commodity flows (higher levels of farmer marketing earlier in the marketing year, high numbers of ships in port and export inspections, low domestic stocks-use ratios).

This study can be broken down into four distinct observations. First, the marketing year average level of export basis in the two primary U.S. export markets (Gulf and PNW) is primarily impacted by both the international (Brazil) and domestic basis markets. U.S. export basis values adjust with changes in competitor's export basis values (in U.S. dollars per bushel) in order to maintain a competitive parity in meeting global demand. Likewise, export basis values adjust accordingly with domestic demand (and prices) in order to assure that an adequate supply of soybeans move to the export channels to meet anticipated export demands.

Second, the seasonal characterization of the Gulf and PNW export basis values vary across marketing years. Simply, different market conditions result in different seasonal basis patterns called *seasonal analogs*. In this study, over the 12-marketing year period analyzed (2004/05 through 2015/16), a total of *five* and *four* unique seasonal analog patterns were derived using statistical clustering applications. For each market, one of these patterns was a unique year (outlier) characterized by extremely high basis volatility.

Third, unlike the average marketing year basis level, the seasonal analogs patterns are primarily driven by three categories mostly unique to each export market: (1) the level of export activity at the particular port, (2) the pace of farmer marketing throughout the marketing year, and (3) the logistical conditions (lateness of railcar placement, cost of secondary railcars, barge and ocean freight rates) present in the marketing year. In particular, the extreme outlier analogs for G4 and G5 were characterized by high demand in the face of concurrent logistical problems.

These results suggest a number of private and public implications. First, analysis of export basis values is far more complicated than analysis of basis at delivery or crop origin markets. The export basis is also impacted by numerous variables including world supply and demand, basis at competing markets, shipping cost, intermonth prices spreads, farmer deliveries, etc. Second, our study analyzes the soybean export basis from the United States, for which the basis at a competing market, Brazil, is of great importance. Ultimately, the competing basis are connected through spatial competition. One would expect that similar phenomena would be apparent in other crops including corn where Ukraine and Argentine export basis would be important, and wheat, where export basis from Canada, Australia, Black Sea would be important. All of these would compound analysis of crop origin basis.

A third implication is the role of logistics and shipping costs. It is commonly recognized that shipping costs and functions impact the export basis. These results indicate that while logistics is important in varying ways, other variables are probably of greater importance. Here, that would include basis at competing export markets, and import demand from the dominant buyer, China. Following these factors, shipping costs and logistics are important in a logical way and include impacts of farmer deliveries, intermonth futures prices spreads (impacting storage decisions) as well as barge rates and rail performance (rail cars late) and ancillary shipping costs (secondary rail market values). Further, that seasonal behavior of the basis is not the same among crop marketing years, would only compound rail shipping and logistics management decisions.

Fourth is the impact and effect of seasonality in the basis. Many of the variables in these results are seasonal, including notably farmer deliveries, export sales, ships in port, futures spreads, among others. These are in addition to the seasonality of the secondary rail market (DCV). Indeed, one of the functions of the DCV is to facilitate intraseason allocation of shipments, effectively having the effect of smoothing demand. Increases in the DCV into an inverse, has the effect of deferring shipments and

STUDIES ON RAIL MECHANISMS SHIPPER STRATEGIES

Two studies were undertaken to analyze how these shipping mechanisms impact shippers. In this section we provide a summary of these studies. In both cases we model a prototypical grain shipper and analyze how the shipping mechanism affects their decisions.

The first interprets rail car mechanisms as a real option, i.e., the option to transfer, and this is valuable to the shipper. An MRP model is developed and solved using real option methodologies (i.e., stochastic binomial pricing tree). These results are an estimate of the value of the transfer option. Sensitivities are conducted to show how other variables impact this value. The second model develops a model to determine optimal grain purchasing strategy given a specified car order strategy. Shippers buy cars through the auction up to 12 months forward, and then have to determine the optimal amount of grain to meet expected car supply. Both cases illustrate the importance of velocity and other random variables on car ordering strategies.

Car Guarantees as Real Options [40]

There has been little research on topics of shipping strategy or valuation of alternative contracts available to shippers, or to value individual options imbedded within these contracts. This analysis develops a model of a grain shipper including rail car instruments and is used to determine the real option value of the instrument. Rail car allocation and pricing mechanisms can be interpreted as a real option. Specifically, the primary market provides the holder of a certificate the option to transfer the shipment to another shipper, either directly or through a broker. This is an option, and has value, and, its value varies with numerous logistical variables.

Real option methodologies have become more commonly used in recent years and are particularly attractive in decisions involving risk and flexibility. This is the case of rail car mechanisms which are both risky, and have embedded optionality, or flexibility. As such, real options methodology is appropriate to value the instruments. The alternative is to use net present value (NPV) as a methodology, but, typically NPV ignores the optionality of the instrument and as a result undervalues the asset.

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

There are two main components to the model. Module 1 is a Material Requirement Planning (MRP) schedule, and Module 2 consists of the stochastic binomial option pricing trees. In general, an MRP model is used to estimate how much of an input would be required in the future to meet a production schedule. The MRP model is based on projected farmer sales, grain prices, and inventory levels, the MRP schedule estimates how much shipping demand the elevator has for each of the next 12 months forward, and therefore how many rail cars are required. Specifically, shipping demand represents how much grain the elevator sells based on returns from storage, and capacity constraints. Shipping supply then refers to the number of railcars that are received based on railroad performance, measured in trips per month. In the base case, we assume the elevator implements a strategy in which they bid for enough shuttles to cover as close to 100% of the forecasted shipping demand as possible.

Due to fluctuations in railroad performance, the exact number of cars received each month fluctuates. This variability in both shipping demand and supply causes either a shortage or surplus of railcars each month. During months when shipping supply exceeds shipping demand, the transfer option has value since the shipper may sell the extra cars into the secondary market. During months when shipping demand exceeds supply, there would be a shortage of railcars and require the elevator to source additional transportation, in which case the transferability has no

[40] This section is a synopsis of a larger research report by Landman and Wilson (2019).

value. After shipping demand levels are derived for each month forward, the volatility of shipping demand can be derived, and these two components are used in option pricing module.

Module 2 consists of twelve stochastic binomial option pricing trees. A shipper with excess railcars can sell the rights to individual trip but retain ownership of the remainder of the

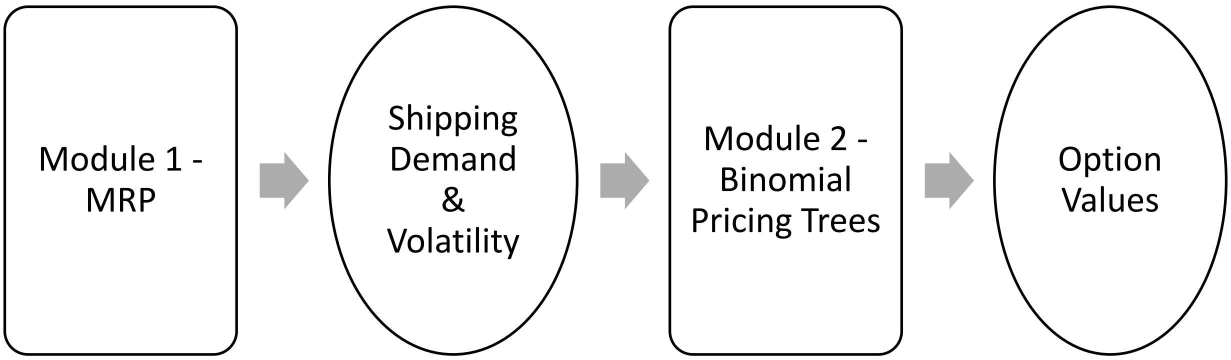


Figure 6.1. Module Flow.

contract. Therefore, each individual trip could be modeled as a separate option. For simplicity, we assume the elevator makes shipping decisions on a monthly basis. Also, we assume that the elevator makes the decision to utilize or sell the monthly railcar supply during the month in which they are delivered. For example, the option on cars arriving four months forward would not be decided upon until that time when the inventory levels are known with higher confidence. This implies that the transferability is a European option since it is not exercised until expiration (Lee 1999).[41] Figure 6.1 shows the flow of the modules and option parameters. Once all option input parameters are specified, Monte Carlo simulation is implemented using @Risk.

A detailed MRP model (similar to that described above) was developed to determine shipping demands by month looking forward. Key elements of that derivation include farmer spot deliveries which are based on monthly sales by farmers as reported by NASS. In addition, a decision process was developed to determine whether it was profitable to store or ship, which are based on intermonth differentials in futures, basis and secondary market values, relative to storage costs. Rail car supply is derived based on velocity and its distribution, ultimately which derives the probability of trains being received within the shipping month. Finally, if the shipper has surplus cars, they can be sold in the secondary market; and if they are short cars, they can be bought from the secondary market. This is critical in part that if it is more profitable to sell primary trains in the secondary market versus selling grain, the shipper would choose to do so; and, vice versa

[41] The alternative would be an American option, which can be exercised at any time prior to expiration. However, modelling the transferability as an American option would add much more complexity to the MRP schedule and require additional assumptions. Option values for each month are presented for the base case, but the average of all monthly values is sufficient to represent the overall option value.

The option payoff was modified for the transfer option. The shipper confronts three alternatives with excess cars: 1) sell cars into the secondary market, 2) cancel the cars for a penalty, or 3) “force” a shipment of grain. There is also the possibility of letting the cars sit unused, but the extreme demurrage costs the shipper would incur makes this an unviable alternative. Forced shipment requires that the shipper is able to source any additional grain necessary to fill the remaining cars. The transfer option then only has value if selling the cars into the secondary market is the most profitable among the three alternatives. When selling cars is the most profitable choice, the option is “in the money” (ITM), and if cancellation or forcing a grain shipment is the most profitable, the option is “out of the money” (OTM). Figure 6.2 illustrates the alternatives available to the shipper at each ending node.

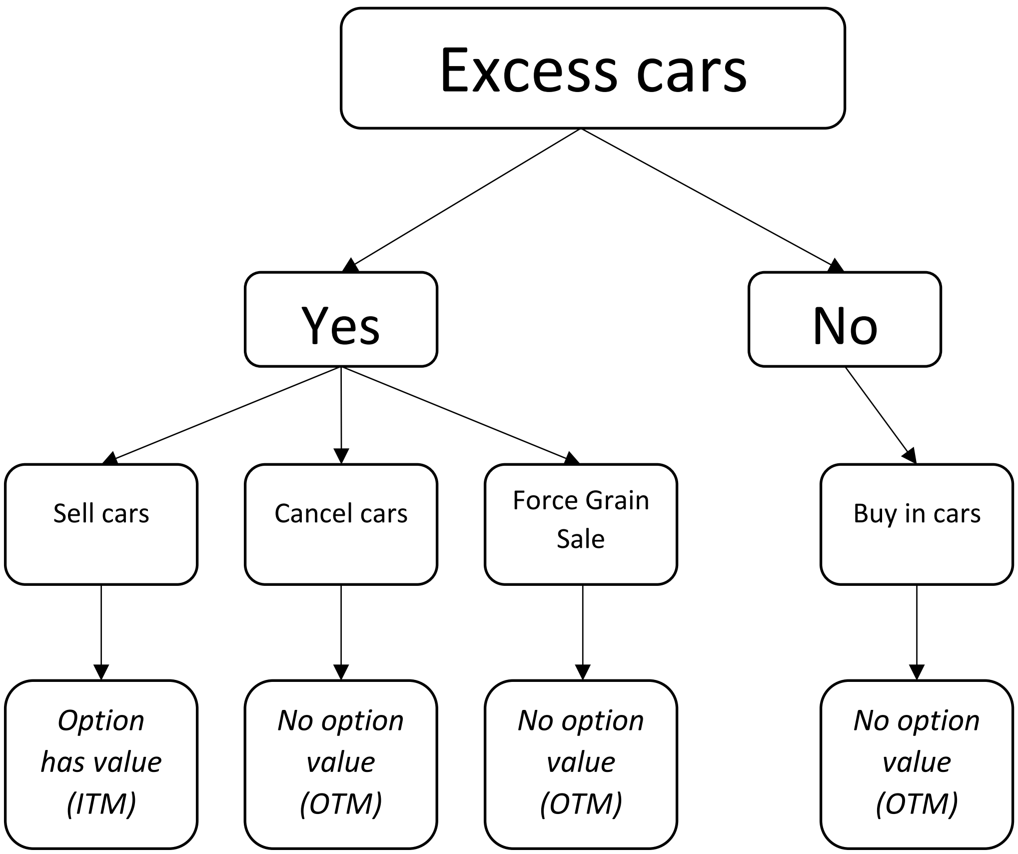


Figure 6.2. Railcar Choice Alternatives.

The base case data and futures prices are shown in Tables 6.1 and 6.2. Data for all other variables and assumptions are in Landman and Wilson (2019).

Table 6.1. Base Case Inputs.

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

Table 6.2. Futures Prices.

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

Base Case Results

Monte Carlo simulation was used to simulate the stochastic binomial options tree. Mean values from the simulated outputs are used for discussion. The transfer option for each month is presented, and the average of the monthly values represents the overall option value for a primary shuttle instrument. These option values are in dollars/car/trip, meaning that the overall effect on bidding strategy depends on how many cars the shipper needs, and their expectation about velocity.

Table 6.3. Base Case Results.

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

Results (Table 6.3) show that the average value of the option is $185. This implies that, of the total contract value, $185 of it is derived from the transfer value. In situations where the contract costs less than $185, this implies an extra value is provided by the carrier to the shipper. The option is worth the least in January at $106, and the most in May at $297. The average shipping demand volatility is 76%. Volatility is higher in deferred months since there is more variability in predicting shipping demand ten months forward, rather than one month.

While there are many factors that affect the option value, the seasonality is partially explained by shipping demand levels. The lowest monthly option value, January, is the month with the highest shipping demand, and the highest option value occurs in the month with one of the lower levels of shipping demand. This relationship between transfer value and shipping demand is shown in Figure 6.3. The negative correlation between option value and shipping demand makes sense intuitively, since months with higher demand would result in fewer excess cars to transfer into the secondary market, and vice versa.

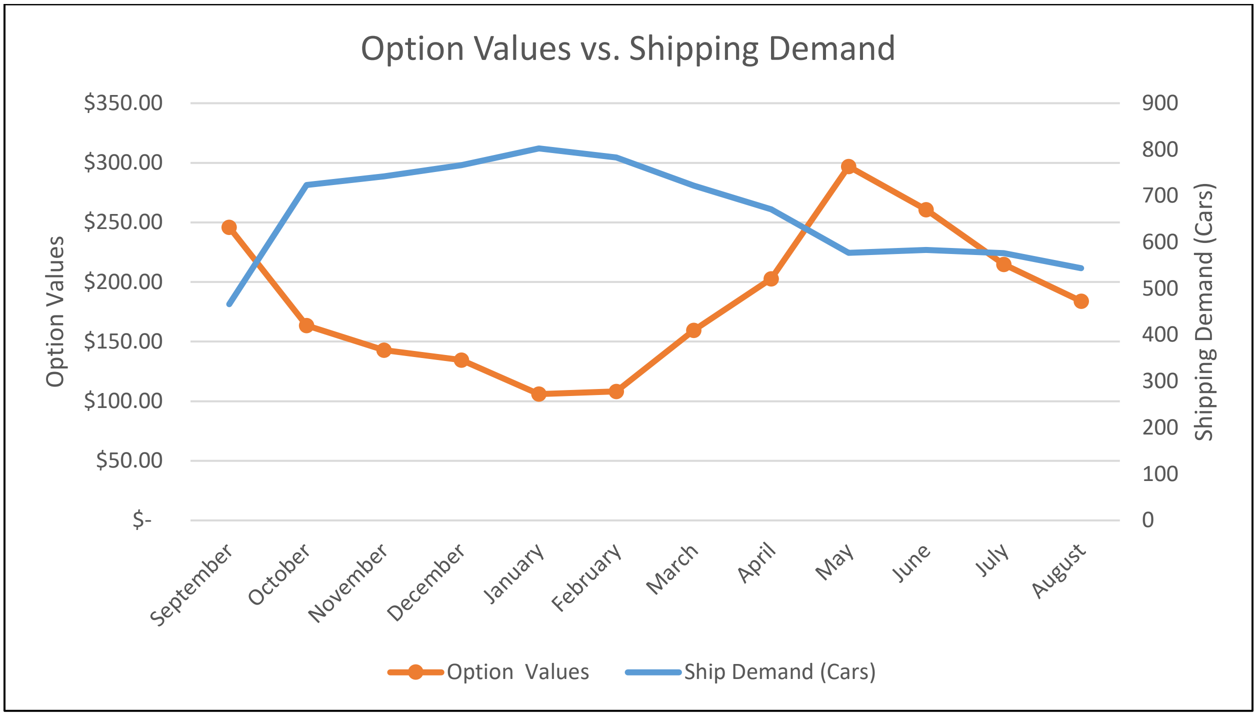


Figure 6.3. Option Values and Shipping Demand.

Another input that affects the seasonality of the option value is velocity. In months where the railroad performance is stronger, there is more supply of railcars in the market. If the elevator receives more cars in certain months, there is a greater chance of having excess cars available for sale into the secondary market. The relationship between option price seasonality and velocity is shown in Figure 6.4. One explanation for the seasonality in velocity is the inter-month export program. The main export season for grain is late fall and winter, which is when performance occurs. High export levels mean that there is relatively more rail tack congestion from elevators attempting to get grain to the port. the lowest railroad

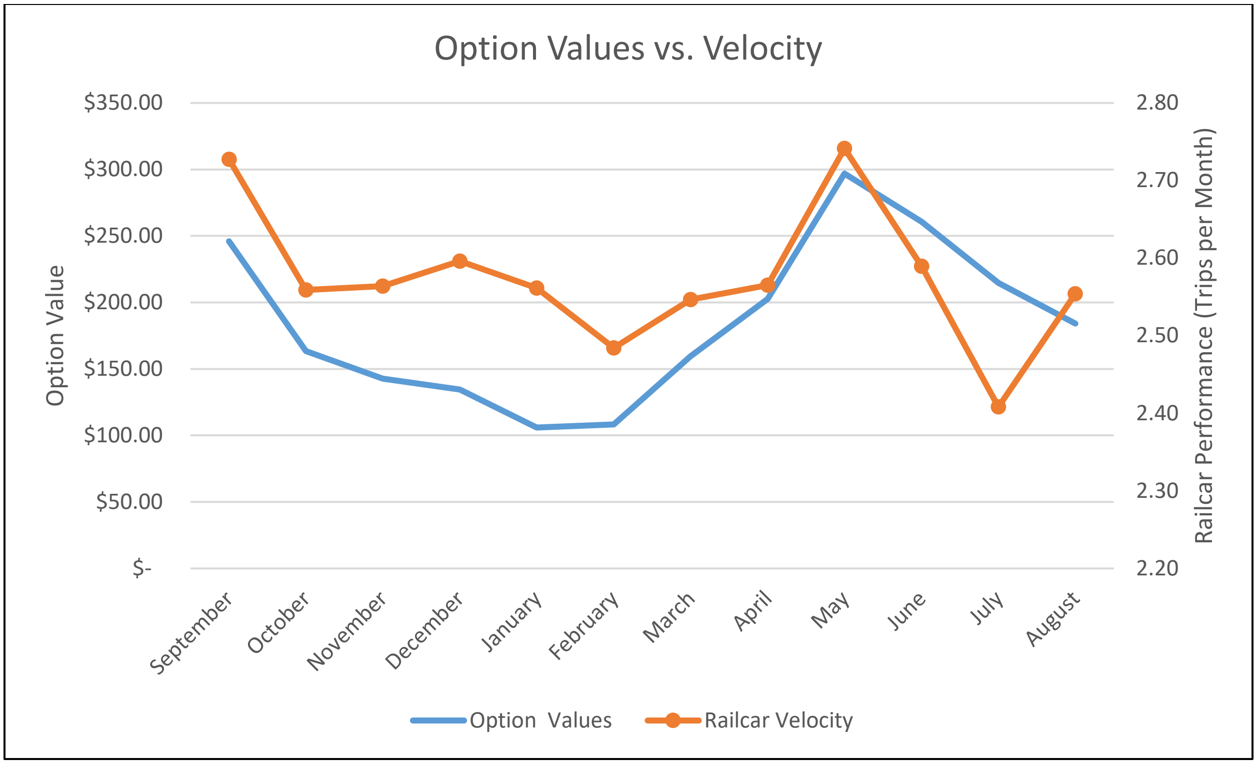


Figure 6.4. Option Values and Railcar Velocity.

Secondary market prices have the largest overall impact on the transfer value, since it is the price the shipper receives for selling excess cars. Volatility also has a large, positive impact on option values, which corroborates with option pricing theory.

Shipping demand has a negative relationship with option values. The reasons for this are that lower shipping demand would produce more excess cars, which increases the value of the transfer option. Velocity has a positive impact on the transfer option value but is much weaker compared to the other inputs. This can be explained by the fact that velocity is just one part of shipping supply. The other component of shipping supply is how many shuttle contracts the elevator owns. Since velocity is the only stochastic part of shipping supply, its impact on the transfer option is much less than shipping demand since demand is more variable.

Under excess car situations, the shipper has three choices: sell, cancel, or utilize the cars. One interesting statistic is the likelihood of each choice providing the best payoff. Simulations indicated in the base case, selling cars in the secondary market would be the optimal strategy 76% of the time. This is followed by a "forced" shipment, at 23% of the time. Cancelling the contract would be the optimal choice for any month in only three out of 10,000 iterations.

Sensitivity – Secondary Market Prices

The first sensitivity is conducted on secondary rail market prices. These are important since it determines the price that the shipper would receive if they sell their excess cars. As shown in Figure 5.4 above, they are highly correlated with the transfer option value. The mean secondary price for the base case was $411. For the sensitivity analysis, prices start at -$200 and increase in $300 increments up to $1,000. Table 6.4 shows the resulting transfer option values from the four simulations and compares them to the base case scenario.

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

These results are very important in that a large portion of the option value is due to the value of the secondary market. Historically, the primary and secondary markets had average values in the area of $54/car and $225/car respectively. As a result, the option value of the primary market instruments was in the area of $150/car.

Recently (early 2019), the secondary market value has decreased to -$200/car (or less), and as a result, the option value would diminish toward zero.

Table 6.4. Sensitivity - Secondary Rail Market Prices.

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

Sensitivity – Shipping Demand Volatility

Volatility is one of the main components that affect any option value. Shipping demand is derived from the material requirement planning schedule, which includes numerous variables including farmer sales, PNW basis values, storage costs, etc. Option theory suggests a positive relationship between volatility and option values for both puts and calls. Therefore, since level of shipping demand is the underlying variable in the transfer option, sensitivity on volatility is conducted to provide insights for different types of shippers, as well as demonstrate robustness of the binomial option pricing model. The base case resulted in an average volatility of 76%. Different sensitivities were run by holding shipping demand volatility constant, starting with 25% and increasing to 125%. Resulting option values are presented in Table 6.5.

Table 6.5. Sensitivity - Shipping Demand Volatility.

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

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

Sensitivity - Rail Velocity

Rail velocity, measured in trips per month (TPM), is an underlying stochastic variable that determines shipping supply, or how many cars the elevator receives each month. Rail performance can be influenced by factors such as weather, track congestion, etc. Shipping supply is important since it represents the trigger point at which the elevator either has an excess or shortage of trains, which is interpreted as the strike or exercise price in the option model. Performance changes every month and through time. The base case resulted in a mean velocity of 2.58 over all months. For the sensitivity analysis, velocity is held constant at 2.0 TPM and increases to 3.5. Resulting option values are presented in Table 6.6.

Table 6.6. Sensitivity - Rail Velocity.

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

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

Sensitivity – Futures Price Spreads

Futures price spreads refer to the inter-month price differences in each contract month. When deferred contract months are at a premium to nearby months, it is a "normal" or positive spread market. When the opposite is true, the market is referred to as "inverted." The same principle applies to basis values, but here we focus on futures. During times with large, positive spreads, the shipper is encouraged to store their grain. Inverted markets encourage shipment of grain since the elevator would be losing money by storing into a contract month with lower prices. Soybeans is a market in particular that exhibits both normal and inverted price spreads at different times.

Results are presented in Table 6.7 and demonstrate a positive relationship between price spreads and option values. In a strongly inverted market, the transfer option is worth $152, and increases to $293 as the market becomes normal with positive spreads. This is largely explained by the impact on ship vs. storage decisions, which is reflected in shipping demand.

Table 6.7. Sensitivity - Futures Price Spreads.

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

Summary

Base case results indicate that this transfer option is worth $185 per car, per trip, meaning that the shipper should pay this much of a premium for a contract that allows transferability versus one that does not. Secondary market prices have a strong, positive relationship with option values, which is expected. Shipping demand volatility also has a positive relationship with option values. Also causing increases in option values are increases in rail velocity, due to the fact that it increases shipping demand, meaning that more excess cars are available for sale. Futures price spreads are shown to have a negative impact on shipping demand, which results in a positive impact on option values.

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

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

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

Optimal Grain Inventory and Purchasing Strategy Under Market and Logistic Risk[42]

Shuttle elevators are exposed to several areas of risk including: the velocity of shuttle trains, market carry, and the price of rail cars on the secondary market. Purchased grain can be viewed as a real option to ship to meet rail car supply. The analysis in this section builds on the Stowe and Su (1997) model which treats inventory as a real option on future sales using a Contingent Claim Inventory (CCI) model. The CCI is a specification that models a call spread as a real option. The same methodology can be applied to grain purchasing and shipping decisions. This is based on real options methodology with a focus on inventories (or excess supply) as a strategic variable. A shuttle elevator that purchases primary rail contracts has an uncertain supply of rail cars due to velocity. To accommodate uncertainty in market variables and car supply, the shuttle elevator determines an optimal grain inventory and purchasing strategy. The model determines a grain purchasing strategy which maximizes the net profits (NPV) to the logistics decision.

Basic Model Overview

The optimal grain inventory and purchasing (the terms purchasing, and inventory are complementary and are used synonymously in this section) strategy of a shuttle elevator depends on three components: the velocity of rail cars, market carry, and secondary-rail-market prices. These three components can be translated into car supply, salvage value, and stockout penalty. The optimal grain purchasing strategy can be derived using the Stowe and Su's (1997) Contingent Claims Inventory (CCI) model). This section specifies and empirical model for determining the optimal grain purchasing strategy.

The model represents a typical shuttle elevator located in the great plains who ships soybeans using primary rail contracts. The model represents a single-elevator shipper but could be adapted to utilize multiple locations. In this application, the elevator procures soybeans from producers via forward contracts and resells the soybeans to terminal markets located in the Pacific Northwest (PNW). The elevator ships soybeans by rail, using primary rail contracts. For simplicity, the shipper only buys and sells soybeans; and does not buy additional rail cars on the secondary market in the base case. However, the elevator can sell any unused trains into the secondary market at a premium or discount. The model represents a purchasing strategy for three months - or fourteen weeks - of soybean forward contracts. This application assumes the elevator makes one purchasing strategy over the course of three months which may be adjusted through time. However, this model can be expanded to a material requirement planning (MRP) model to reflect the weekly inflow and outflows of grain as well as account for the randomness of spot deliveries (Stowe and Su 1997).

The model maps the demand of a product onto the price level of an underlying state variable. The firm in their model maximizes the NPV of inventory to meet uncertain demand. The firm possesses a number of call options equal to the slope of marginal profit gained per unit increase in the underlying state variable. In this application, the underlying state variable is the velocity of rail cars. Velocity is not a financially traded asset, so the Black-Scholes's model is not valid and real option binomial trees are used to value the call options.

[42] The analysis in this section is based on an MS Thesis, and a research report by Klebe and Wilson (2019).

There are two components to the overall model: Module 1 consists of a stochastic-binomial-option-pricing tree and Module 2 is the purchasing strategy contingent claim (Figure 6.5). First, option strike velocities are derived from the input parameters in the Contingent Claims Inventory (CCI) module based on the chosen purchasing strategy. Second, the option strike velocities are evaluated using the binomial tree from Module 1. Finally, the derived premiums are used in the CCI module to generate an NPV of the purchasing strategy. The process continues until the NPV of the shuttle elevator is maximized. The model is a dynamic iterative model and uses @Risk and risk optimizer (Winston, 2008).

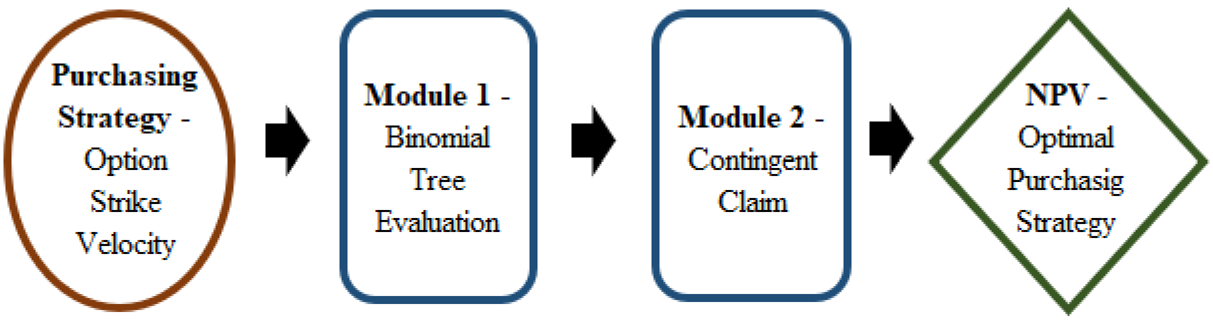


Figure 6.5. Module Flow.

When the shuttle elevator purchases soybeans, the shuttle elevator gains the right to ship bushels between a minimum and maximum level of car supply. Car supply is contingent on the velocity of shuttle trains from the railroad; therefore, car supply can be modeled as a call spread. The call spread is made up of a portfolio of long call options and short call options. The long call option strike velocity coincides with the minimum car supply which is zero. The short call option strike velocity coincides with the purchasing strategy and is determined based on the parameters in the CCI module. Once the strike velocities are determined, they are an input into Module 1 for option evaluation.

The input parameters are split into two groups: non-random inputs and random inputs. Non-random inputs do not change during the sensitivity analysis. The random input parameters are either linked, or have calculations linked, to distributions in @Risk. The non-random inputs are summarized in Table 6.8 and the random input parameters are summarized in Table 6.9.

Table 6.8. Non-Random Model Inputs.

Non-Random Inputs	Value	Units
Current State Velocity:	2.9	Trains Per Months
SB Bushels/Car:	3500	Soybean Bushels
Cars Per Shuttle:	110	Rail Cars
Bushels/Shuttle:	385000	Soybean Bushels
Number of Contracts:	2	Primary Rail Contract
Number of Months in Purchasing Strategy:	3	Months
Min # Trains:	0	Shuttle Trains
Max # Trains:	24	Shuttle Trains
Increase Shipping Demand due to Car Supply per Velocity Increase:	2,310,000	Soybean Bushels
Risk Free Interest Rate:	2.7%	Interest Rate
Loan Interest Rate:	5.0%	Interest Rate
Purchasing Strategy Maturity:	0.27	Years
Nearby Futures:	$9.67	Dollars Per Bushel
Nearby PNW Basis:	$0.68	Dollars Per Bushel
Nearby RR Tariff:	$1.54	Dollars Per Bushel
Elevator Margin:	$0.20	Dollars Per Bushel
Investment/Bushel:	$8.62	Dollars Per Bushel
Net Price Per Bushel Sold:	$8.82	Dollars Per Bushel
Weekly Storage Rate:	$0.01	Dollars Per Bushel
Storage and Interest of Unsold Bushels:	$0.26	Dollars Per Bushel

Table 6.9. Random Model Inputs.

Random Inputs Means	Input Mean	Units
Forecast State Velocity:	2.96	Shuttle Trains Per Month
Velocity Volatility:	21%	Annual Percentage Change
Deferred PNW Basis:	$0.94	Dollars Per Bushel
DCV:	$0.01	Dollars Per Bushel
Soybean Futures Spread:	-$0.02	Dollars Per Bushel
Deferred Tariff Rate:	$1.54	Dollars Per Bushel
PNW Basis Spread:	$0.26	Dollars Per Bushel
Tariff Spread:	$0.00	Dollars Per Bushel
Market Carry:	$0.24	Dollars Per Bushel
Returns to Storage:	-$0.02	Dollars Per Bushel
Shortage Penalty:	-$0.01	Dollars Per Bushel
Salvage Value:	$8.60	Dollars Per Bushel

Base Case Results

The base case results are formulated using distributions from data collected in the Soybean crop marketing year of September 2015 through August 2016. The base case results, and subsequent sensitives, reflect the mean values of the stochastic simulation for a specific purchasing strategy. The maximum value would be enough bushels to meet the car supply of 24 soybeans shuttle trains over the course of 3 months. A Value of 24 trains is chosen because it is assumed that the maximum an elevator can ship is four trips per month per primary contract. The base case results are in Table 6.10.

Table 6.10. Base Case Results.

Observation	Value
Inventory and Purchasing Strategy	7,150,000
Trains Acquired Based on Purchasing Strategy	19
Percent of Forecast	105%
NPV	$874,873
Standard Deviation	$139,087
Short Call Strike Velocity	3.10
Number Short Call	463,854
Short Call Premium	0.091
Number Long Calls	487,218
Long Call Premium	2.96

The optimal purchasing strategy is 7,150,000 bushels of soybeans for a shuttle elevator possessing two primary contracts over the course of three months. This value is 105% of the forecast level of car supply. The forecast level of car supply is 2.96 trains per month per contract. A purchasing strategy of 7,150,000 bushels of soybeans is enough to meet a rail velocity of 3.1, which exceeds the expected value of car supply.

Figure 6.6 shows the payoff function for the optimal purchasing strategy which reflects the call spread on the option to ship. The shuttle elevator is long 487,218 call options at a strike velocity of zero. Being long 487,218 contracts at a strike velocity of zero means the elevator possesses the right to ship grain whenever velocity is greater than zero and the elevator's profit would increase $487,218 per one unit increase in velocity. The shuttle elevator has a minimum profit level of negative $73,500 when velocity is zero (Figure 6.6). This value reflects the fact there is a moderate salvage value for unshipped bushels.

The shuttle elevator is short 463,854 call options at a strike velocity of 3.1. This means that if velocity is at or above 3.1 the shuttle elevator would lose $463,854 in profit per one unit increase in velocity. However, the elevator still possesses 487,218 long call options at a strike velocity of zero. Therefore, the shuttle elevators net profit per unit increase in velocity is $23,364 when velocity is at or above 3.1. Figure 6.6 reflects the decrease in marginal profit by flattening of the payoff function after a velocity of 3.1.

The payoff function shows how the elevators profit would change (Y-axis) relative to changes in velocity (X-axis). The X-axis shows the possibility for velocity to be below zero, however this is impossible. Velocity values below zero are depicted graphically to show the relevance of possessing long call options with a strike velocity of zero.

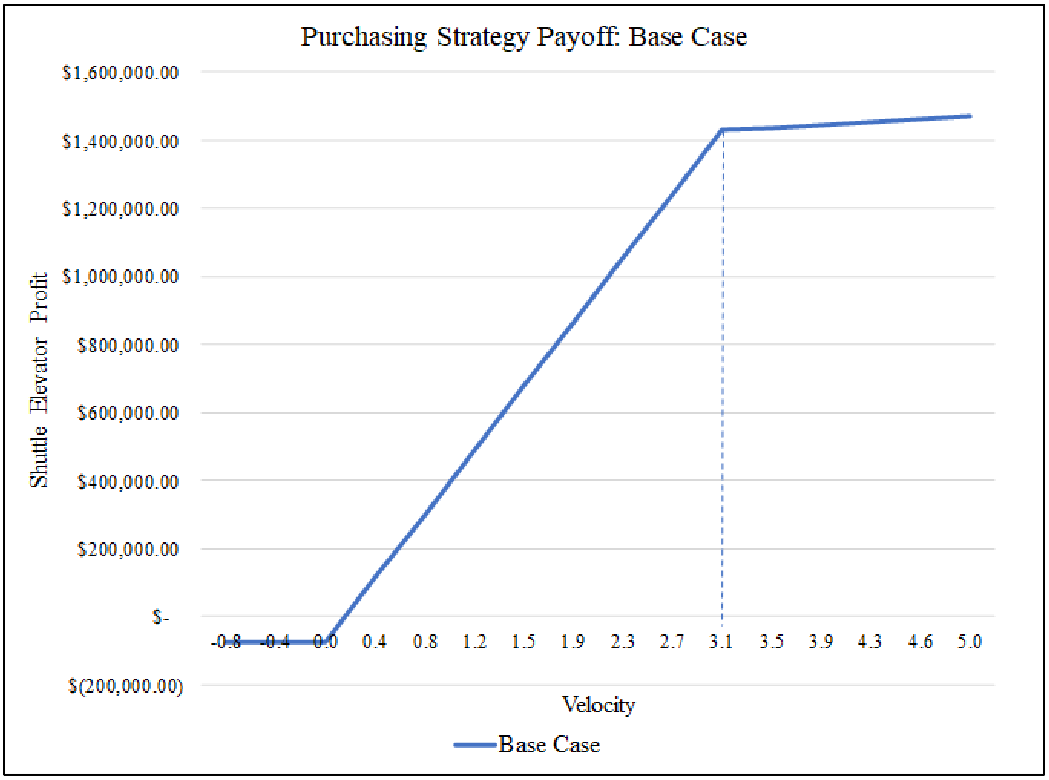


Figure 6.6. Base Case Payoff Function.

Figure 6.7 shows the frequency distribution of NPV. The base case results are highly clustered between $800,000 and $1,000,000. The standard deviation of the NPV is $139,086 and is slightly skewed to the left. The 90% confidence interval is between $601,000 and $1,036,000 which further demonstrates the NPV distribution's skewness.

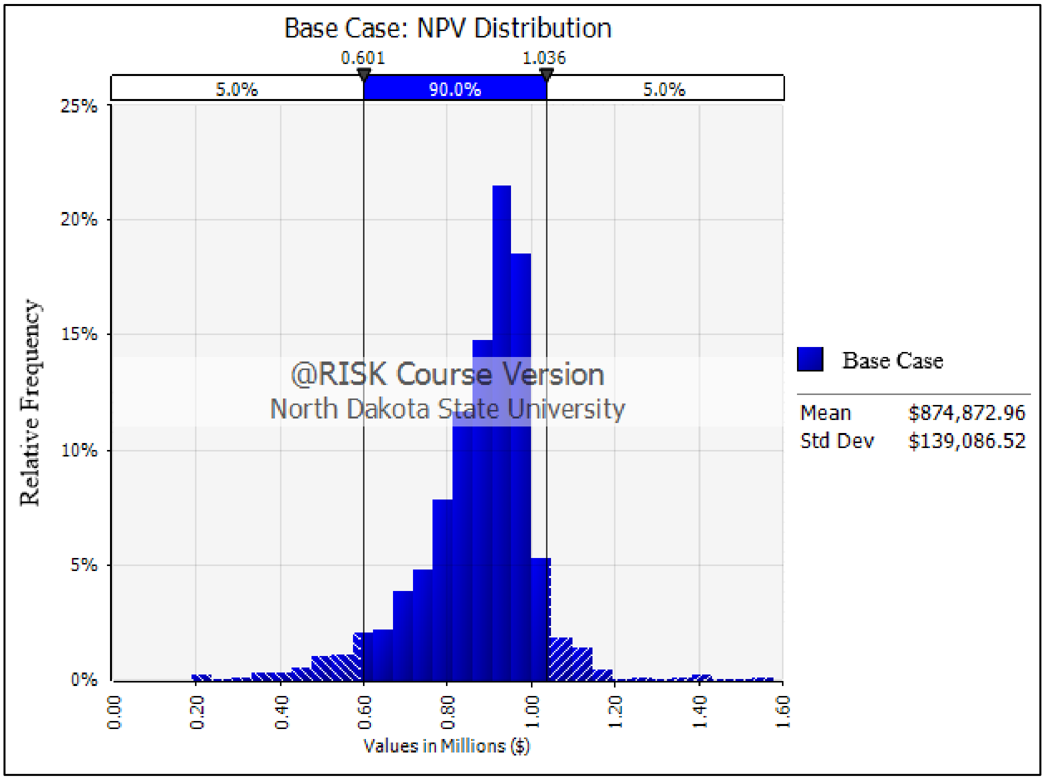


Figure 6.7. Base Case: NPV Distribution (@Risk).

Figure 6.8 is an E-V frontier of different purchasing strategies in the base case. The strategies are reported as a percentage of the forecast car supply. The X-axis represents the standard deviation of purchasing strategies in 100,000's. The Y-axis represents the expected NPV of the purchasing strategy. The base case purchasing strategy of 105% has a maximized mean NPV of $874,873 and a standard deviation of $139,087. However, a purchasing strategy of 93% has the lowest risk with a standard deviation of $87,251 and a mean NPV of $851,234. A 93% purchasing strategy has an expected profit $23,639 less than the optimal strategy of 105%; however, the risk in expected profit is reduced by more than $50,000.

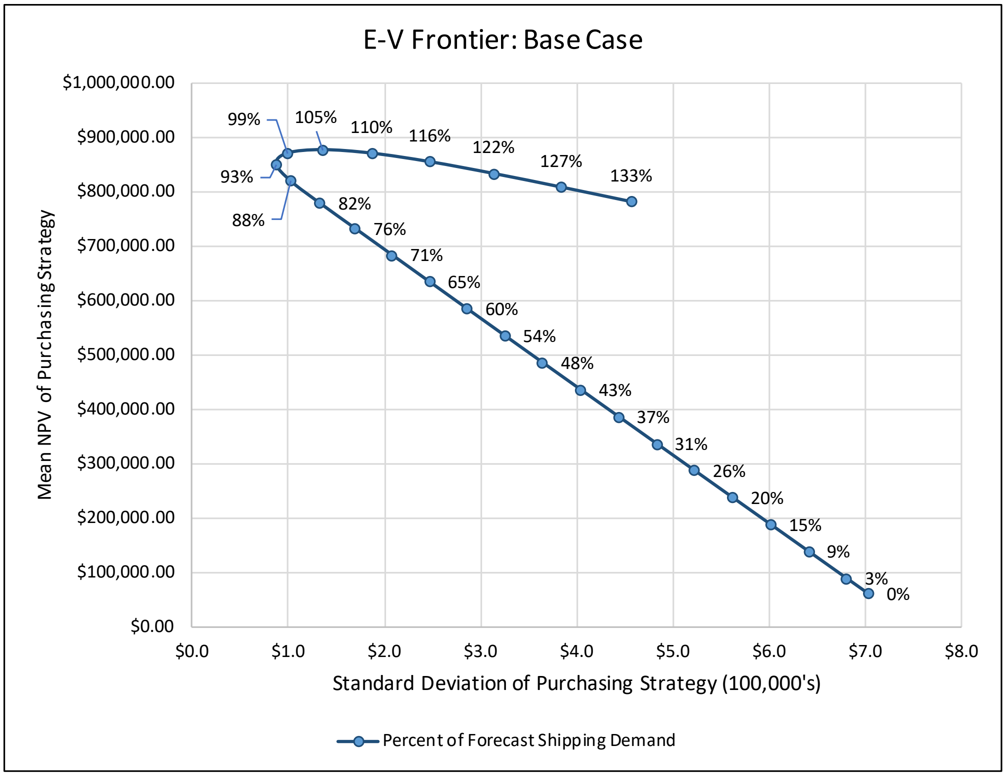


Figure 6.8. E-V Frontier: Base Case.

Sensitivities[43]

The variables which have the greatest effect on the mean NPV of the purchasing strategy are PNW basis, DCV, and velocity volatility. Sensitivity analysis is conducted by shifting the input means of the stochastic variables. The PNW basis is an input to the market carry which directly influences the salvage value. The market carry is equally affected through changing any one of the distributions for PNW basis, futures spread, or change in rail tariff. Therefore, sensitivity analysis on market carry can be conducted through any one of these three variables. Sensitivity analysis is also conducted on DCV, which has a direct effect on stockout penalty; as well as velocity volatility which influences the option premium.

In the base case, the market carry equals $0.24 per bushel and the costs of storage and interest equals $0.26 per bushel. The return to storage is therefore -$0.02 per bushel. Salvage value causes the profit function in the base case to be near zero if velocity were to be 0. This is because the overall carry in the market, $0.24 per bushel, is very close to the total cost of storage and interest for unshipped bushels. Table 6.13 shows how shifting the distribution of carry affects the optimal purchasing strategy.

[43] Other sensitivities, including the option to buy secondary rail cars and the impact of disallowing transferability, are shown in Klebe and Wilson (2019).

Table 6.11. Sensitivity to Change in Carry.

Observation	Decrease Carry $0.10	Base Carry	Increase Carry $0.10
Gross Market Carry	$0.14	$0.24	$0.34
Storage and Interest	$0.26	$0.26	$0.26
Returns to Storage	-$0.12	-$0.02	$0.08
Inventory and Purchasing Strategy	6,670,000	7,150,000	9,240,000
Trains Prepared for Based on Purchasing Strategy	17	19	24
Percent of Forecast	98%	105%	135%
NPV	$844,808	$874,873	$994,757
Standard Deviation	$111,397	$139,087	$494,313
Short Strike Velocity	2.89	3.10	4.00
Number Short Call	694,854	463,854	232,854
Short Call Premium	0.184	0.091	0.001
Number Long Calls	718,218	487,218	256,218

Increasing the carry by $0.10 per bushel causes the optimal purchasing strategy to be 135% of the forecast velocity. The assumption that the shuttle elevator does not forward contract soybeans to be delivered to the PNW allows the option to ship or store to be retained by the shuttle elevator. When the optimal purchasing strategy is 135% of forecast car supply, the shuttle elevator has the option to either ship excess soybeans as trains arrive or store the soybeans until the next shipping period. The shuttle elevator maintains this flexibility to ship or store bushels but assumes the added risk of being at the mercy of the PNW basis. The drastic increase in purchasing strategy is due to the salvage value being raised to levels where a manager would benefit from either shipping or storing the grain. Simply, when the carry is large, the shipper would over-purchase grain relative to expected rail cars. If they receive more cars than expected, they simply ship. If they do not, they store the extra grain and accrue earnings to storage. Hence, the incentive to buy more grain than forecast car supply.

Figure 6.9 shows the how the NPV distribution of the base case purchasing strategy changes with differences in market carry. An increase in market carry raises the mean NPV and lowers the risk of expected profit. Contrary, a decrease in market carry decreases mean NPV while increasing the standard deviation.

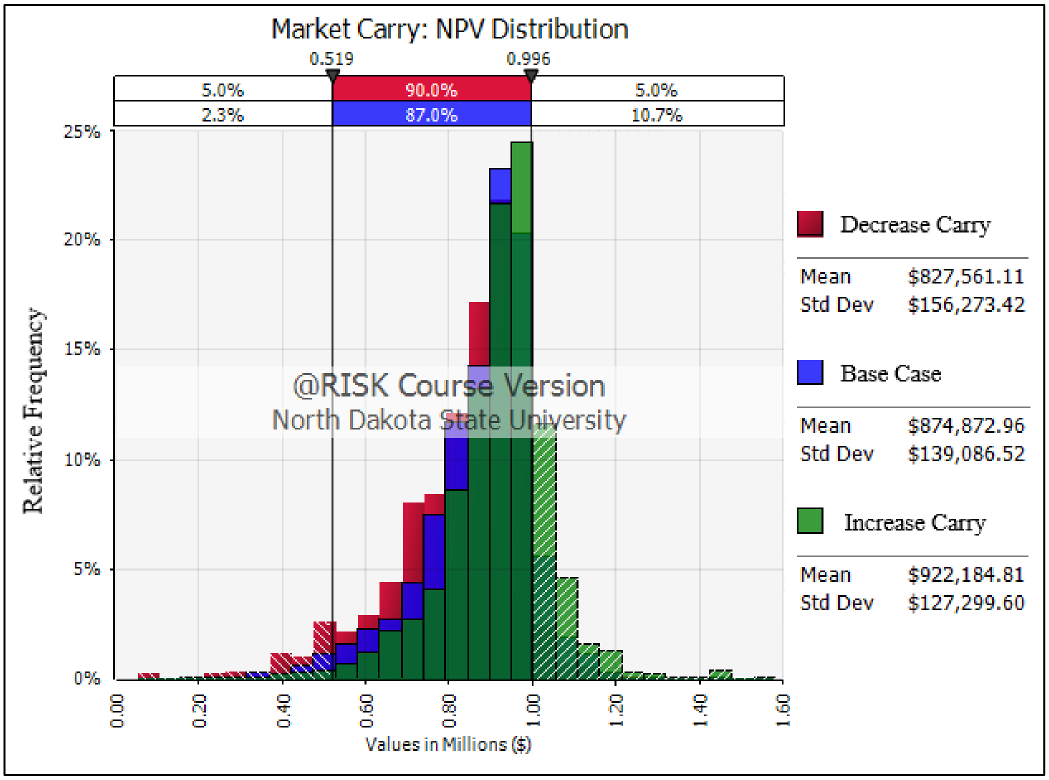


Figure 6.9. Carry Change NPV Distribution (@Risk).

The daily car value (DCV) reflects the market value of excess shuttle trains on the secondary rail market. The DCV represents the stockout penalty in this application. If the shuttle elevator underestimates rail velocity, car supply would be greater than inventory. When this happens the shuttle elevator would sell excess rail cars into the secondary market at either a premium or discount. The base case example has DCV at $31/car or about $0.01/bushel. When there is no stockout penalty for unmet car supply, the number of short calls is equal to the number of long calls. When the two values are equal, the resulting slope in profit is flat when car supply is not met. The base case of $0.01/bushel acts as a negative stockout penalty. A negative stockout penalty reduces the number of short calls and cause the net profit of unmet car supply to be slightly increasing. The sensitivity on DCV shifts the mean value to a negative $0.14 per bushel and a positive $0.16 per bushel as shown in Table 6.12.

Table 6.12. Change in DCV.

Observation	Decrease DCV $0.15/Bu	Base DCV	Increase DCV $0.15/Bu
DCV $/Bu	-$0.14	$0.01	$0.16
DCV $/Car	-$494	$31	$556
Inventory and Purchasing Strategy	7,540,000	7,150,000	0
Trains Prepared for Based on Purchasing Strategy	20	19	0
Percent of Forecast	110%	105%	0%
NPV	$848,940	$874,873	$1,094,446
Standard Deviation	$188,820	$139,087	$813,682
Short Strike Velocity	$3	$3	$0
Number Short Call	810,354	463,854	117,354
Short Call Premium	0.046	0.091	2.958
Number Long Calls	487,218	487,218	487,218

A decrease in DCV from $31/car to -$494/car results in a large stockout penalty. The large stockout penalty increases the number of short call options and decreases the overall profit level when car supply is not met. When DCV decreases, the optimal purchasing strategy increases to 110%; however, the expected profit decreases by $25,900. This occurs due to the high stock out penalty which increases the number of short call options by 346,500 while the number of long calls stays the same. The increase in short call options causes the net profit gained after a strike velocity of 3.1 to decreases to a negative $323,136. This red dashed line in Figure 6.11 shows this change in slope.

An increase in DCV, which is a negative stockout penalty, reduces the number of short call options and results in a slope increase of profit when car supply is not met. When supply is not met the elevator makes money by selling their primary instrument into the secondary market, despite not having inventory to sell. The elevator thus sells the excess rail cars for a profit. Optimal purchasing strategy is reduced to zero when DCV increases by $0.15/bushel (Table 6.12). When the purchasing strategy is 0%, the shuttle elevator intends to sell all the shuttle trains which arrive into the secondary market for spot DCV value and make more money than shipping grain.

Figure 6.13 shows how the NPV distribution of the base case purchasing strategy changes with differences in daily car value. Increasing DCV increases the mean NPV and increases the standard deviation. The increase in standard deviation results from instances of stockout resulting in higher profit and thus widening the distribution to the right. The decrease in DCV lowers the mean NPV and lowers the standard deviation. When DCV is lower, instances of stockout have a great negative effect on profit and narrow the distribution to the left.

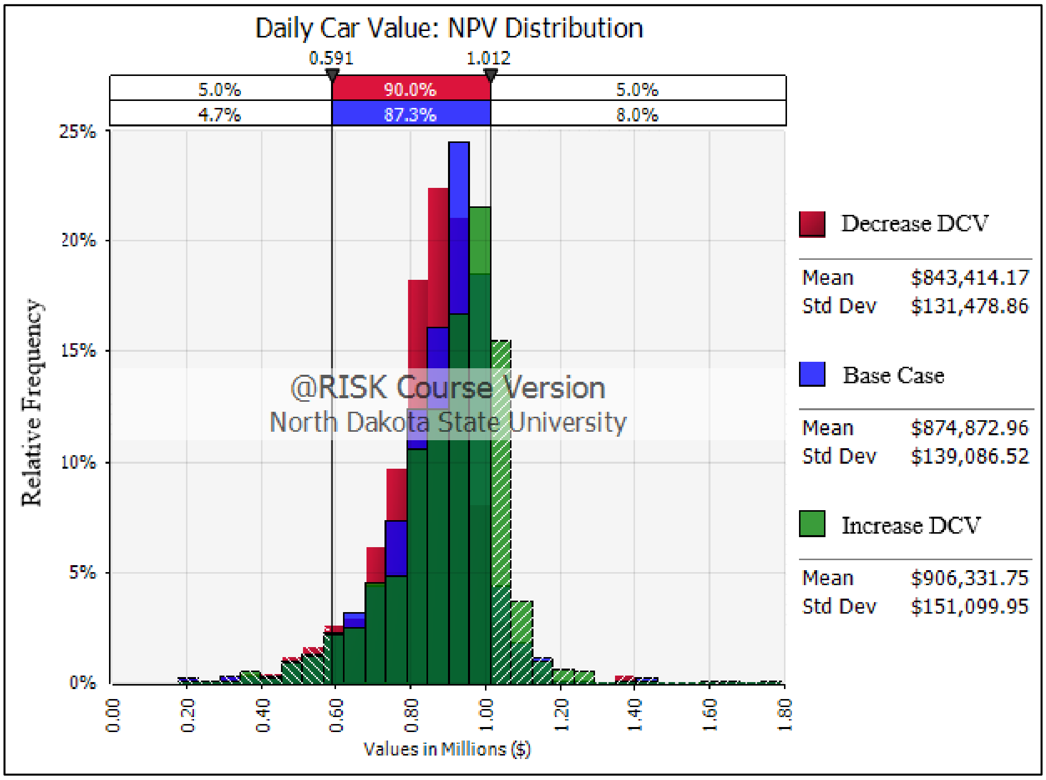


Figure 6.10. DCV Change: NPV Distribution (@Risk).

The velocity volatility affects the riskiness of how many shuttle trains would arrive per month. Increasing the velocity volatility adds uncertainty to car supply. This uncertainty greatly impacts the expected payoff of the shuttle elevator's purchasing strategy when there is a high stockout penalty or if the salvage value of unshipped bushels is low. Unlike the previous two sensitivities, changing the velocity volatilely does not affect the shape of the payoff function. However, it does have a great impact on standard deviation of NPV as well as the short call premium. Table 6.13 shows how changing velocity volatility affects the NPV of the purchasing strategy.

Table 6.13. Sensitivity to Velocity Volatility.

Observation	Decrease Volatility	Base Volatility	Increase Volatility
Velocity Volatility	0.00	0.21	0.50
Inventory and Purchasing Strategy	7,010,000	7,150,000	7,340,000
Trains Prepared for Based on Purchasing Strategy	18	19	19
Percent of Forecast	103%	105%	107%
NPV	$904,257	$874,873	$795,878
Standard Deviation	$108,419	$139,087	$234,899
Short Strike Velocity	3.04	3.10	3.18
Number Short Call	463,854	463,854	463,854
Short Call Premium	0.043	0.091	0.228
Number Long Calls	487,218	487,218	487,218

If the velocity volatility decreases to zero, there is an impact on the optimal purchasing strategy and distribution of profits. Simply, if there is no risk in velocity, the shuttle elevator has a high degree of certainty on the number of shipments. As a result, the shuttle elevator would buy fewer bushels. A lower purchasing strategy of 103% would have an increase in expected profit and a decrease in the standard deviation.

When velocity volatility increases, the purchasing strategy increases to compensate for the added risk of stockout. Mean NPV of the purchasing strategy decreases and the risk increases substantially. This occurs because an increase in velocity volatility increases the short call premium which reflects the likelihood of incurring a stockout. The shuttle elevator would increase its purchasing strategy to increases the strike velocity of the short call which has a lower option premium. Even so, a velocity volatility of .5 causes the premium to be more than double that of the base case. This increase in call premium increases the effect of the short calls on NPV and thus lowers the NPV even though the purchasing strategy is increased.

Figure 6.11 shows how the NPV distribution of the base case purchasing strategy changes with differences in velocity volatility. Increasing velocity volatility decreases the mean NPV and increases the standard deviation. The increase in velocity volatility increase the effect of the short call options and widens the distribution to the left. The skewness decreases the mean when standard deviation increases.

When velocity volatility decreases the mean NPV increases and the standard deviation decreases. Again, the distribution is skewed to the left, so a decrease in standard deviation narrows the distribution to the right and increases the mean.

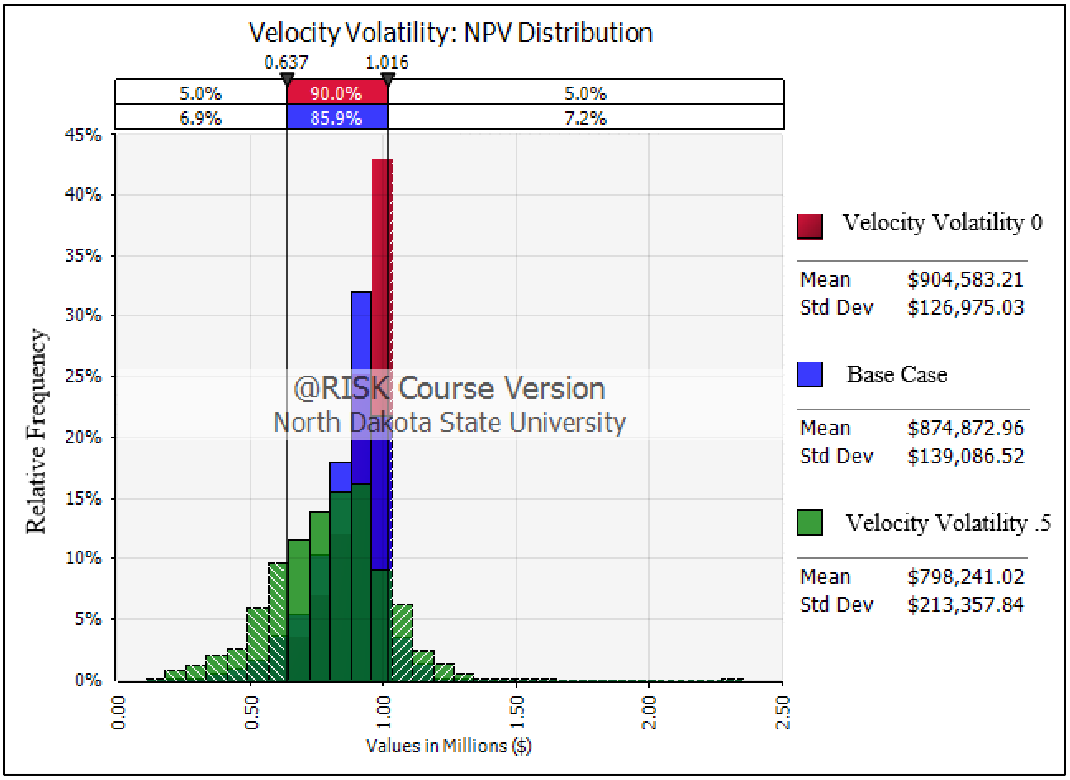


Figure 6.11. Velocity Volatility Change: NPV Distribution (@Risk).

Summary

Shuttle elevators with primary rail contracts have several uncertainties when developing a purchasing strategy. Sources of uncertainty arise from the market spread of soybeans, changes in the secondary rail car values, and fluctuation in velocity. Shuttle elevators are left with the task of developing an optimal purchasing strategy which would maximize their expected profit.

This section determines an optimal grain purchasing strategy over a three-month period to illustrate the role and effect of rail market strategies. Real option methodology is used to value the uncertainty in velocity, which is the demand to ship grain due to expected car supply. The shuttle elevator gains the right to ship grain when bushels are purchased. The shuttle elevator also loses the right to ship grain if the shuttle elevator runs out of inventory when velocity increases beyond the short exercise velocity. This relationship results in a call spread.

The model uses data from the soybean crop marketing year of 2015/16 when relatively stable market conditions existed. The optimal purchasing strategy from the base case shows that an elevator should purchase 5% more bushels than forecast velocity to account for the volatility in car supply.

Sensitivities on the input parameters of market carry, daily car value, and velocity volatility changes the optimal purchasing strategy in predictable ways. An increase in the market carry by $0.10 causes the shuttle elevator to max out their storage capacity and purchase 135%

of the forecast car supply. In this situation, the shuttle elevator has the right to either ship bushels for their marginal value or store the bushels and earns the carry. Either way, the shuttle elevator would make money, and thus encourages an excessive grain purchasing strategy. When the DCV is increased by $0.15 the optimal purchasing strategy was to not buy any bushels and sell all available shuttle trains into the secondary market for a profit. This strategy is profit maximizing but is also very risky. Changing velocity volatility from 21% to 50% would cause the elevator to purchase more bushels to avoid the possibility of stockout.

The overall result from this analysis is that due to uncertainties, from numerous sources, shippers should buy more grain than they would likely need to meet expected car supply. This is not an obscure idea in grain trading and marketing. Indeed, processors routinely buy or store more grain than they need; growers would normally under-hedge their production in anticipation of random yields; traders should under hedge position, or offset them with an option, if they anticipate counterparty risk; among other examples. In all these cases there is some type of uncertainty, and it affects a risk mitigation decision. In this case, there are uncertainties, and the shipper should appropriately respond in most cases by either overbuying, or, assuring he/she has more grain available for the expected car supply. Hence, here the excess inventory of grain can be viewed as a real option.

SUMMARY AND IMPLICATIONS

An important feature of the U.S. grain marketing system is that most rail carriers have adopted pricing and allocation mechanisms in response to rail deregulation and to the increased volatility in shipping demands and risks of shippers. Risks for shippers include rail rate risk and risk about timing of car placement. In the United States, these mechanisms have evolved since the late 1980s and have had multiple changes in their features over time. These mechanisms serve important functions that are critical to the grain marketing system, including allocating capacity across shippers both temporally, seasonally and geographically, in addition to determining price or value of the service. Finally, logistics management has evolved to be one of the most important sources of strategic and competitive advantage for grain marketing firms, and these mechanisms are central to this function.

In response to these dynamic challenges faced by shippers, railroads offer various types of forward contracting instruments. These mechanisms have important impacts on interfirm competition and strategy, in addition to affecting intermarket variability in basis or price relationships. The impact of shipping costs on basis values is important and has had differing interpretations among grain traders and academic researchers. There are many issues related to this problem, including whether the origin or destination basis is analyzed, which shipping costs are included, and how they are included. In practice, changes in shipping costs likely impact both the origin and destination basis, and in some sense they are endogenous.

The purpose of this study is to provide a comprehensive review, description and analysis of these mechanisms. Specific objectives are to 1) Document the evolution and operations of these mechanisms over time and across carriers; 2) Determine and describe the impacts of these practices on basis, both spatially and temporally, and on trading firms and other market participants; and 3) Summarize and assess the operations on these mechanisms relative to alternative pricing mechanisms.

Multiple empirical models were developed and used to analyze two important aspects of this problem. One is the role and relationship of the shipping costs and performance on basis values. These results show that basis is more complicated than previously modeled. The other analyses examine the impact of these mechanisms on shipper conduct, specifically, how risks and the availability of the transaction mechanisms impact shipper strategies.

Current Rail Pricing and Allocation Mechanisms

Rail car allocation and pricing mechanisms in the United States evolved from 1988 with the introduction of the initial COT program. Since then, these programs have undergone many changes to the specific features and terms offered. However, the general concept of having forward contracted freight, auction mechanisms, cancellation penalties, and transferability are common features of these programs. The general goals of these programs are to efficiently allocate cars among shippers and provide mechanisms for risk management.

The western carriers use some form of an auction system in which shippers place bids to receive access to cars. Shippers bid on the added benefits of an auction-based system, such as forward pricing, and transferability, each of which are factors that reduce overall risk for the shipper. This also helped ensure efficient allocation during times of shipping surplus or shortage, since supply and demand factors would be reflected in bids. The auction-based system improves economic efficiency, since cars are allocated to shippers that value them the most, rather than who applied first. There are numerous features of these programs and there are subtle differences among carriers. Most important include the bidding mechanism, transferability, the window for car placement, transparency of values in the primary and secondary markets, cancellation penalties and rail guarantees.

There are two important features of the primary transaction. One is that the quantity of cars placed depends on rail velocity (at least for several of the major carriers). For this reason, the shipper is exposed to quantity risk which is not easily mitigated. In general, the primary market eliminates risk of rate changes, but, exposes the shipper to velocity risk.

The second feature of the primary transaction mechanism is their transferability, which is the foundation for the secondary market. Indeed, the secondary market can only exist due to that the railroads allow transferability which gives the owner of the contract the right to sell a number of cars to another shipper. This is important to shippers because there is large risk (variability) in inter-month shipping demand due to intra-seasonal supply and demand levels.

The secondary market has some key differences in comparison to the primary market which are important. One is that transactions are made typically through 3rd party brokers, or through inter-firm trades. Typically, these values are disseminated to market participants, which provides transparency to the market. The other form of inter-firm transactions are direct offers from grain companies to shippers. In this case, individual grain companies accumulate varying positions in trains and from this would offer trains to other shippers.

While the underlying tariff rates, and primary market values are highly stable over time, values in the secondary market are much more volatile. It is this volatility that is important as for shippers that are short freight (i.e., have under-ordered, or over-purchased their requirements) are exposed to the risk of changes in secondary market values. Indeed, the standard deviation of this market is fairly substantial which is the risk absorbed by shippers.

Impacts of Shipping cost and Velocity on Export Basis

Shipping costs have numerous impacts, one of which is its impact on the basis. One of the analyses in this study was to evaluate how the basis impacts the basis market.

The results indicated that values for the export basis and secondary market are determined simultaneously. This is important as it indicates the market for freight and that for commodity basis are interdependent. The results also indicate there is significant seasonality in each market, and a partial adjustment process for each.

Velocity is one of the most important variables impacting these relationships. The velocity has an inverse impact on secondary market values, which have a positive impact on the basis. Importantly, higher values of rail car velocity, lowers the secondary market value, and therefore the basis. Second, the basis has a positive impact on the secondary rail car market value. A higher basis reflects greater demands for nearby deliveries, and the secondary rail market is one of the means of meeting these demands, without which shippers would accrue penalties, demurrage and other costs of not conforming to temporal demands for shipments. The secondary rail market value also impacts the basis equation.

Impacts of Shipping Costs on Origin and Destination Basis

In this analysis we used a panel data to analyze factors affecting the origin and destination basis using a panel simultaneous equations model. There are a number of results of importance.

One is that there were significant differences across origins. Second is that the origin and destination basis are determined simultaneously. This contrasts with common interpretations, and some previous results which assume *apriori* that the origin basis is dependent on the destination basis and shipping costs. Another important result is how changes in shipping costs impact the origin and destination basis. These results indicate that changes in shipping costs: on average (of our sample period and observations), a dollar increase in shipping cost results in 19 cents decrease in origin basis and 82 cents increase in the destination basis given all other variables are constant. Thus, changes in shipping costs are shared between the grower and the buyer in the form of reduced origin basis and increased destination basis respectively, and a greater share is absorbed by the buyer. This is analogous to an incidence of a tax on buyers versus sellers, which inherently may depend on the supply and demand for underlying products.

Traditionally, it is assumed that if rail cars are late it negatively impacts origin basis. These results indicate that late rail cars have the impact of lowering origin basis (by 1.6c/b for 1000 late cars), and raising the destination basis (by 2.9 cents per bushel). Thus, while late car placement impacts both the origin and destination basis, it has a greater positive impact on the destination basis, versus the negative impact on the origin basis. This indicates that buyers are more adversely affected by late car placements than sellers.

Impacts of Competition on the Export Basis

This study examined the impact of supply/demand and logistical variables upon both the level and seasonality of U.S. export basis values for soybeans

The results indicate that the marketing year basis for the Gulf and PNW markets is primarily influenced by international and domestic competitive pressures. The most significant variable impacting both the Gulf and PNW export basis values is the Brazilian export basis which the U.S. export markets respond in order to be competitive in the export market. The positive sign of the coefficient (in both markets) indicates that the U.S. export basis responds to changes in the Brazilian export basis.

The export basis levels are also significantly impacted by the level of imports by China which is by far the largest soybean buyer from both port areas. While the dominance of China to the PNW market is well known, the results show that China is also of paramount importance to the Gulf export basis values with significant and positive coefficient values in both markets.

The seasonal analogue analysis identified a total of 5 and 4 distinct seasonal basis patterns for the Gulf and PNW respectively. In each market, there is a distinct outlier analog containing just one marketing year (2013/14 for Gulf, 2014/15 for the PNW) and these particular analogs were characterized by extreme seasonal swings in the basis. The results indicated that the seasonal analogs have varying and diverse sets of explanatory variables – however, these were mostly related to variables characterizing the level of export activity, farmer marketings, and logistical situations.

There are three important conclusions from these results. First, the marketing year export basis in the two U.S. export markets (Gulf and PNW) is primarily driven competition from the international (Brazil) and domestic markets. U.S. export basis values adjust with changes in competitor's export basis values (in U.S. dollars per bushel) as expected. Likewise, export basis values adjust accordingly with domestic demand (and prices) in order to assure that an adequate supply of soybeans move to the export channels to meet anticipated export demands. Second, seasonality in the Gulf and PNW export basis values is not consistent across marketing years. Third, the seasonal analog patterns are primarily driven by three categories mostly unique to each export market: (1) the level of export activity at the particular port, (2) the pace of farmer marketings throughout the marketing year, and (3) the logistical conditions (lateness of railcar placement, cost of secondary railcars, barge and ocean freight rates) in the marketing year along with transportation cost differentials (between the two ports and primarily barge and rail).

Impacts on of Rail Shipping Mechanisms on Grain Shippers

These rail shipping mechanisms have implications for shippers. Two analysis were conducted in this study to analyze how these mechanisms impact shippers.

We analyzed the value of a primary rail instrument to a shipper, as a 'real option'. Important is that the primary contract has a feature which is the option to transfer the contract. This can be interpreted as a 'real option' which has value. The methodology used allowed determination of the value of the transfer option, and factors that impact that value.

The results indicate that in our base case (based on average values in our sample) the option value of a primary contract is $185/car. This value implies that whenever the primary shuttle contract cost is less than the transfer option value, there is extra value for the shipper since the transferability alone is worth, on average, $185. Since primary shuttle contracts typically are between $50 and $150, and the average transfer option value is $185, this transferability provides value to the shipper. Shippers typically under-value the transferability embedded within these shuttle contracts. Factors that impact this value include seasonal variability, rail car velocity, secondary market values, volatility in shipping demand and spreads in the futures and basis market.

In the second study we developed a model of a prototypical shipper buying and selling soybean, ordering and shipping rail cars. Shuttle elevators with primary rail contracts have several uncertainties when developing a purchasing strategy including the market spread of soybeans, changes in the secondary rail car values, and fluctuations in velocity. Shuttle elevators have to develop a purchasing strategy which would maximize their expected profit. The model was solved treating rail car orders as a real option and solved using stochastic optimization.

The results determined that generally it is optimal to buy more grain then planned shipments, due to the multitude of uncertainties confronting the shipper. In the base case the elevator should have an inventory of 5% more bushels than forecast velocity to account for the volatility in car supply and other random variables. Sensitivities were evaluated on input parameters regarding market carry, daily car values, and velocity volatility to determine how changes the optimal purchasing strategy in predictable ways.

Summary Overview, Implications

Railroads have adopted pricing and allocation mechanisms in response to market risks and shipper demands. These mechanisms provide alternatives to mitigate risks that would otherwise adversely impact shippers and carriers. In the process, these mechanisms provide a number of important functions including allocation, rail price discovery and dissemination (transparency) of information.

The allocation mechanism is particularly important. It entails allocating across shippers, cars for spot shipments, and capacity for deferred shipments. There are many mechanisms for allocations including allocation by historical averages, allocation based on time of request (first-order-first-served), allocation by contracts, random allocation, among others. Each of these in one way or another have been used in rail grain. However, allocation using some form of an auction-based system is more efficient in terms of assuring cars are allocated to shippers with the greatest value. It is for these reasons that auctions generally are revered by economists. In this process, including transparency and transferability, important signals are conveyed to shippers in making merchandising decisions (i.e., when to ship, ship versus storage, etc.) and to carriers regarding indicators of temporal demands.

In addition, these mechanisms impact and are impacted by variability in the basis which is impacted by numerous variables in a complicated including basis in competing markets, rail car velocity, exports, among many other variables. For these reasons, shippers have to be very strategic and integrative in making logistics and merchandising mechanisms.

Implications for Railroads

These results also have implications for rail carriers and a few are mentioned. One is to compare the efficiency and effectiveness of alternative allocation mechanisms (auctions versus contracts, etc.). Second would be to compare the design of the auction mechanism. There are many auction types and design decisions for each and a comparison of the features may be useful as these mechanisms are fine-tuned. Third relates to the value and practicality of transferability and transparency. Different railroads have taken varying approaches to these; and they have changed over time. Generally, the market is better served by having transferable instruments and transparent price (or price discovery).

Fourth is the role and impact of velocity which has numerous impacts as shown in this study. Velocity impacts secondary car values, and through that impacts basis values. In addition, velocity has an impact on shipper strategies for merchandizing and impacts the value of the transfer options. Since the option value alone is worth more than what the contracts usually sell for, it shows that the carriers have designed instruments so that they provide value for their customers. Importantly, these results show that the transferability provides value for shippers. Finally, the volatility of velocity is indeed one of the more important metrics for which carriers can strive to reduce.

Implications for Shippers and Markets

These results have important implications for commodity trading firms, as well as analysts of the commodity marketing system.

The shipping and basis markets are interdependent and simultaneously determined in a complicated way. One is that the origin and destination basis are determined simultaneously. This is obvious given operations of the trading industry in which traders determine the destination basis adding shipping costs from the origin basis; and, determine the origin basis by deducting relevant shipping costs from the destination basis at the targeted market. Thus, a simultaneous specification is more appropriate. Second, that changes in shipping costs, and late rail car placements, impact both the origin and destination basis is important in understanding market interrelationships. These results suggest while both adversely impact the basis, there is a greater impact on terminal markets and therefore buyers, than at the origin (at least on average). Last, these results provide an explanation of factors which impact the volatility of basis at both the origin and destination, as well as the spread between them.

Shippers confront a choice about taking coverage in either the origin basis, the destination basis, or both, in addition to taking coverage in the rail rate market, or, all three markets. These are crucial strategic decisions impacting risk and profits in trading. The results here provide an indication that these variables are determined simultaneously and would suggest that traders strategically participate in each of the three markets. Last, the export basis is impacted by many factors. In the case of soybean, most important are the export basis in Brazil, and the level of imports by China, in addition to many other factors.

The overall implication for shippers is that shipping and logistics strategies should be integrated and managed accordingly. Indeed, shippers that are long grain are simultaneously short freight. There are several risks associated with this position. The mechanisms described in this study are mostly transferable and provide additional value to shippers. However, shippers that coordinate their rail car position with the buying and selling would have lower risks and profits. This typically requires owning a buffer stock of grain to account in part for the volatilities in the market.

Contributions

This study provides a comprehensive summary of the evolution and current rail allocation and pricing mechanisms. Second, while a number of studies have analyzed the relation between shipping costs and basis, this study analyses some subtle features including 1) the simultaneity of secondary market values and basis; 2) the simultaneity of origin and destination basis; and 3) measures the distribution of changes in shipping costs on the origin and destination basis.

Third, these results provide a contribution in terms of understanding how these shipping mechanisms impact shippers. Few studies have done this and there are numerous impacts. Most important are for shippers to understand: 1) intermarket basis differentials are impacted by values of shipping instruments; 2) most carriers provide a transfer option, which has value to a shipper, but is impacted by numerous variables; and 3) shippers need to be simultaneously making shipping and merchandising decisions, and that normally it would be best to carry more inventories than required in part to offset risks and preclude lost opportunities.

Future Research

There are numerous areas of future research and outreach related to these topics, and, a few are mentioned. One would be to analyze alternative forms of allocation to assess their relative efficiency. Related to this would be to analyze alternative auction-types or auction features to assess the efficiency of alternatives. This could be expanded further to explore adoption of varying forms of internet auctions/allocation mechanisms which are becoming more practical. These could build upon current practices and explore how the escalating digitalization in grain marketing could enhance product offerings. Second would be to analyze the impacts of transferable versus non-transferable, and transparency of the instruments. These mechanisms provide signals throughout the marketing system which are important to carriers and shippers. Different carriers have varying approaches to these issues and research may be able to provide further direction to their implementations.

Further research could also be pursued to explore some managerial implications of these mechanisms. For railroads, a critical unexplored issue is that of making temporal rail fleet decisions. This ultimately is a process of making capacity decisions based on uncertainty in forward demand. Methods exist now for doing this type of analysis. Second would be to explore more detailed analysis of shippers managing car cycles to exploit how different shipments (i.e. destination) accrue different car-cycles. Third, would be to develop VaR (Value-at-Risk) models of grain shippers. While VaR is gradually being adopted at higher levels within grain firms for measuring and managing risks, these could certainly be adopted for rail (and barge) shipping risks.

Finally, these are important instruments in the grain marketing industry, and, they are evolving. As such, developing some type of outreach and education program for shippers should be viewed as important. Indeed, any shipper that is long-grain, is also short freight. For the latter they have numerous alternatives and it is important to assess the value and risk of alternative strategies.

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