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FORWARD SHIPPING OPTIONS FOR GRAIN BY RAIL: A STRATEGIC RISK ANALYSIS

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ABSTRACT

Grain hauling railroads began offering shipping alternatives in the late 1980s that have made transportation decisions more strategic. Shippers now confront alternatives ranging from nearby and unguaranteed ordering to various durations of forward and guaranteed shipment. A dynamic stochastic simulation model was developed to analyze grain shipping and merchandising strategies that integrate these alternatives.

Key words: railroads, grain merchandising, logistics, simulation, risk analysis

HIGHLIGHTS

Grain hauling railroads began offering shipping alternatives in the late 1980s that have made transportation decisions more strategic. Shippers now confront alternatives ranging from nearby and unguaranteed ordering to various durations of forward and guaranteed shipments. Each has various penalties for cancellation and payments from the railroad for non-performance and differing risks and payoffs. As a result of the configuration of choices, shippers confront a portfolio of shipping alternatives.

This research analyzes grain shipping and merchandising strategies that integrate these alternatives. Specific objectives are: 1) to develop a logistics model capturing critical components of operations and costs and 2) to analyze a spectrum of rail logistical strategies representing varying degrees of forward commitment. Key elements of merchandising and shipping uncertainty were taken into account to be reflective of a typical North Dakota elevator.

A dynamic stochastic simulation model was developed based on inventory management, transportation choice, and scheduling theories. An expected payoff function was defined as the difference between expected total revenues and total costs. Total revenues consist of grain sales and non-performance receipts from rail carriers. Total costs include those associated with acquisition, transportation, carrying, handling, and cancellation costs. The analysis includes the effect of uncertainties in tariff rate levels, car premiums, basis levels, forward and spot grain purchases, and receiving railcars under general tariff service. Shipping demand is determined by inter-month price differences and carrying costs, transport costs, and storage capacity. Considering these factors, the shipper chooses grain sales and shipping strategies that maximize net payoffs.

In the base case, simulations were conducted on designated shipping strategies. Various levels of long-term contractual car guarantees (G^L), i.e., SWAPs and GEEPs, were chosen. Shipping demand not met with G^Ls and general tariff cars were filled with shorter-term, auction-based car guarantees (G^S), i.e., COTs or PERX. Simulations were conducted to determine effects of different strategies on payoffs and risk. Results indicated that, in general, the strategy with the lowest risk required a greater use of G^Ls. Strategies making greater use of G^S provided increased payoffs, but also greater risk.

Simulations were conducted to evaluate effects of uncertainty on a spectrum of shipping strategies. Four important elements of uncertainty were examined: 1) shipping demand, 2) carrying cost, 3) general tariff service reliability, and 4) G^S premium levels. Sensitivity analysis provided some insight on relationships between G^S and G^L shipping strategies and changes in these key elements of uncertainty. The G^S Intensive strategy provided the greatest expected payoff in addition to the greatest risk. Uncertainty in shipping demand had the most influence on risk. Integration of G^L into a shipping strategy reduces risk. Increased use of contracts with growers for forward delivery reduces uncertainty and significantly reduces risk in grain shipping.

The model was simulated assuming different levels of longer-term forward coverage in the freight market. A number of general effects can be identified as shipping strategies make greater use of long-term guarantees:

- Forward contracts for grain purchases escalate in importance.
- Shipment patterns become less seasonal.
- G^S (G^L) premiums become less (more) critical to the expected payoff.
- The reliability of receiving cars under general tariff has an important influence on expected payoff levels across strategies.

Findings from this study provide a better understanding of G^S and G^L strategies for shippers, carriers, and public policymakers.

FORWARD SHIPPING OPTIONS FOR GRAIN BY RAIL: A STRATEGIC RISK ANALYSIS

Steven R. Priewe and William W. Wilson[*]

INTRODUCTION

Railcar allocation strategies have evolved dramatically since passage of the Staggers Rail Act of 1980. To become more efficient and meet the needs of logistically differentiated grain shippers, the rail industry has focused more on service, by providing more shipping options. Of particular interest, railroads have developed forward service options with guarantees for railcar supplies that provide logistical alternatives to grain shippers. As a result, shippers have more logistics planning tools, but are challenged with the integration of grain merchandising and logistical decisions.

Chronic post-harvest rail transportation problems have adversely affected those in the grain industry for some time (Norton 1995). Before 1987, rail rate and car supply guarantees were not offered in the grain transportation market. Service was determined to some extent by luck, but more important, the ability to integrate and execute shipping and merchandising strategies was limited. Shippers had few alternatives to manage railcar risks (rates and service) and had to absorb greater merchandising risks (Gelston and Greene 1994). During peak demands, cars were normally allocated on a first-order, first-serve basis. Shippers tended to inflate orders to secure railcars because of the absence of car cancellation penalties. "Phantom orders" were prevalent, and general car allocation mechanisms did little to address post-harvest transportation problems confronting the grain merchandising/transportation industry (Wilson 1989).

Railroads addressed these problems through development of innovative railcar allocation mechanisms. Beginning in the late 1980s, major railroads began to renovate traditional allocation methods. Burlington Northern (BN) pioneered these efforts with the introduction of its Certificates of Transport (COTs) program in 1987. Under COTs, forward guarantees are offered to grain shippers using a bidding mechanism. Shipper prepayments served as cancellation penalties and discouraged "phantom orders." Because of these mechanisms, shippers were segmented and cars were allocated according to shipping priorities. Since then, CPRS, Union Pacific, CSX, and other major Class One rail lines have adopted certain aspects of auction-based rate and car guarantee programs. Transferability of these instruments provided shippers flexibility and has resulted in informal secondary markets and transaction mechanisms for COTs, PERX, and other short-term guarantee instruments.[1]

In the early 1990s, longer-term guaranteed freight programs were introduced. These mechanisms allowed grain companies to enter longer-term contractual arrangements where railcars are leased to the carrier in return for a negotiated fee and a number of guaranteed trips per month. Examples of such programs include BN SWAPs and CPRS GEEPs. These rail

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[1] See Priewe and Wilson (1997) for a detailed description of these mechanisms.

equipment supply packages generally consist of an annual contract for a monthly number of guaranteed unit train placements. These programs also have cancellation penalties for carrier and shipper non-performance. Shippers participating in these pooling arrangements redeem their obligations or sell them through secondary markets. The contracted nature of guaranteed freight programs and transferability of these instruments have led to informal secondary markets where these instruments trade.

Taken together, these innovations present grain shippers with options, including general tariff, shorter-term, auction-based rate and car guarantees (e.g., COTs and PERX), and longer-term contractual car guarantees (e.g., SWAPS and GEEPs). The advent of forward guaranteed transportation services in grain merchandising has given shippers options for strategically integrating logistics and merchandising decisions.[2] Each has various penalties for cancellation and payments for the railroad for non-performance and differing risks and payoffs that must be an integral component of the decision analysis. Because of the configuration of choices, shippers can view a portfolio of alternatives, increasing the importance of integrating grain merchandising and shipping decisions.

This research analyzes grain shipping and merchandising strategies which integrate these alternatives. Specific objectives include: 1) to develop a logistics model applicable to grain shippers which capture critical components of operations and costs and 2) to analyze a spectrum of rail logistical strategies representing varying degrees of forward commitment and their relationships with key elements of planning uncertainty for a model of a typical North Dakota grain shipper.[3]

MODEL DESCRIPTION

A dynamic stochastic simulation model was developed based on inventory management, transportation choice, and scheduling theory.[4] A simulation approach to the modeling logistical system allows inclusion of interrelated components and multiple sources of uncertainty.[5]

The model was applied to a shipper characterized by a single origin country elevator shipping to competing markets, in this case either Minneapolis or Portland. The model is dynamic in the sense that grain selling and shipping decisions are made through time, and

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[2] Others have indicated the need for strategic analyzes of grain shipping decisions (Baumel and Van Der Kamp 1996, Frost 1996, Niedens 1996 and Moser 1995).

[3] However, the model is generally applicable to most grain shipping firms.

[4] Uniqueness of chronic post-harvest logistical problems has been addressed in previous studies on logistics theory and rail industry applications. Studies on time reliability (Allen et al. 1985), railroad service (Ainsworth 1972), requirements planning (Bookbinder and Serenda 1987), and modal selection (Sheffi et al. 1988) provided foundational literature for model development.

[5] Noted advantages of simulation modeling reside in the ability to experiment with policy changes within a controlled environment. Such models have been widely applied to transportation, inventory, and economic systems (Bierman et al. 1991).

residual inventories are stored to the next month. Shipping demand is determined by an evaluation of inter-month price differentials, interest and transport costs, and storage capacity. The shipper maximizes the expected net payoff each month by shipping in the month and market with the highest net payoff. Expected Annual Net Payoff [E(ANP)] is the difference between total revenues and total costs. Revenues consist of receipts from grain sales and non-performance payments from rail carriers. Costs include transportation, handling, carrying (including interest) costs, and shipper cancellation penalties.

The analysis captures uncertainties confronting shippers, including tariff rates, car premiums, basis, forward/spot purchases from farmers, and receipt of railcars under general tariff service.

SIMULATION PROCEDURE AND DATA SOURCES

The model was developed in a *@RISK* stochastic simulation format compatible with *Lotus 1-2-3*.[6] A specified number of iterations of the model are made; and, in each, distributions for random parameters are sampled, and estimates for derived parameters are calculated. Specified outputs are recorded from each iteration, and expected values and standard deviations are computed at the end of the simulation.

Model Simulation Procedure

The model consists of three modules: (1) parameter values, (2) statistical distribution of data, and (3) output variables are derived and recorded for specified ranges.

Input Parameters

The following input variables are specified: train size, railcar capacity, tariff rates, carrier performance payment for a Short-term (G^S) and a Long-term (G^L) Guarantee, uncertainty about forward and spot purchases, storage capacity, turnover ratio, annual carrying cost (interest rate), handing cost, and probabilities of receiving trains for the different service options. Table 1 presents the fixed input variables for the model.

Statistical Distributions

The following variables are included as random variables: MPLS and PNW basis, expected tariff rate changes to MPLS and PNW, G^S and G^L premiums, spot and forward contract deliveries, and variables used to derive allocation of general tariff cars. Statistical distributions for these and other variables are shown in Table 2.

[6] The mathematical formulation of the model is presented in Appendix I. Winston (1996) provides a guide to simulation modeling with *@RISK*.

Output

Output variables include annual revenues and costs based on monthly profit-maximizing, shipping decisions. Revenues consist of revenue from grain sales and carrier non-performance receipts. Costs include transportation, carrying (interest), handling, and shipper cancellation penalty expenditures. General tariff, short-term guarantee, and long-term guarantee costs are each components of transportation costs. Expected profit is derived from these values. Statistics are reported for mean, minimum, maximum, standard deviation, and percentiles for all specified inputs and outputs.

Table 1. Fixed Input Variables for Country Elevator Logistical Model

Parameter	Value
Train size	26 cars/unit train
Car capacity	3,300 bushels/car
Unit train elevator storage capacity	1,107,262 bushels
Unit train elevator turnover ratio	5
Carrying cost	9.25 percent
Excess carrying cost	12.25 percent
Handling cost	12 cents/bushel
Minneapolis 26-car tariff rate	$2,063/car
Pacific Northwest 26-car tariff rate	$4,280/car
Forward purchase contract percentage	25 percent
Spot purchase percentage	75 percent
Forward contract uncertainty: August-November	5 percent of Expected Value
Forward contract uncertainty: December-March	10 percent of Expected Value
Forward contract uncertainty: April-July	15 percent of Expected Value
G^S carrier performance guarantee	$400/car
G^L carrier performance guarantee	$250/car
Shipper cancellation penalty	$250/car

Table 2. Data Distribution Parameters

	Units	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July
MPLS Basis													
Average	c/bu	42	40	43	48	46	36	40.67	42.63	51.54	58.13	50.42	52.23
Standard Deviation	c/bu	33	42	47	44	36	31	39.17	34.41	33.75	35.79	24.63	32.84
PNW Basis													
Average	c/bu	103	99	101	111	102	102	101.50	110.63	113.88	118.87	109.25	107.32
Standard Deviation	c/bu	42	39	47	43	45	46	54.59	61.24	60.33	57.95	33.34	35.72
MPLS Rate Change													
Average	%	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.01
Standard Deviation	%	0.01	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.15	0.03	0.00	0.02
PNW Rate Change													
Average	%	1.00	1.01	1.01	1.00	1.01	1.00	1.00	1.00	0.99	1.00	1.00	1.00
Standard Deviation	%	0.00	0.15	0.13	0.00	0.02	0.01	0.00	0.00	0.02	0.00	0.00	0.02
G^S Premium (Discount)													
Average	$/car	18	48	155	225	220	140	128	105	36	22	9	4
Standard Deviation	$/car	30	47	37	43	22	52	44	37	11	50	4	2
G^L Premium													
Average	$/car	130	130	130	130	130	130	130	130	130	130	130	130
Spot Transactions													
Average	%	12.23	11.46	8.92	8.38	8.46	8.54	6.23	7.38	6.69	5.92	9.00	6.77
Standard Deviation	%	5.43	1.98	2.29	1.50	2.40	3.78	1.24	1.39	1.18	2.18	2.12	2.17
General Tariff Allocation													
Three Year Moving Average of Cars in District	cars	4,192	6,116	5,967	5,642	5,727	4,326	4,395	4,667	3,926	3,175	3,193	3,440
Shipped Production in Region	cars	15,387	15,407	13,703	13,057	13,462	15,776	9,213	10,675	8,126	5,504	9,993	7,696
Estimated Supply-Demand Ratio	%	0.27	0.40	0.44	0.43	0.43	0.27	0.48	0.44	0.48	0.58	0.32	0.45

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Data: Sources and Behavior

This section describes parameters, data sources, and estimation procedures. Market prices, grain supplies, shipping costs, railcar placements, and related parameters are presented.

Market Prices

Market prices were based on futures prices and basis values in April 1996. Average basis levels for HRS wheat were derived for 1989 to 1994 (Flaskerud 1995) and are treated as random variables with normal distributions. This basis component reflects the random nature of market movements which trigger shipping demand (see Figures 1 and 2). The correlation between MPLS and PNW basis levels of .81 was incorporated into the model.

Grain Purchases

Estimates of grain purchases were derived to reflect a typical single origin shipper in North Dakota. Estimates for forward and spot and beginning/ending stocks were obtained from several sources as described below.

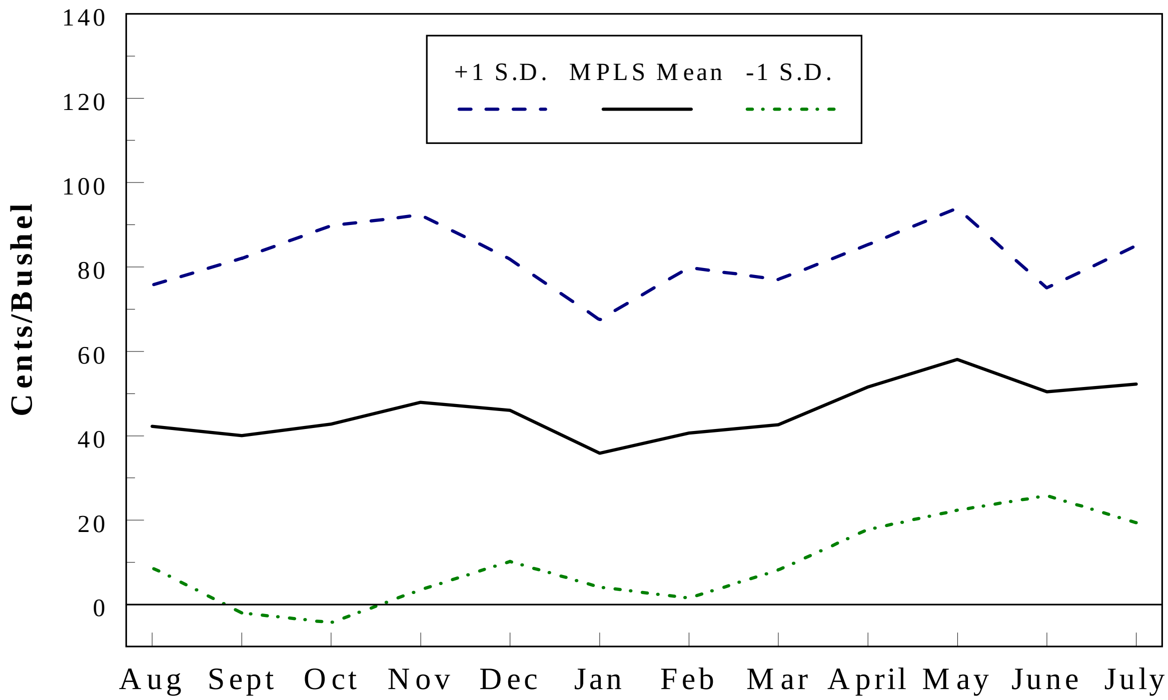

Figure 1. Minneapolis Basis Levels.

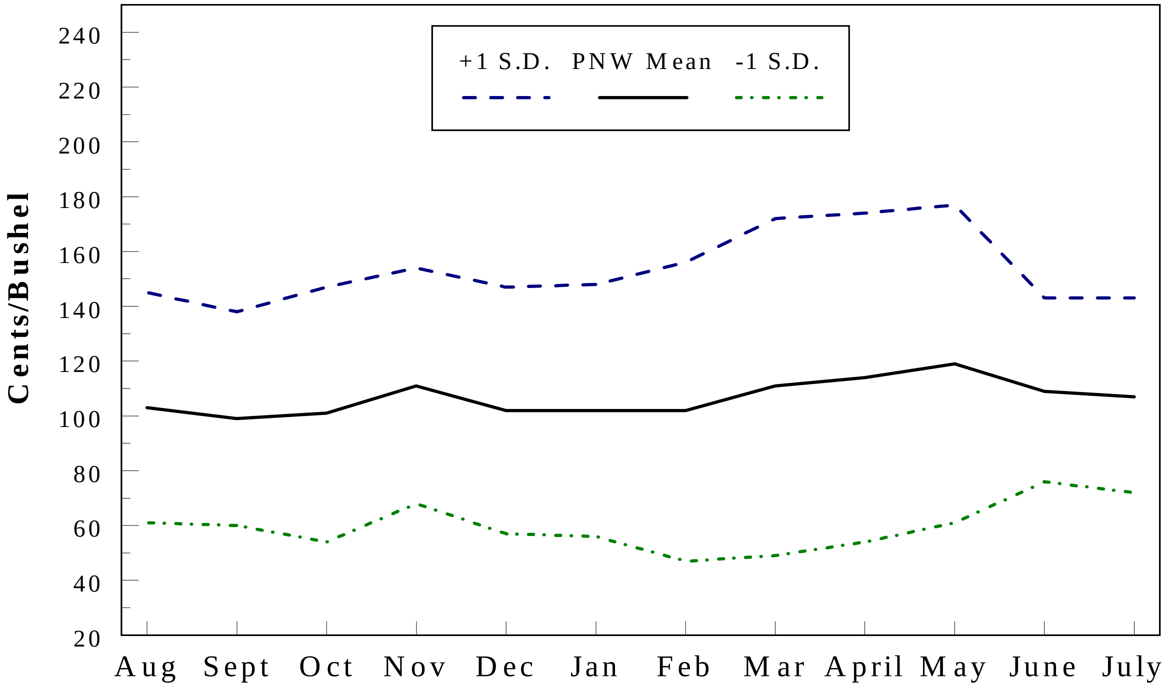

Figure 2. Pacific Northwest Basis Levels.

Estimates of Grain Purchases. Grain purchases were derived as follows. First, the expected annual shipment volume of a typical North Dakota elevator was derived. A typical elevator storage capacity and an average turnover ratio were used to derive total volume (Gelston and Greene 1994; Andreson and Vachal 1995). The percentage of crop year totals sold by producers (North Dakota Agricultural Statistics 1991-95) and, therefore, purchased by elevators was applied to determine monthly purchases by elevators.

Monthly purchases consisted of both spot and forward transactions, each with different levels of uncertainty. The split between forward and spot delivery transactions (forward/spot delivery ratio) was 25 percent and 75 percent, respectively (Stearns 1994).[7] Spot deliveries are treated as a random variable with a normal distribution. Monthly expected values and standard deviations for this parameter were calculated from the North Dakota Agricultural Statistics.

Forward purchases were derived similarly. The volume purchased under forward contracts was assumed to have less uncertainty, with the level increasing in more distant months.[8] Graduated levels were established around a fixed level of forward contracts: 5 percent standard deviation for one to four months forward positions; 10 percent standard deviation for five to nine months forward positions; 15 percent standard deviation for 10 to 12 months forward positions. This feature was added to reflect uncertainty shippers confront during the post-harvest season. Figure 3 illustrates the seasonal and volatile nature captured of grain purchases used in the model.

[7] These were rounded from 34 percent forward and 66 percent spot to simplify later sensitivity analyzes.

[8] An *@RISK* simulation procedure was used to add uncertainty around a fixed trend.

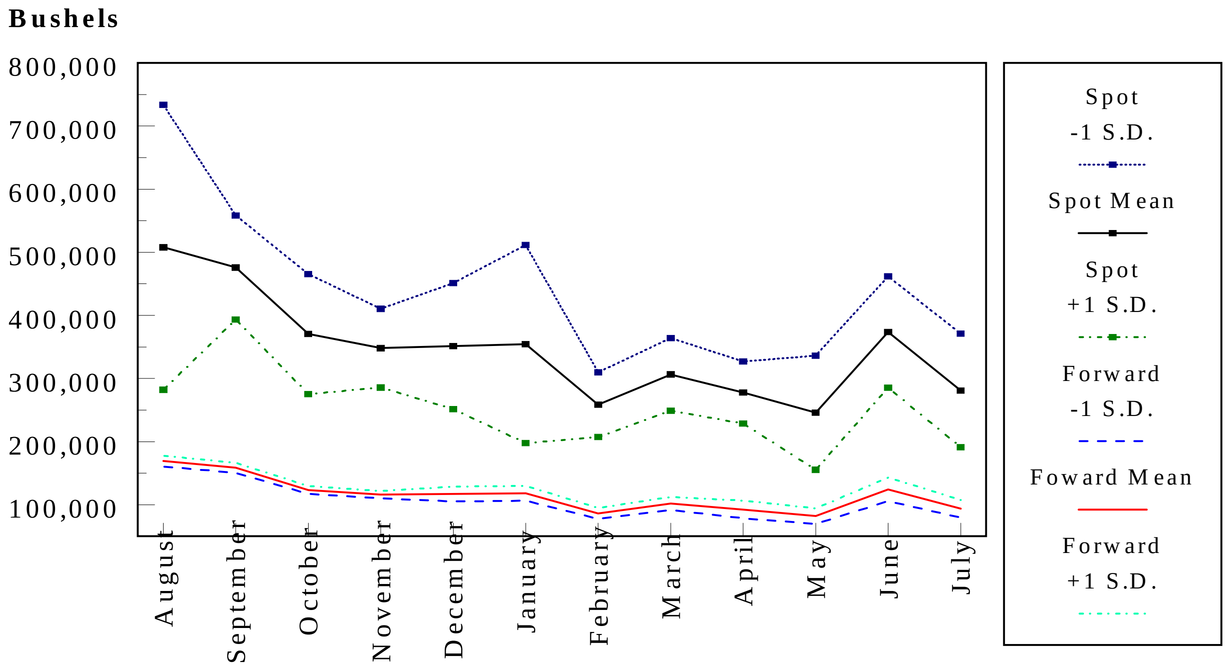

Figure 3. Estimate Levels of Forward Contracted and Spot Deliveries to Elevator.

Shipping Costs

Shipping costs were comprised of several elements.

Tariff Rate Levels. Burlington Northern 26-car tariff rate levels from Devils Lake, ND, to Minneapolis and Pacific Northwest markets were used as of April 1, 1996 (Burlington Northern Tariff ICC-BN-4022 G-I). However, shippers confront the risk that rail rates may increase. Figure 4 illustrates the frequency of historical rate changes.

The potential for changes in tariff rates was included in the model using a procedure of "variation around a fixed trend" (*@RISK* 1994, p. 5-13). Monthly average rate changes were derived from tariff rate data from 1990 to 1994.[9] Ratios of monthly rates and estimated standard deviations provide the necessary data to establish an average monthly rate trend and uncertainty

Grain shippers face tariff rate uncertainty in addition to car placement uncertainty when making forward rail transportation plans. While G^L instruments have only tariff rate uncertainty, G^S instruments have both tariff rate and premium uncertainties. Tariff rates indicate a greater likelihood of rate changes in certain months for both the Minneapolis and Pacific Northwest markets. Expected rate changes were limited to increases because of the rare occurrence of rate decreases. The MPLS and PNW tariff rates had a correlation of .82 for 1990-94. This value was included in the *@RISK* correlation matrix to capture the effects in these random variables. Figure 5 illustrates the rate change relationships between MPLS and PNW tariff rates represented in the model. Inclusion of these rate relationships in the model captures the potential rate risks confronting grain shippers among logistical options.

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[9] Estimates were obtained with a commonly utilized method for measuring commodity market volatility (Cox and Rubenstein 1985, pg. 257). Under this procedure, the logarithm of inter-month rate ratios is computed. The square root of the natural logarithm provides estimated standard deviation for each month.

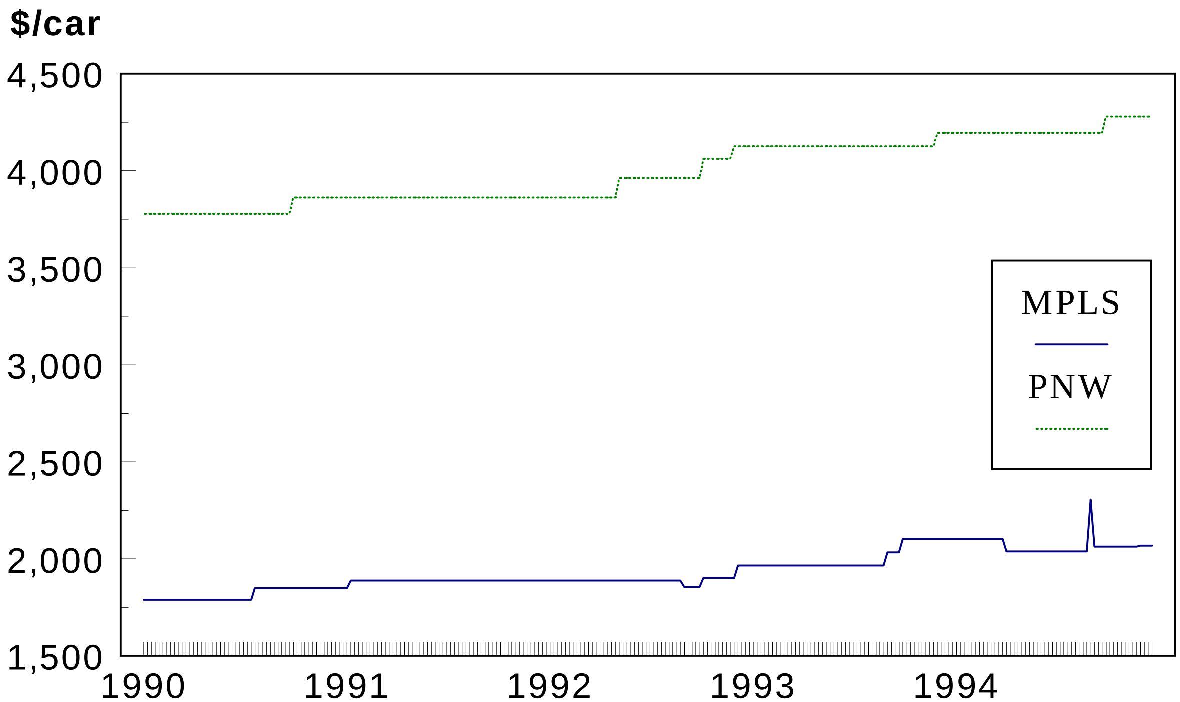

Figure 4. Minneapolis (MPLS) and Pacific Northwest (PNW) Tariff Rates, 1990-94.

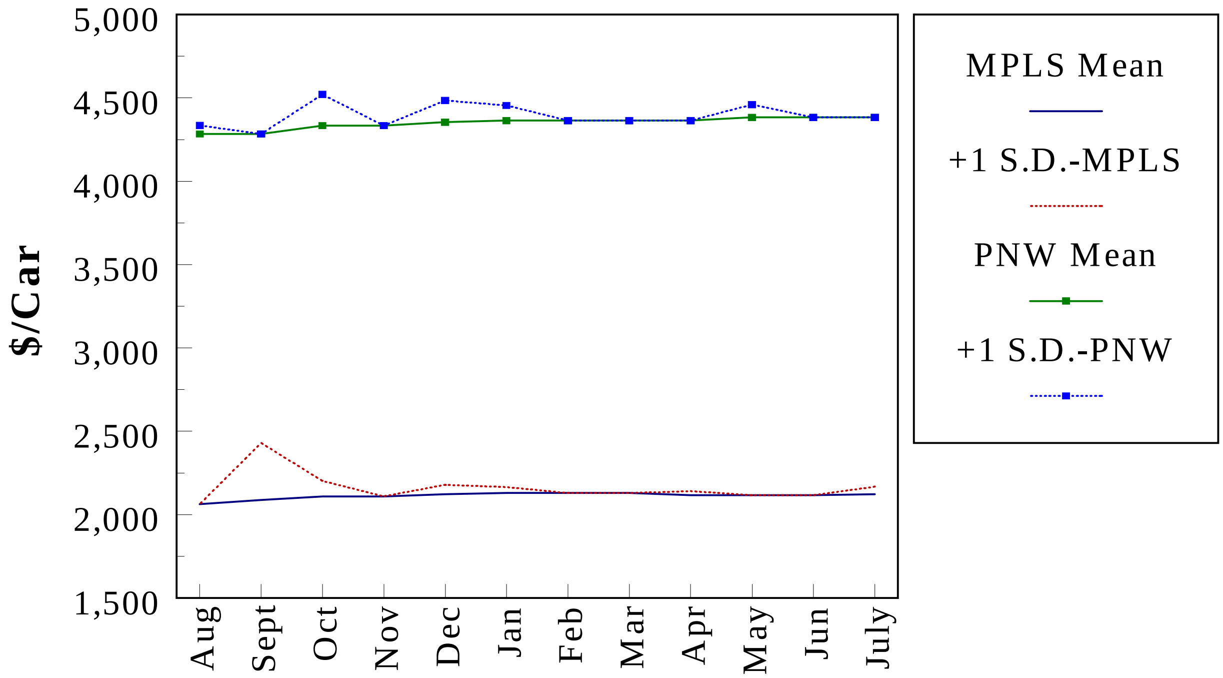

Figure 5. Monthly Tariff Shipping Costs to Minneapolis and Pacific Northwest.

Short-term Guarantee Premiums (Discounts). Means for G^S were assumed equal to the 1995 monthly averages, and the parameter was treated as a random variable. Average monthly BN COTs values for 1993-95 were used to estimate distribution parameters for Short-term Guarantees (G^S) (Figure 6).[10] Premium levels are identical for the MPLS and PNW movements, and all rate differences between the two markets are captured in the tariff rates. Therefore, G^S shippers confront both tariff rate and premium uncertainties in the model. All G^S are assumed to be purchased through the primary market.

Long-term Guarantees. Long-term Guarantee (G^L) premiums are treated as a non-random variable to reflect the contracted nature of the instrument. Examples include BN SWAPs and CPRS GEEPs which typically have one to three-year terms. G^L rates were obtained from Harvest States transportation packages for Spring 1996 (Figure 6).[11] These premiums are fixed, but the rate level is subject to the tariff rate at the time of shipment.

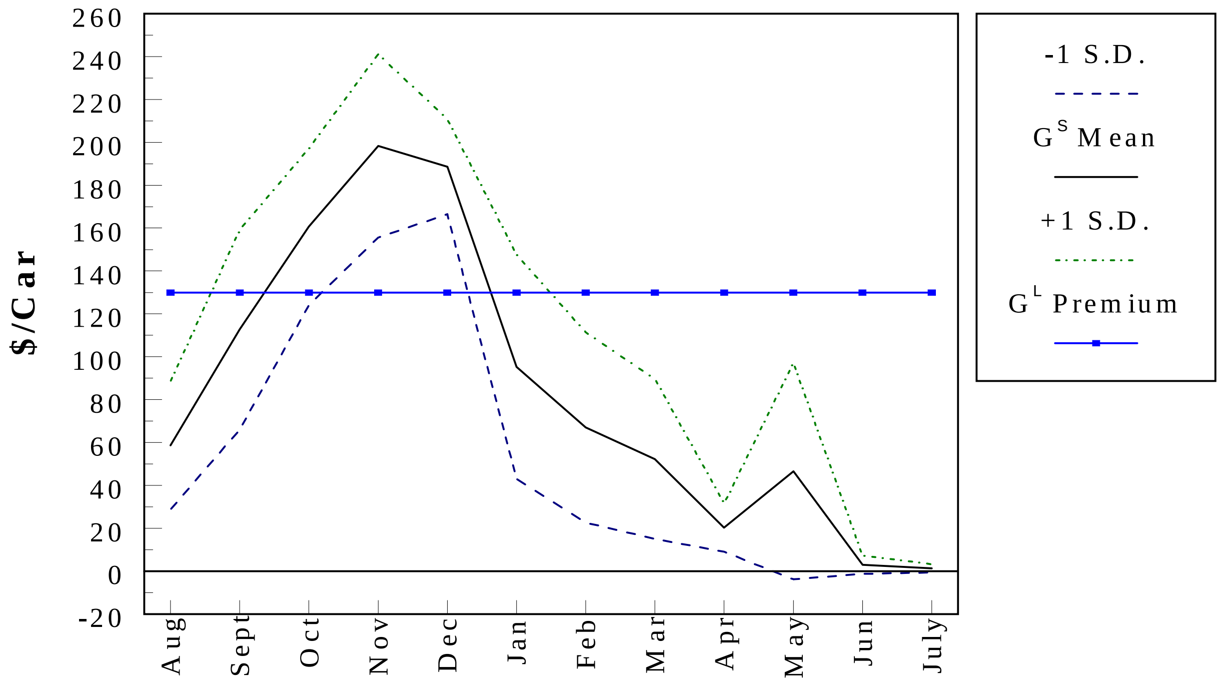

Figure 6. Short-term and Long-term Guarantee Premiums (Discounts).

Railcar Placements

Allocation mechanisms have differing degrees of reliability. Service differentials between rail logistical options were included in the model for general tariff and non-tariff (G^S and G^L) allocation mechanisms. This section describes the procedures used to derive railcar placements for each option.

[10] Average monthly COT premiums for 1995 were used in the base case to more accurately reflect the market situation for Spring 1996.

[11] Harvest States Cooperatives' "Rail Equipment Supply Program" facsimile for February 8, 1996.

Service Reliability Under Guaranteed Service Options. Service parameters for Short-term and Long-term Guarantees were treated as discrete probabilities. The probability of receipt was defined as one minus the likelihood of carrier default. Estimates of the probabilities of receiving cars within the shipping period were obtained through interviews with rail and grain industry contacts (Wood 1996, Strege 1996). Both sources noted a slightly higher performance level for G^S over G^L due to the carrier performance incentives associated with the G^S instrument. Table 3 and Figure 7 present these probabilities.

Table 3. Probability of Car Placement Estimates for Short-term and Long-term Guarantees

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
G^S	.99	.99	.98	.98	.95	.95	.95	.95	.98	.99	.99	.99
G^L	.95	.95	.90	.90	.85	.85	.85	.85	.90	.90	.95	.95

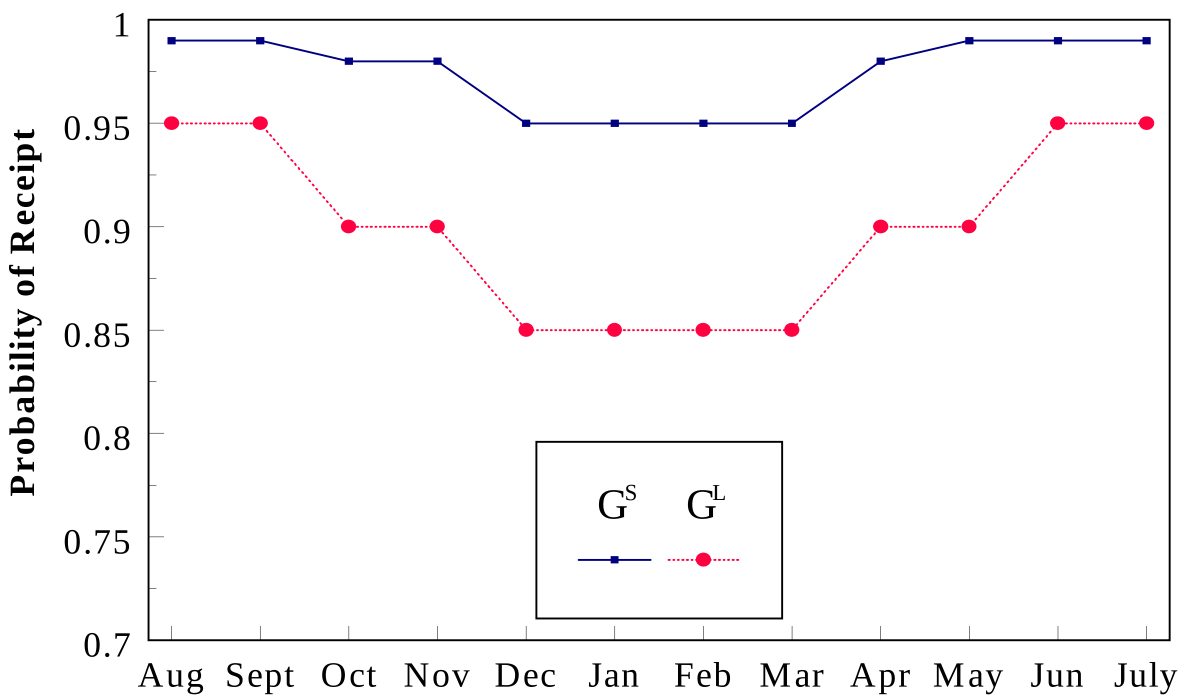

Figure 7. Probability of Receipt for Short-term (G^S) and Long-term (G^L) Guarantees.

Car Allocation for General Tariff Services. Similar data are not attainable for car placement under general tariff services. Thus, a method was developed to approximate the probability of receiving general tariff cars. These estimates were incorporated with general tariff allocation logic to determine the likelihood of receiving cars under this option.

Monthly railcar supply and demand estimates were calculated for North Dakota. Demand estimates were derived from several sources. First, average production levels for 1990-94 were computed for wheat, barley, sunflower, oats, soybeans, flaxseed, and corn from historic estimates of principle crops harvested in North Dakota (North Dakota Agricultural Statistics 1995). rucking shares of the average annual production (tons) were netted out, assuming a fixed annual rail-truck ratio for each commodity using average annual rail and truck percentages for 1990-94 from North Dakota Grain and Oilseed Transportation Statistics (Andreson and Vachal 1995, Andreson et al. 1994, Busch and Vachal 1993). Rail shares of annual production were converted to car units, using load factors for each commodity (BN State Statistics 1993). Average total monthly grain and oilseed market sales were computed by multiplying derived average percentages of crop year totals sold in open market for 1990-94 (North Dakota Agricultural Statistics 1995). This total served as the railcar demand estimate for North Dakota.[12]

Railcar supply estimates for North Dakota were derived using several sources. North Dakota grain movement for 1993-95 served as the basis for these estimates (Andreson et al. 1994, Andreson and Vachal 1995). First, three-year average monthly totals were computed for wheat, barley, sunflowers, oats, flaxseed, and corn. These totals were converted into cars using 1993 BN load factors (BN State Statistics 1993). Non-tariff movements were subtracted from these totals, assuming a fixed annual percentage of tariff movements (Vachal 1995). This total served as the railcar supply estimate for North Dakota.

An algorithm was developed to simulate the general tariff allocation procedures used by the BN (Burlington Northern Tariff ICC-BN-4022 I). If car supply exceeded car demand, the shipper receives one train for that month; otherwise, a random draw is conducted to determine receipt. A shipper was awarded one 26-car unit-train if a randomly generated number from a uniform distribution in the model is less than the supply and demand ratio. Otherwise, the elevator receives no general tariff cars for the month. The uniform distribution between zero and one assures that each number has an equal likelihood of occurrence. Residual supplies, if present, are also randomly allocated to shippers.

Shipping Demand

Shipping demand was derived from the value of the expected net payoff of holding grain for an additional month. This formulation evaluates inter-month price differences of interest costs, transport costs, and storage capacity to determine whether stocks should be shipped or stored. Monthly grain stocks are shipped if $(P_{t+1} - P_t) < (I + E(\Delta S))$. If the inter-month price spread $(P_{t+1} - P_t)$ is greater than the estimated marginal cost of storage (I) and the expected change in transport ($E(\Delta S)$), then grain is stored. Specifically, grain stocks are not shipped and are stored if $(P_{t+1} - P_t) > (I + E(\Delta S))$. However, if the total monthly grain supplies (TGS) exceed the storage capacity (SC), then shipping demand is equal to the excess inventory. These conditions are summarized in Table 4.

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[12] Shippers are assumed to prefer to move grain with lower-cost tariff cars if possible. For this reason, the summation of the monthly car totals for each commodity serves as the proxy for the total monthly general tariff demand.

Table 4. Determination of Monthly Shipping Demand

Evaluation	Ship/Store
$(P_{t+1} - P_t) > (I + E(\Delta S))$	Store
$(P_{t+1} - P_t) < (I) + (E(\Delta S))$	Ship
TGS > SC	Ship excess grain stocks

When there is a carry in the market $((P_{t+1} - P_t) > (I + E(\Delta S)))$ and total monthly grain supplies are less than storage capacity, shipping demand is zero. If the inter-month total price spread is less than the cost of storage and transport, the shipping demand is total monthly grain supplies. Ultimately, random movements in the inter-month price spreads and basis levels generate shipping demand in the model.

Car-ordering Strategies

Shipping demand is the basis for implementing the car-ordering strategies. Shippers use of general tariff orders for a component of their requirements, accepting them whenever positive shipping demand is present and they are awarded one. Varying levels of long-term commitments (G^L) were evaluated and any monthly shipping demand not met with G^L and general tariff cars would be filled with short-term guarantees (G^S). The shipper orders general tariff cars, accepting cars whenever positive shipping demand was present and they were awarded.
Alternative shipping strategies considered in the analysis are presented in Table 5.

Table 5. Spectrum of Shipping Strategies

Strategy	G^L		General Tariff	G^S
	Trains/Month	% of Annual Volume Under G^L **		
G^S Intensive (0-G^L)	0	0	Random	*
G^S Mix (2-G^L)	2	33	Random	*
G^L Mix (4-G^L)	4	67	Random	*
G^L Intensive (6-G^L)	6	100	Random	*

* Determined dynamically within the model. Specifically, each shipping strategy consists of a given G^L position with general tariff and G^S cars filling residual shipping demand, when present.

** Derived as the expected value of car placement under longer-term guarantees. These represent the actual percentage times the probability of car placement under that service option.

The base case scenario is presented first, followed by simulations of changes in key variables affecting uncertainty.

Base Case: Expected Annual Net Payoff

A fundamental question for all shippers is the portion of shipments made under longer-term guarantees versus shorter-term options. Results from this analysis illustrate the differences. As the shipper's strategy makes greater use of longer-term guarantees, the E(ANP) decreases at an increasing rate. The maximum E(ANP) was $582,085 with a shipping strategy of zero G^Ls (i.e., G^S Intensive).[13] Under the G^S Intensive strategy the shipper relies on general tariff cars and supplements the remainder of shipping demand solely with G^S (i.e., $G^L = 0$). The E(ANP) declines to $(248,335) with a G^L strategy of six unit trains per month (Figure 8).[14] Results indicate a $541,880 reduction in total revenues on grain sales going from the E(ANP) maximizing strategy to 100 percent coverage with longer-term guarantees (Figure 9). Total revenues on grain sales are affected by grain prices and the quantity shipped in a given month.

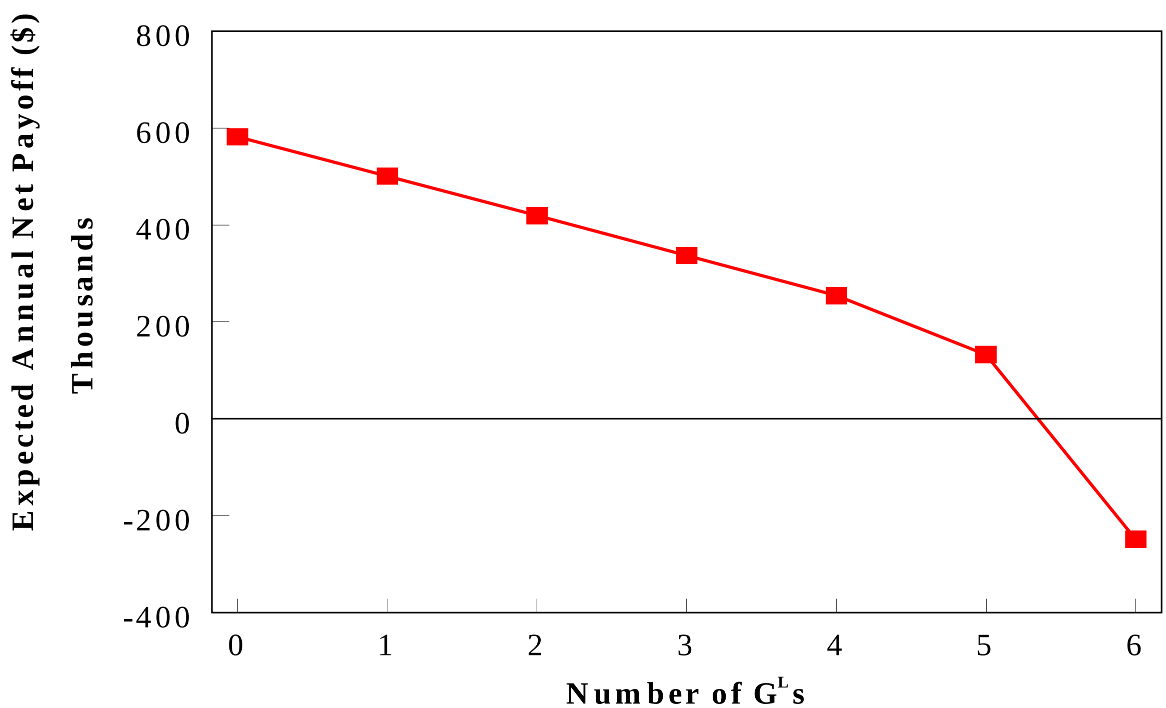

Figure 8. Expected Annual Net Payoff by Shipping Strategy.

[13] The E(ANP) was solved without deducting the cost of wheat. The estimated cost of wheat for the elevator was defined as the average of the gross revenue on grain sales less transportation costs across the established shipping strategies. This value was deducted from the solution value from the simulations.

[14] The model was also run assuming 0-G^L and 0-G^S, implying that the shipping strategy was 100 percent on the general tariff option. Simulations indicate that the E(ANP) was ($21,230,016) and excess grain stocks reached 3.8 million bushels. Effectively, these results illustrate an inability to meet annual shipping requirements and the need to expand storage capacity if the shipper relied solely on general tariff cars.

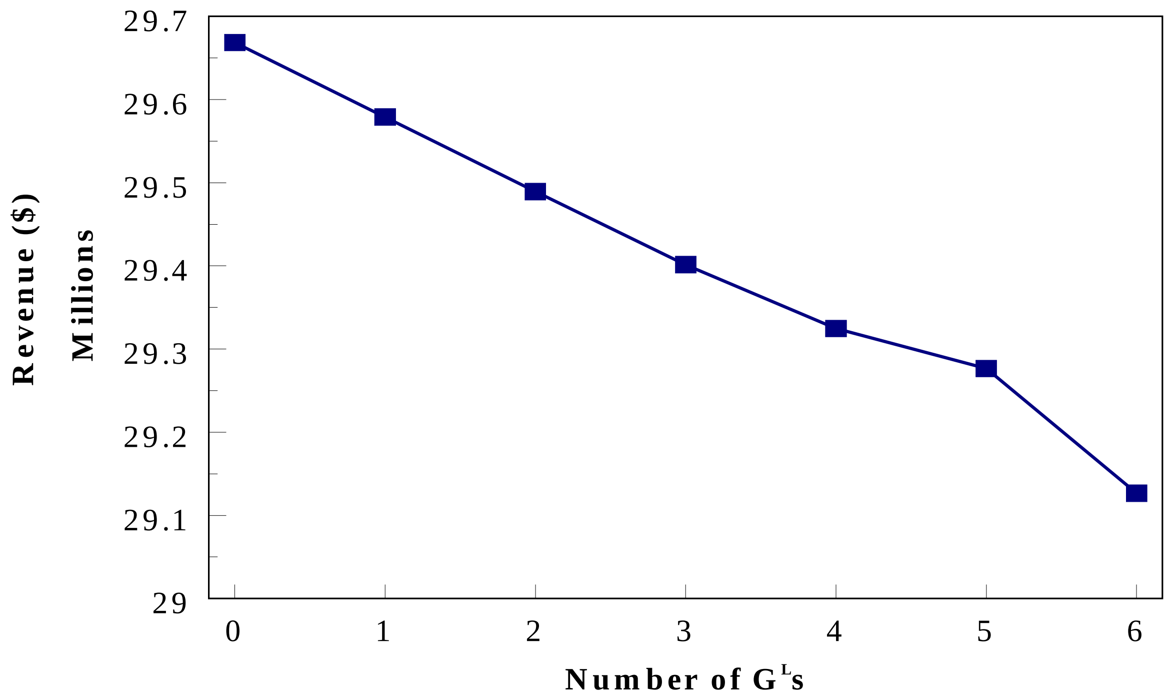

Figure 9. Total Annual Revenue on Grain Sales by Shipping Strategy.

The relationship between E(ANP) and shipping strategy is a result of a number of factors. First, G^Ls remove marketing flexibility, forcing shipments in otherwise sub-optimal shipping periods. As the number of G^Ls increase, the country elevator's shipping patterns are governed less by market spreads and more by railcar positions and associated obligations. Figure 10 illustrates the monthly shipping patterns in G^S and G^L Intensive strategies. As illustrated, strategies using more G^L smooth out monthly shipments.

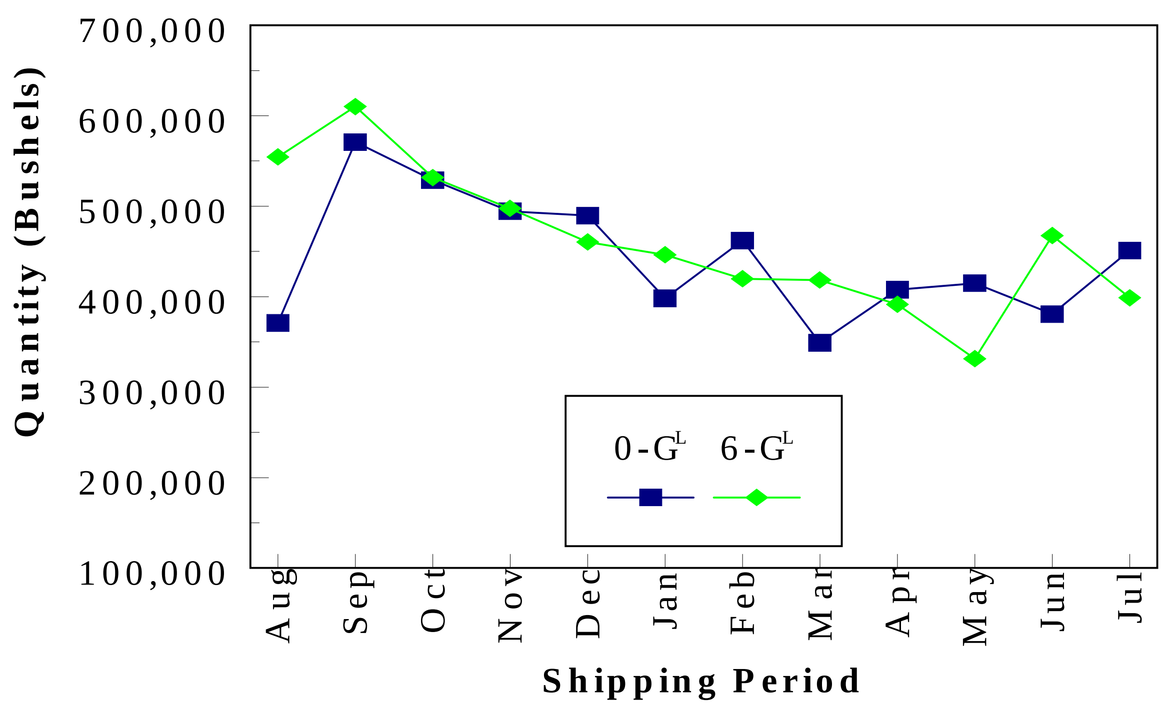

Figure 10. Relationship Between Shipping Strategy and Monthly Shipments.

A second factor is that Shipper Cancellation Penalties are more frequent with greater use of G^L, increasing from nil with the G^S Intensive strategy to $48,428 with the G^L Intensive strategy (Figure 11). Uncertainties in the level of grain supplies generate a greater frequency of being in an excess car position with more fixed shipping strategies. Declining carrying costs reflect the lower levels of grain stocks. G^S strategies enable shippers to better target months with favorable prices and to avoid cancellation penalties when grain stocks and therefore shipping demand are nil.

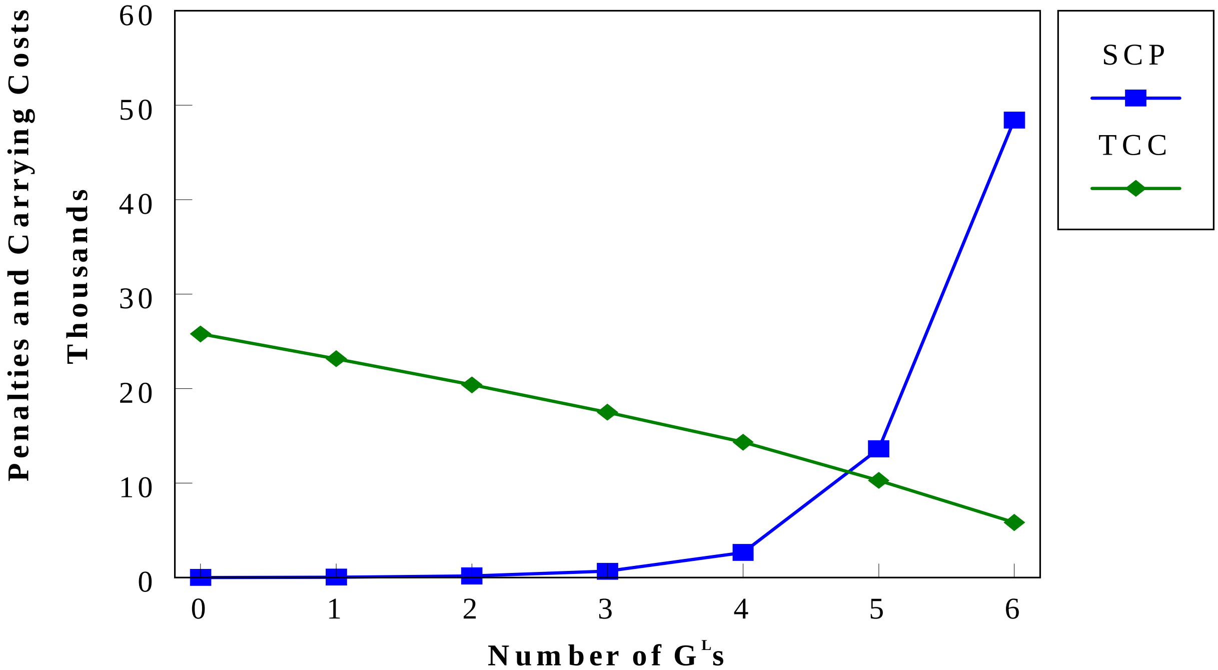

Figure 11. Relationship Among Shipper Cancellation Penalties (SCP), Total Carrying Cost (TCC), and Shipping Strategy.

Standard Deviation of Expected Annual Net Payoff

As the shipper's strategy becomes more long-term intensive, the standard deviation of E(ANP) diminishes and reaches a minimum at 5-G^Ls, increasing thereafter (Figure 12).[15] Lower risk levels reflect the stability in the shipping patterns that are realized with such commitments, as well as reduced risk of changes in shipping costs and storage.

[15] Absolute risk (standard deviation) is minimized somewhere between the 4-G^L and 5-G^L strategy at about $1.8 million. A strategy of 5-G^Ls results in an E(ANP) of $132,595 and a standard deviation of $1.831 million; the 4-$G^L$ strategy results in a standard deviation of $1.835 million and an E(ANP) of $254,275. An additional $121,680 could be added to the E(ANP) by accepting a $3,894 increase in risk with the 4-G^L strategy.

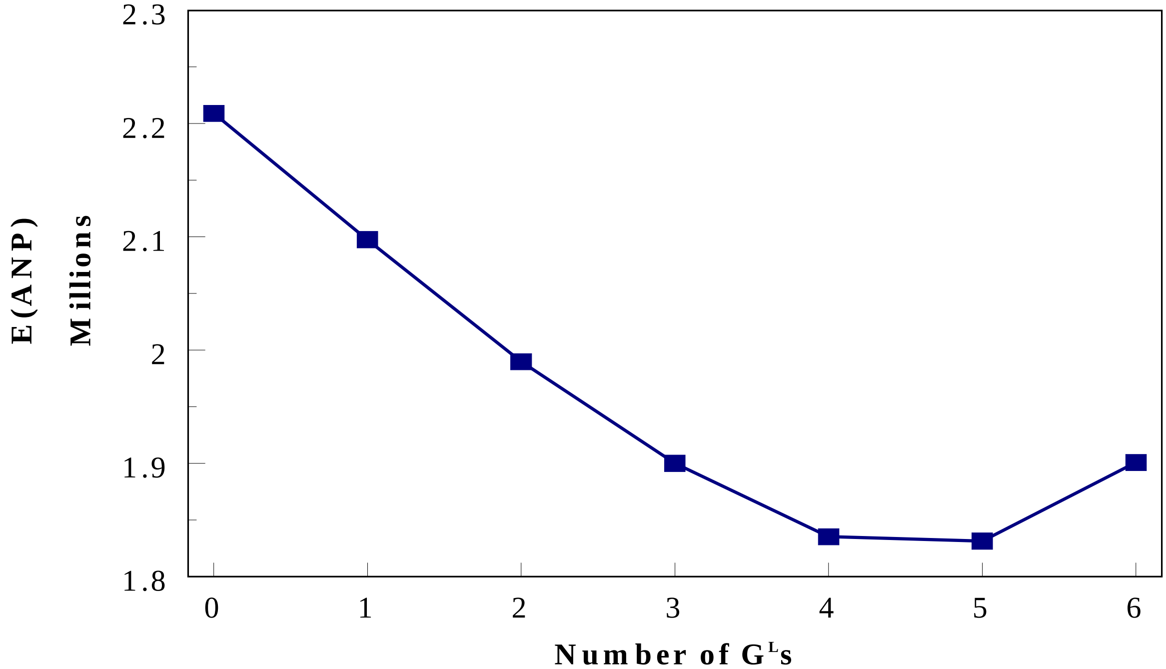

Figure 12. Standard Deviation of Expected Annual Net Payoff by Shipping Strategy.

Trade-offs between E(ANP) and risk are illustrated in Figure 13. These typify a conventional trade-off between risks and payoffs. Generally, increased profits can be attained with different strategies, but only by incurring greater risks. In this case, risks for the shipper would be minimized with a longer-term car guarantee strategy of 4-5 trains per month, or, more generally, covering between 66 and 83 percent of annual shipping requirements using longer-term guarantees. The residual would be covered using service either under shorter-term guarantees or general tariffs. Profits increase with less use of longer term guarantees and increased use of shorter term guarantees. By only using tariffs and shorter term guarantees, profits would increase by 56 percent, but risk would also increase, relative to the minimum risk strategy. Ultimately, the selection of a shipping strategy depends on the risk preferences of the decision maker.

Results of Sensitivity Analysis

Simulations were conducted to evaluate effects of sources of uncertainty on the spectrum of shipping strategies. To do so and simplify the presentation, 50 percent increases and decreases were assumed from base case values. Important elements of uncertainty were selected for analysis: 1) general tariff service reliability, 2) G^S premium levels 3) the ratio of forward to spot grain purchases (F/S Ratio), and 4) carrying cost. A summary of results from sensitivity analyzes on key elements is presented (Table 6 and 7). The effects of these variables on E(ANP) and risks are discussed with respect to the G^L and G^S Intensive strategies.

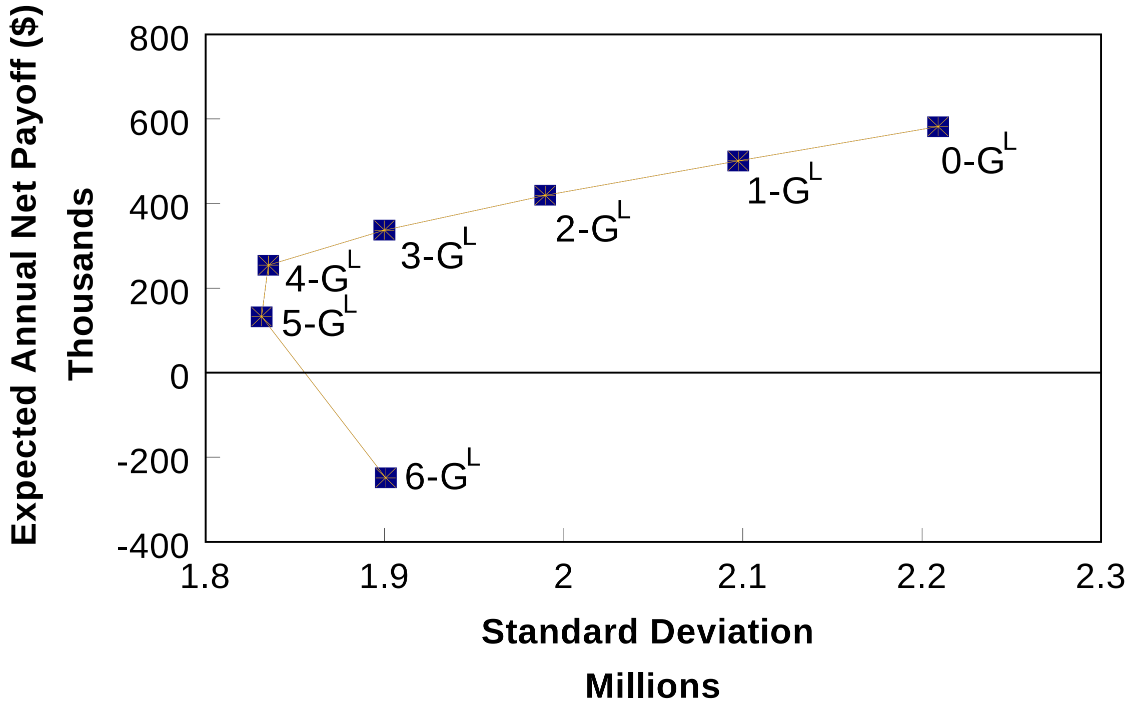

Figure 13. Shipper Trade-offs for Alternative Rail Strategies.

Reliability of General Tariff Service. Reliability in car placement under general tariff shipments is an important problem for grain shippers (Pedraza 1996). The likelihood of receipt of general tariff cars depends on the distribution of the supply-demand ratio, and thus, whether cars are randomly allocated, or not. Simulations were conducted on a 50 percent increase and decrease in this supply-demand percentage which affects the probability of receiving general tariff cars. Such changes in reliability levels could be the result of irregularities in the grain transportation market.

Reliability of general tariff service had the greatest effect on shipping strategies that depend more on shorter-term commitments. E(ANP) is positively affected by changes in general tariff service reliability. Increases in service reliability resulted in increases in profit from the base case levels for each strategy ranging from 16 percent (0-G^L) to 29 percent (6-G^L). Decreases in service reliability result in negative percentage changes ranging from -14 percent (0-G^L) to -31 percent (6-G^L).

Improvements (declines) in the service reliability lead to less (greater) uncertainty in tariff car receipt. The impact of service reliability on E(ANP) increases with the more G^L Intensive strategies. This suggests that the G^S strategy is less affected by swings in tariff service. The more fixed G^L Intensive strategies realize greater revenue on grain sales and lower shipper cancellation penalties from higher service reliability.

Table 6. Summary of Simulation Results: Expected Annual Net Payoff and Standard Deviation [1]

	Expected Annual Net Payoff				Standard Deviation of Expected Annual Net Payoff			
	Shipping Strategy				Shipping Strategy			
	0 G^L	2 G^L	4 G^L	6 G^L	0 G^L	2 G^L	4 G^L	6 G^L
Adjusted Base Case Level	582,085	419,455	254,275	(248,335)	2,209,116	1,989,782	1,835,187	1,900,693
150% Tariff Service Reliability	94,090	92,580	68,480	71,540	(2,708)	205	11,711	12,198
50% Tariff Service Reliability	(81,670)	(80,840)	(70,060)	(77,290)	(8,328)	(5,924)	(4,641)	(9,519)
150% G^L Premium	0	(36,680)	(73,350)	(110,020)	0	0	0	0
50% G^L Premium	0	36,670	73,340	110,020	0	0	0	0
150% F/S Ratio	280	890	5,860	29,330	(186,640)	(213,358)	(237,953)	(261,648)
50% F/S Ratio	(1,050)	(1,660)	(10,320)	(35,770)	206,740	232,445	258,638	278,231
150% G^S Premium	(75,670)	(50,600)	(25,060)	(5,290)	(2,633)	(3,191)	(3,556)	(1,871)
50% G^S Premium	72,030	47,430	22,840	4,200	3,376	3,415	3,469	1,664
150% Carrying Cost	(6,390)	(9,080)	(8,340)	(9,860)	(9,584)	(3,490)	(998)	(2,161)
50% Carrying Cost	(25,460)	(14,720)	(40)	10,070	24,809	12,719	2,078	1,291

[1] Values in cells below the first row are change in E(ANP) from the adjusted base case level.

Table 7. Summary of the Simulation Results: Percentage Change from the Base Case

	Expected Annual Net Payoff				Standard Deviation of Expected Annual Net Payoff			
	Shipping Strategy				Shipping Strategy			
	0 G^L	2 G^L	4 G^L	6 G^L	0 G^L	2 G^L	4 G^L	6 G^L
150% Tariff Service Reliability	16.2	22.1	26.9	28.8	(0.1)	0.0	0.6	0.6
50% Tariff Service Reliability	(14.0)	(19.3)	(27.6)	(31.1)	(0.4)	(0.3)	(0.3)	(0.5)
150% G^L Premium	0.0	(8.7)	(28.8)	(44.3)	0.0	0.0	0.0	0.0
50% G^L Premium	0.0	8.7	28.8	44.3	0.0	0.0	0.0	0.0
150% F/S Ratio	0.1	0.2	2.3	11.8	(8.4)	(10.7)	(13.0)	(13.8)
50% F/S Ratio	(0.2)	(0.4)	(4.1)	(14.4)	9.3	11.7	14.0	14.6
150% G^S Premium	(13.0)	(12.1)	(9.9)	(2.1)	(0.1)	(0.2)	(0.2)	(0.1)
50% G^S Premium	12.4	11.3	9.0	1.7	0.2	0.2	0.2	0.1
150% Carrying Cost	(1.1)	2.2	(3.3)	(4.0)	(0.4)	(0.2)	(0.1)	(0.1)
50% Carrying Cost	(4.4)	(3.5)	0.0	4.1	1.1	0.6	0.1	0.1

The standard deviation was relatively unaffected by changes in the tariff service reliability. This is likely due to the general tariff allocation logic which depends on a random draw and the limited percentage of total shipments made with the tariff option.

G^L Premiums. G^L premiums had the greatest impact on Expected Annual Net Payoffs for strategies with more longer-term coverage. This parameter had an inverse relationship with the E(ANP).[16] Increases in G^L premiums resulted in a decrease from the base case levels for the G^S Mix (-8 percent), G^L Mix (-29 percent), and G^L Intensive (-44 percent) strategies. Decreases in G^L premiums resulted in increases from the base case levels for the G^S Mix (8 percent), G^L Mix (29 percent), and G^L Intensive (44 percent) strategies.

G^L premium changes had no impact on the standard deviation of E(ANP) for each shipping strategy. This relationship reflects the fixity of the contract premium levels.

Uncertainty in Forward Grain Purchases. Purchases of grain from farmers result in a great source of uncertainty for shippers. During pre-harvest, producers and, therefore, shippers have a high degree of uncertainty due to growing season risk. In the post-harvest period, uncertainty also exists around farmer delivery patterns. However, grain bought under forward contracts has less uncertainty, resulting in a greater ability to plan logistics requirements. Uncertainties about farmer sales patterns result in uncertainty in shipping demand and, therefore, risks associated with railcar strategies. These effects are an important part of the model. To evaluate this effect, simulations were conducted on a 50 percent increase and decrease in the forward contracted level across each forward shipping strategy. Changes in the level of forward purchases ultimately affect the level of spot purchases since these two parameters complement one another to comprise total purchases. This relationship is refer to as the Forward/Spot (F/S) ratio.

E(ANP) has a positive relationship with changes in the percent of forward purchases (i.e., the portion of the crop purchased under forward contract versus spot). Increases (decreases) in the level of forward contracted deliveries increases (decreases) the expected payoffs across strategies. Increases in forward deliveries result in positive percentage increases in the base case levels for each strategy, ranging from 0 to 12 percent with the 0-G^L and 6-G^L, respectively. Decreases resulted in negative percentage changes ranging from 0 to -14 percent. The G^L Intensive strategy was the most responsive to changes in the forward/spot delivery ratio.

Forward deliveries had the largest absolute and percentage impact on risk across strategy. Sensitivities showed an inverse relationship between changes in the level of forward contracts and the standard deviation of Expected Annual Net Payoff. Greater use of forward contracted deliveries results in less risk. Forward contract purchases are more important as the strategy becomes more G^L Intensive (see Table 7). The strategic implication of this is important: an increase in grain purchased under forward contract reduces uncertainty in shipping demand, making forward shipping alternatives more effective and lessening the risk of cancellation penalties.

[16] The G^S Intensive strategy was unaffected by G^L premium changes since this strategy does not use the G^L instrument.

G^S Premiums (Discounts). G^S and G^L premiums vary with grain transportation market conditions. Shippers can take positions as far forward as six months before the shipping period with certain G^S programs. However, premiums tend to be seasonal, and volatile annual production levels can result in unanticipated shifts in G^S premiums (Wilson 1995). Positions and premiums for G^L instruments can be made one to three years in advance at fixed premiums through forward contracts. Uncertainty also exists over the actual future value of the G^L instrument. Thus, the relationship between G^S premiums, which are random, and G^L premiums, which can be locked for extended periods, is critical.

Volatility in G^S premiums was captured in the model with the normal distribution based on monthly BN COTs data from 1993-95 (Wilson 1996). G^L premiums were fixed at their April 1996 value of $130 per car to reflect their contractual nature. Changes were evaluated with 50 percent increases and decreases in the mean to reflect potential longer-term shifts in premium levels. Simulations were conducted on upward and downward shifts across shipping strategies.

The G^S premium level had an inverse relationship with E(ANP). Higher premiums result in reduced profits in base case levels for each strategy ranging from -2 percent to -13 percent, therefore making G^L intensive strategies more attractive. Conversely, lower premiums result in percentage increases ranging from 2 to 12 percent. As expected, the G^S Intensive strategy was the most sensitive to changes in premiums.

The standard deviation of E(ANP) was unaffected by changes in the G^S premium level. The G^S Intensive strategy displayed a relatively minor inverse relationship with changes in this parameter.

Carrying Costs. Spatial, capital, storage, and risk costs are all components of the cost of carrying grain. Shippers are confronted with the challenge of balancing irregular levels of shipping demand with variable delivery schedules, costly demurrage penalties, and fixed storage capacities. Costs of carrying grain stocks fluctuate with the grain market. Price movements (including basis and spreads), storage availability, and interest rates each affect the cost of holding grain. The carrying cost was set at 1 plus the current prime rate (8.25) in the base case. Excess carrying costs were set at the prime rate plus 4 percent to capture the added cost of storage contingencies. Simulations were conducted on a 50 percent increase and decrease in the annual carrying cost level across shipping strategies.

Expected Annual Net Payoff had a mixed relationship with changes in the carrying costs and was relatively unresponsive to changes in this parameter. This relationship is a result of the complexity of the shipping demand calculations and their relationship to price spreads, transport costs, and carrying costs. An increase (decrease) in the carrying cost led to -1 percent (-4 percent) changes in the expected payoff with the G^S Intensive strategy. The G^L Intensive strategy, however, had a positive relationship with changes in the carrying cost. Here, an increase (decrease) in carrying cost resulted in a 4 percent decrease (increase) in the payoff level. Lower carrying costs expand the horizons in which it is feasible to carry grain forward, resulting in greater holding costs and risk in future basis movements. Conversely, higher carrying costs generate greater certainty in shipping demand and relatively higher total carrying costs.

Changes in the carrying cost had little effect on the standard deviation of Expected Annual Net Payoff. However, results did exhibit an inverse relationship with risk (see Table 7).

Summary. These results provide insight into effects of changes in key elements of uncertainty and the relationships between G^S and G^L shipping strategies. A number of general trends were identified as the shipping strategy makes greater use of G^Ls. First, reliability of general tariff service has the greatest impact on expected payoff levels for the G^S Intensive and G^S Mix strategies. The discrete and random nature of the general allocation mechanism leads to relatively large changes in E(ANP).[17] Second, G^L premium changes have the greatest impact on the G^L Mix and G^L Intensive strategies. The contracted nature of the forward rate becomes more critical than the general tariff reliability as the shipping strategy becomes more long-term intensive. Third, grain purchases on forward contracts increase in importance as the shipper becomes more G^L orientated in strategy. Uncertainty in spot purchases results in greater risk of being understocked. Securing stocks through forward contracts leads to greater E(ANP) and lower risk. Finally, G^S premiums become less important as the shipping strategy becomes more long-term. However, shippers implementing G^S strategies must consider the premium risks associated with such positions.

The G^S Intensive (i.e., 0-G^L) strategy consistently provided the highest E(ANP) in addition to the greatest risk. Carrying cost, G^S premiums, and tariff service reliability had little impact on the standard deviation of risk. The ratio of forward to spot purchases (F/S Ratio) had the most influence on risk for each strategy. However, such changes only have a significant impact on E(ANP) with the G^L Intensive strategy. Integration of G^Ls into a shipping strategy result in less risk.

[17] Appendix II provides figures which illustrate the sensitivity of Expected Annual Net Payoff for these shipping strategies to changes in the forward/spot delivery ratio, carrying cost, general tariff, service reliability, and G^S premium levels.

CONCLUSIONS

The railcar market has evolved dramatically since the passage of the Staggers Rail Act of 1980. Railroads have addressed chronic problems with the introduction of several innovative market-based allocation and ordering mechanisms. As a result of these innovations, grain marketing participants are confronted with three logistical options: general tariff, short-term guarantees (G^S), and long-term guarantees (G^L). Such forward guarantees (G^Ss and G^Ls) are attractive to shippers because of seasonal demand fluctuations in railcar demand. Shippers must consider among different combinations of these strategies to maximize expected profits, recognizing that each strategy has different risks.

This study evaluated rail logistical options confronting grain shippers. Analyses reveal that as shipping strategies make greater use of short-term guarantees (G^S Intensive strategies), the E(ANP) increases, as does risk. Second, reliability of general tariff service has the greatest impact on the expected payoff levels. In addition, the ratio of forward to spot grain purchases has the most influence on standard deviation of E(ANP). Such changes in the level of forward contracts, however, only affected E(ANP) with the G^L Intensive strategy. Hence, integration of G^L into a shipping strategy and contracting forward purchases results in lower risk. However, shippers must coordinate their forward car and grain positions.

Results from this dynamic stochastic simulation model can put perspective on the importance of the variables in this system. This study illustrates the role of G^S and G^L strategies and their relationships to uncertainties in deliveries, premium levels, carrying costs, and tariff reliability.

Shippers

Some important implications can be identified for shippers.

Integrating Merchandising and Forward Transportation Strategies

Shippers must develop forward strategies that integrate grain trading and logistics strategies. Shippers need to make projections of future car requirements based on projected grain market conditions. Coordination of expected grain purchases, sales, and shipping requirements results in increased profits. Grain shippers also need to accurately assess the general tariff service reliability when developing forward logistical strategies. In doing so, managers must integrate grain marketing and transportation decision planning. Indeed, these results illustrate that grain merchandising decisions that are not integrated with forward shipping strategies are highly risky and payoffs would be substantially less. In the extreme, the 100 percent general tariff shipping strategy would result in negative profits and the need to expand storage capacity.

Shipping Patterns

Implementing forward car ordering strategies has an effect on shipping patterns. First, as G^L use increases, elevator shipping patterns become less governed by market spreads and more by railcar commitments. Such strategies remove a degree of market speculation and induce shipments in otherwise "sub-optimal" shipping demand periods relative to the more flexible G^S strategies. As use of G^Ss increases, shipping decisions become more governed by the grain market conditions. The value of G^Ss rests with the strategic flexibility of this instrument to target peak demand shipping periods.

Risk Management

Mixed strategies, shipping a portion of shipments on long-term guarantees (G^Ls), increase stability in shipping patterns and reduce risk, up to a point. As the shipper's strategy depends more on G^Ls, risk diminishes, reaches a minimum and then increases. Results for the simulation suggest that longer term freight positions of 66-83 percent of annual shipments would minimize risk for a shipper with logistical characteristics similar to a typical North Dakota elevator.[18] Fixed G^L strategies may be viewed as risk-reducing tools when used in conjunction with adaptable G^Ss. Success of such efforts, however, ultimately depends on the accuracy of shipping demand projections. Since shipping positions are taken over a year in advance, elevators ought to develop projections of minimum monthly shipping demands from which to fill a portion with long-term contractual commitments.

Demand Certainty

The importance of forward contracts for grain purchases escalates as shippers integrate grain merchandising and transportation strategies. Increased use of forward contracts reduces uncertainty about forward shipping demand, making longer-term shipping options more attractive and less risky. Shipping strategies with longer-term guarantees require more planning and scheduling of grain flows. In this analysis, the ratio of grain purchases under forward contract has a great impact on the expected payoffs levels and risk, particularly for G^L Intensive strategies. Greater certainty in monthly grain stock levels through forward contracts reduces the likelihood of shipper cancellation penalties.

Secondary Markets

Transferability of the forward instruments has led to the development of informal secondary markets. The emergence of transportation brokers and packages put together by grain trading firms has created more options for the grain shipper. Secondary markets can serve as a means of adjusting the size of railcar positions. Brokerage firms (e.g., Trade West, Joiner Co.) can serve

[18] It is important to note that the simulation results reflect a shipping year with market conditions and peak railcar demand periods such as 1995-96.

as a source of added flexibility with any logistics strategy. Shippers with greater uncertainty in shipping needs can defer positions until demand becomes more apparent and purchase instruments on the secondary market. Risk-averse shippers can also reduce the degree of uncertainty in primary market G^S positions by purchasing instruments closer to the delivery period.

Railroads

Railroads must closely monitor the effectiveness of the design of these instruments. Objectives should be to develop and offer options for shippers. Proper levels of shipper cancellation and carrier default penalties must be monitored to ensure appropriate incentives are present.

Market-based allocation mechanisms have led to greater sophistication of logistical decision making. Options are likely to result in productivity gains that will benefit carriers. Most obvious is that the forward dimension of some shipping options provides incentives for shippers to even out seasonal extremes, and concurrently provides less uncertainty and variability in forward shipping demand for the carrier.

Public Policy

Guaranteed rail transportation services have generated a number of public policy concerns. First, results from this study indicate demand exists for forward guarantee mechanisms in the grain industry. Shippers which develop integrated logistical strategies can reduce merchandising risk using these mechanisms. Second, G^S and G^L instruments encourage greater sophistication of grain marketing decisions. Forward guarantee mechanisms ration demand during peak demand periods and level out shipping patterns. Such developments generate improvements in grain transportation efficiency which benefit shippers and carriers.

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APPENDIX I
MATHEMATICAL SPECIFICATION OF THE MODEL AND STOCHASTIC SIMULATION IN @*RISK*

Model Specification

The model used to represent the country elevator's logistical system is given as:

$$ANP_{Net} = \sum_{t=1}^{12} Maximum\,[\,\pi_{Net}^{MPLS},\, \pi_{Net}^{PNW}\,]$$

given

$$\pi_{Net}^{MPLS} = R^{MPLS} + R_{NP} - (TC_{OGT} + TC_{G^S} + TC_{G^L}) - CC - TSCP - HC$$

$$\pi_{Net}^{PNW} = R^{PNW} + R_{NP} - (TC_{OGT} + TC_{G^S} + TC_{G^L}) - CC - TSCP - HC$$

where

ANP_{NET}	=	Annual Net Payoff
π_{Net}^{MPLS}	=	Monthly Minneapolis Net Payoff
π_{Net}^{PNW}	=	Monthly Pacific Northwest Net Payoff
R^{MPLS}	=	Monthly Revenue on Minneapolis Grain Deliveries
R^{PNW}	=	Monthly Revenue on Pacific Northwest Grain Deliveries
R_{NP}	=	Monthly Non-Performance Receipts from Carrier
TC_{G^S}	=	Monthly Short-term Guarantee Transportation Cost
TC_{G^L}	=	Monthly Long-term Guarantee Transportation Cost
TC_{OGT}	=	Monthly Obligated General Tariff Transportation Cost
HC	=	Handling Cost
CC	=	Monthly Carrying Cost
TSCP	=	Monthly Total Shipper Cancellation Penalties
t	=	Month

Simulation Inputs

The number of iteration settings is specified under the simulation settings icon. This allows the specification of the number of iterations that will be executed during a simulation. During each iteration, all distribution functions are sampled. Sample values are placed in the worksheet formulation, and the worksheet is recalculated. Values for the designated output fields are saved in an output data set. In *@RISK*, stable results probably need 300 to 500 iterations (*@RISK* 1994). For this analysis, simulations were set at 1000 iterations since all revenue and cost components of the net payoff calculation converged at this level during the base case analysis.

The preferred sampling type is also specified under the simulation settings icon as either the Monte Carlo or Latin Hypercube method. The Monte Carlo sampling technique selects stratified sampling through an entirely random process. Input distributions are recreated through sampling. Potential problems with this technique may surface when there are too few iterations or a small likelihood of occurrence exists for an event. Ranges of possible values may not be represented in the distribution. The Latin Hypercube sampling technique selects standard Monte Carlo sampling within established ranges. Samples are forced from equal intervals on the cumulative probability scale. This method employs "sampling without" replacement and forces consideration of outlying events. *@RISK* (1994) recommends the Latin Hypercube method unless Monte Carlo simulation is explicitly needed. The Latin Hypercube sampling technique was selected for this model for these reasons.

A random number generator seed option is also under the simulation settings icon. This option permits the entry of a seed value for the random number generator so that the exact sequence of random numbers will be applied across all simulations. This function is important in controlling the simulation environment to analyze the impact of parameter changes. A seed of 1000 was set in the model.

Simulation Outputs

@RISK provides statistics and data reports for both input and output variables. The statistics report displays the mean, minimum, maximum, standard deviation, and percentiles. The data report provides input and output calculations for each iteration conducted during the simulation. *@RISK* also provides a sensitivity feature which identifies the most influential inputs in the model. Sensitivities are calculated using either regression analysis or rank correlations. Scenario analyzes are also performed on target variables. This process identifies the inputs within the simulation data set which meet the target value and are significant. In addition, *@RISK* provides graphing capabilities which summarize the input and output data collections.

APPENDIX II
SENSITIVITY OF SELECTED PARAMETERS ON SHIPPING STRATEGIES

The effect of forward/spot delivery, carrying cost, general tariff service reliability, G^S premium level, and G^L premium level are evaluated using sensitivity analysis. Fifty percent increases and decreases are introduced to present the relationship between changes in these parameter values and their impact on the expected value of Annual Net Payoff and the standard deviation across various shipping strategies. G^S Intensive (0-G^L), G^S Mixed (2-G^L), G^L Mixed (4-G^L), and G^L Intensive (6-G^L) strategies are evaluated with respect to changes in key elements of uncertainty in this section.

G^S Intensive Strategy

Expected Value. The G^S Intensive Strategy is defined as the 0-G^L mix on the spectrum of shipping strategies. Under this shipping strategy, the country elevator relies solely on the G^S market and the random general tariff allocation mechanism. In the base case, this strategy had the highest E(ANP) value of $582,085. Relative sensitivity analysis[19] revealed that the expected value of Annual Net Payoff (E(ANP)) was most sensitive to general tariff service reliability and G^S premium levels. Figure 14 illustrates the impact that 50 percent changes in the model parameters have on the expected value of annual net payoff.

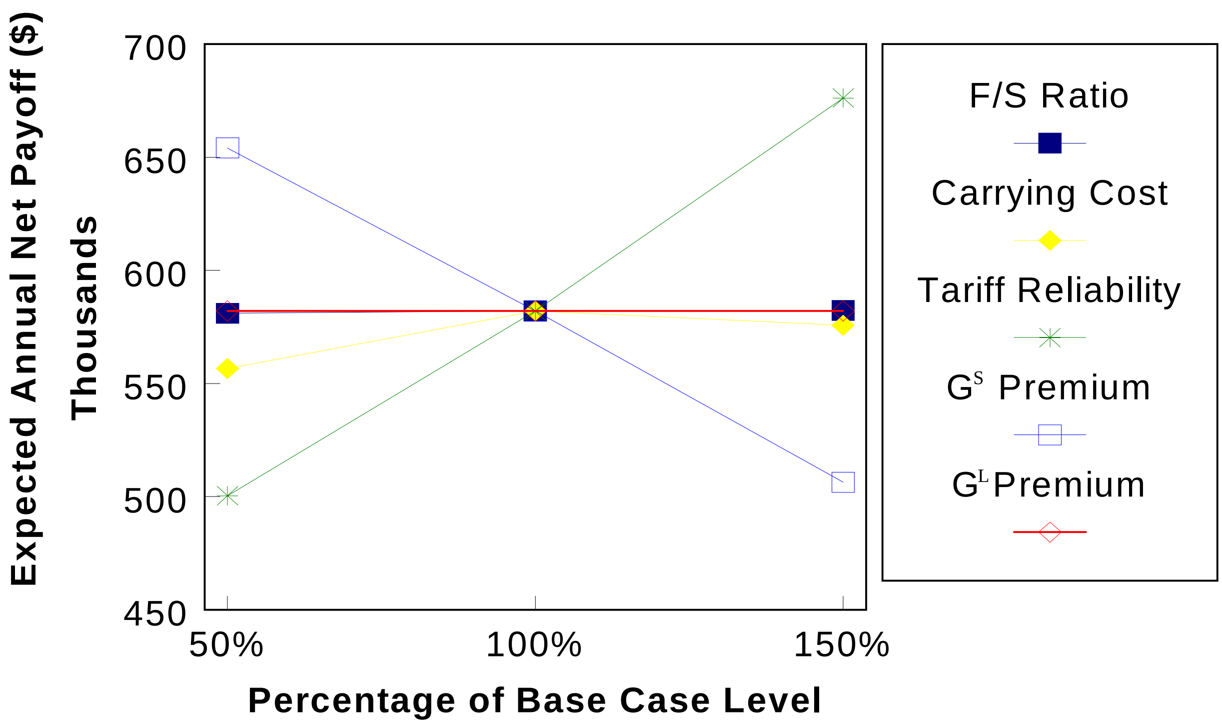

Figure 14. Sensitivity of Expected Annual Net Payoff to Changes in the Parameter Values for the G^S Intensive Strategy.

[19] "Relative sensitivity analysis" refers to the response of E(ANP) to equal percentage changes in the given problem element parameters being evaluated.

Changes in general tariff service reliability exhibited a positive relationship with E(ANP). A 50 percent increase (decease) in the service reliability of general tariff cars results in a $94,090 increase ($81,670 decrease) in E(ANP) due to the increased (decreased) shipments made by general tariff and decreased (increased) in premiums paid for G^S. This relationship suggests that the random nature of general tariff allocations has a significant influence on the G^S Intensive strategy.

G^S premiums have a negative relationship with E(ANP). A 50 percent increase (decrease) in the G^S premiums results in a $75,670 decrease ($72,030 increase) in E(ANP). For simplification, the model assumed that all G^S were purchased on the primary market. However, changes in G^S market conditions may significantly influence country elevator margins. Primary market G^S's can be purchased as far out as six months before the shipping period. Deferring purchases and relying on secondary markets with shorter windows could result in significantly higher premiums. Conversely, over-committing to primary market G^S could result in the payment of higher premiums than necessary.

The forward/spot delivery ratios have relatively little impact on expected payoff levels. E(ANP) remained virtually fixed. This suggests that the flexibility of this strategy is able to withstand changes in the uncertainty of grain deliveries within the range of analysis.

Carrying cost changes result in lower expected payoffs. The 50 percent increase in the carrying charge resulted in a marginal $6,390 decrease in E(ANP), while a decrease resulted in a $25,460 decrease in the base case payoff level. This counter-intuitive relationship with carrying cost decreases is due to the more volatile nature of shipping demand that results from lower carrying costs. Lower carrying costs result in higher volumes of inventories and also higher total annual carrying costs.

The G^S Intensive strategy does not use the G^L instrument. For this reason, G^L premiums had no impact on the E(ANP).

<u>Standard Deviation.</u> The standard deviation of E(ANP) for the base case level was $2,209,116. For the G^S Intensive Strategy, the standard deviation of E(ANP) was most responsive to the forward/spot delivery ratio. Simulation results indicate that higher levels of forward commitment, for a shipper in this environment, leads to lower levels of uncertainty in the expected payoff value. A 50 percent increase (decrease) in the base case forward delivery percentage resulted in a $186,640 decrease ($206,740 increase) in the standard deviation of E(ANP). Carrying cost, general tariff service reliability, and G^S premiums were less influential on the standard deviation of E(ANP). Again, G^L premiums had no impact on this strategy. Figure 15 illustrates the impact that these elements have on the standard deviation of E(ANP).

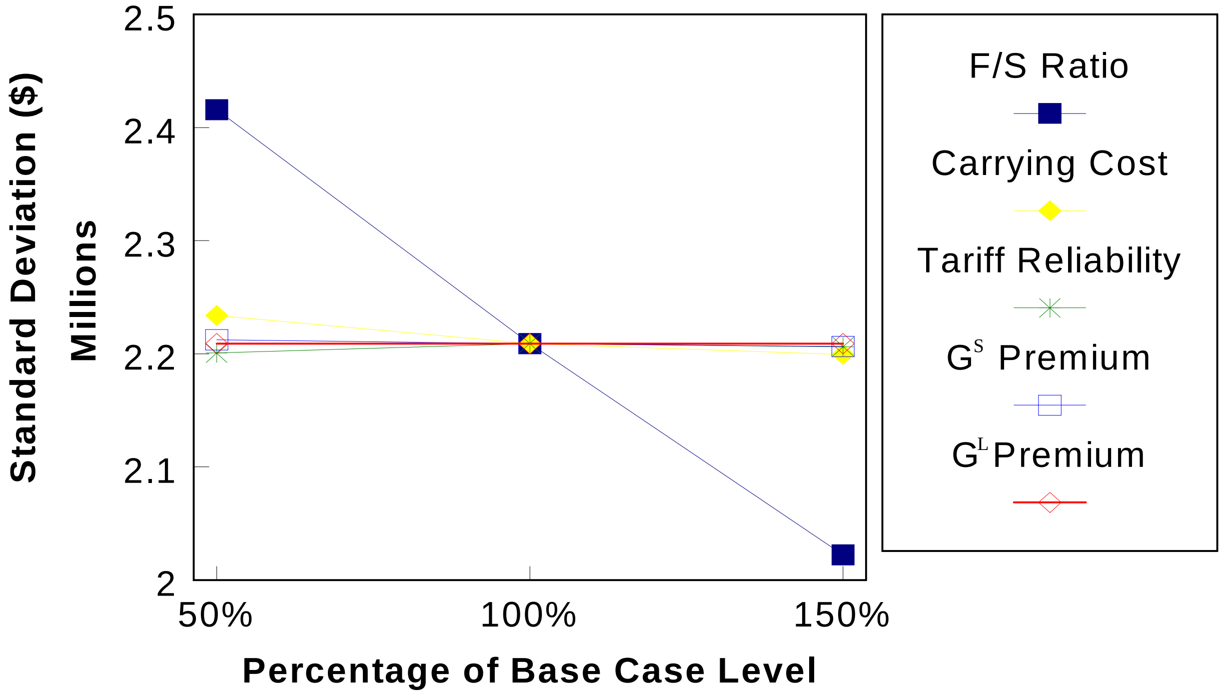

Figure 15. Sensitivity of the Expected Annual Net Payoff Standard Deviation to Changes in the Parameter Values for the G^S Intensive Strategy.

G^S Mix Strategy

Expected Value. The G^S Mix strategy is defined as the 2-G^L mix on the spectrum of shipping strategies described in the discussion of the base case. Under this strategy, the shipper takes a 2-G^L position and relies on the G^S market and the general tariff allocation mechanism to fill any other residual shipping demand. Initially, the G^S Mix strategy had an E(ANP) value of $419,455 in the base case. Relative sensitivity analyzes revealed that the expected value of Annual Net Payoff (E(ANP)) for the G^S Mix strategy was most sensitive to general tariff service reliability and G^S premium levels. Figure 16 illustrates the effect that 50 percent changes in the model's parameter values have on the expected value of annual net payoff.

General tariff service reliability exhibits a positive relationship with E(ANP). A 50 percent increase (decrease) in the reliability of general tariff cars resulted in a $92,580 increase ($80,840 decrease) in E(ANP). These values are relatively close to the G^S Intensive strategy. This relationship suggests that the random nature of general tariff cars also has a relatively significant influence on the G^S Mix strategy. However, increases in reliability have a 15 percent greater influence on E(ANP) than do decreases.

Like the G^S Intensive strategy, G^S premiums display an inverse relationship with E(ANP). A 50 percent increase (decrease) in the G^S premiums resulted in a $50,600 decrease ($47,430 increase) in E(ANP). This was a $25,000 decrease in the responsiveness from the G^S Intensive strategy. G^S market conditions have lower relative influence on the G^S Mix strategy than does the G^S Intensive strategy.

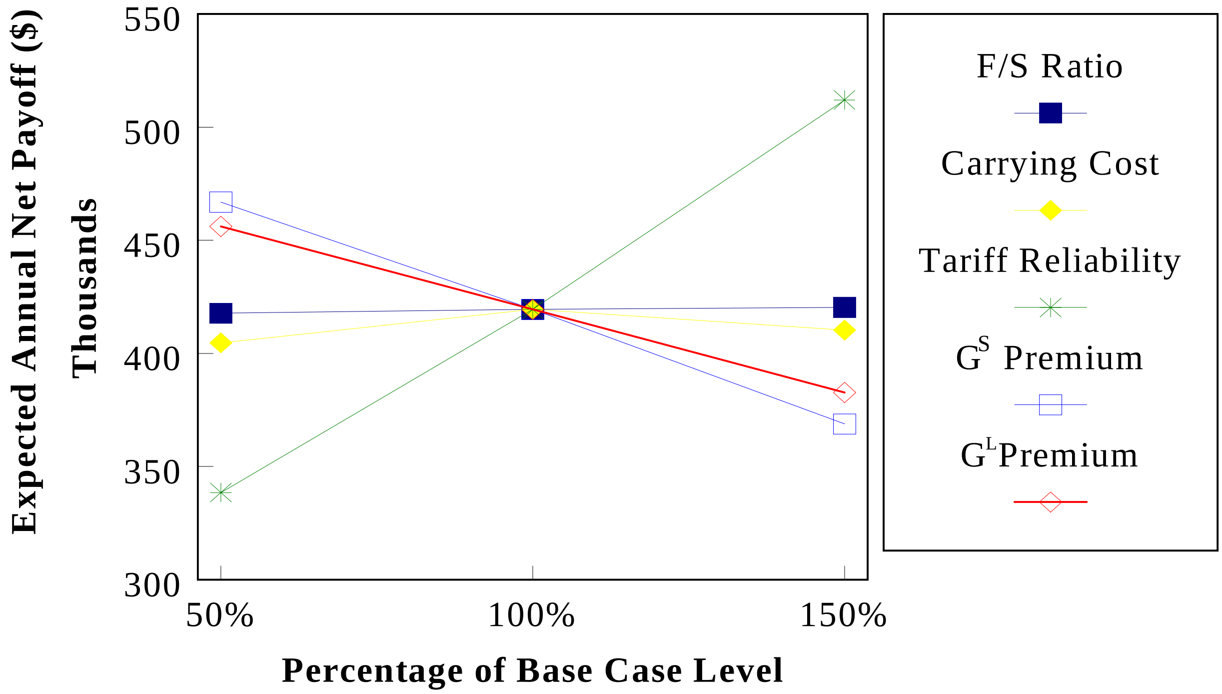

Figure 16. Sensitivity of the Expected Annual Net Payoff to Changes in the Parameter Values for the G^S Mix Strategy.

G^L premiums also have an inverse relationship with the E(ANP). A 50 percent increase (decrease) in the G^S premiums resulted in a $36,680 decrease ($36,670 increase) in E(ANP).

Forward/spot delivery ratios has relatively little impact on expected payoff levels, as E(ANP) remained virtually fixed at $24 million. This relationship suggests that a monthly G^S strategy adds flexibility and is able to withstand changes in the uncertainty of grain deliveries.

Carrying cost changes result in lower expected payoffs. A 50 percent increase in the carrying charge resulted in a $9,080 decrease in E(ANP), while a 50 percent decrease resulted in a $14,720 decrease in the base case payoff level. This relationship is likely a result of the greater deferment in shipping demand that results in the holding of greater inventory levels. Further increases in deferred shipping demand tend to be limited by grain stocks and storage capacity. Decreases in shipping demand that result from higher carrying costs are also limited by grain positions. The G^S Mixed strategy was less responsive to changes in the carrying cost than the G^S Intensive strategy.

Standard Deviation. The standard deviation of E(ANP) for the G^S Mix strategy was most responsive to the forward/spot delivery ratio. Initially, the standard deviation of the base case was $1,989,782. A 50 percent increase (decrease) in the base case forward delivery percentage resulted in over a $213,358 decrease ($232,445 increase) in the standard deviation of E(ANP). These findings suggest that greater levels of forward delivery commitments with the G^S Mix result in lower Annual Net Payoff risk. Carrying cost, general tariff service reliability, and G^S premiums were less influential on the standard deviation of E(ANP). G^L premiums had no impact on risk. Figure 17 illustrates the impact that these elements have on the standard deviation of E(ANP). The results are similar to the G^S Intensive strategy.

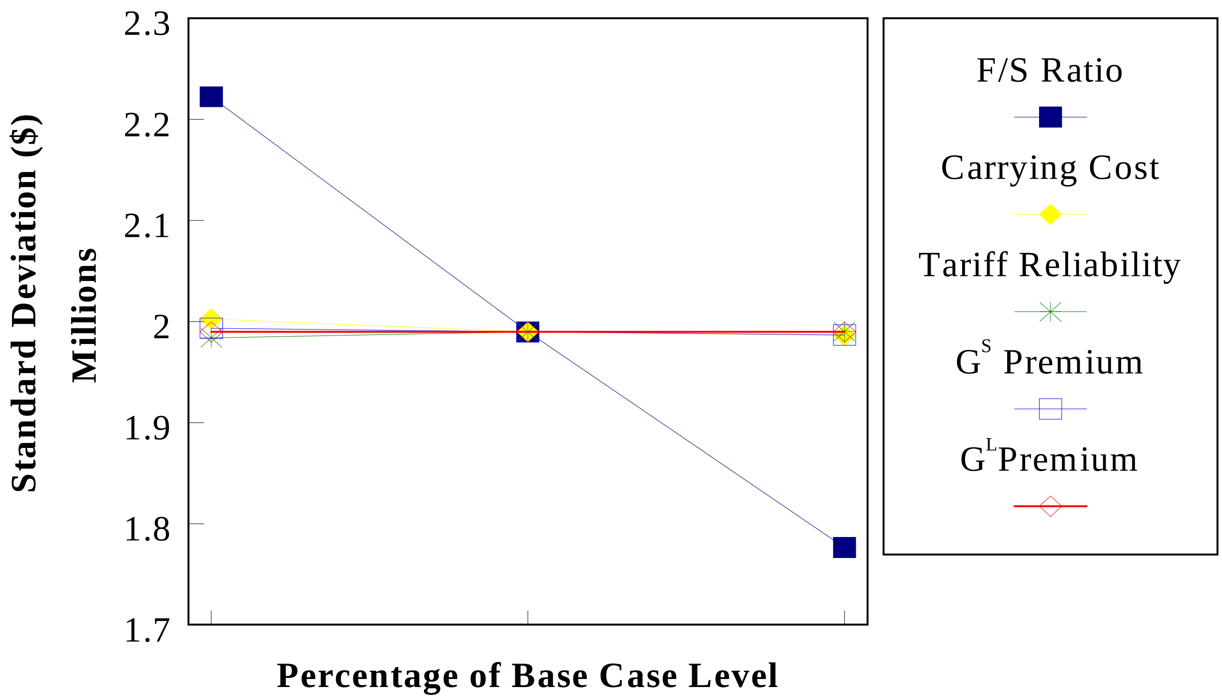

Figure 17. Sensitivity of the Expected Annual Net Payoff Standard Deviation to Changes in Parameter Values for the G^S Mix Strategy.

G^L Mix Strategy

Expected Value. The G^L Mix strategy is defined as the 4-G^L level of forward commitment. The country elevator takes a 4-G^L position and relies on general tariff and G^Ss for any residual monthly shipping demand that exceeded this position. Initially, the G^L Mix strategy had an E(ANP) value of $254,275 in the base case. Simulation results reveal that Expected Annual Net Payoff (E(ANP)) is most sensitive to G^L premium levels and general tariff service reliability under the G^L Mix shipping strategy. A 50 percent increase (decrease) in the G^L premium level results in a $73,350 decrease ($73,340 increase) in E(ANP). Conversely, a 50 percent increase (decrease) in the reliability of general tariff cars results in a $68,480 increase ($70,060 decrease) in E(ANP). Carrying cost and forward/spot deliveries had less influence on E(ANP). Figure 18 present the relationships between changes in the parameter values and E(ANP).

Standard Deviation. Under the G^L Mix, the standard deviation of E(ANP) is most responsive to the forward/spot delivery ratio. The base case level had a standard deviation of $1,835,187. This strategy was the closest to the minimum risk level in the base case analysis. A 50 percent increase (decrease) in the base case forward delivery percentage results in a $237,953 decrease ($258,638 increase) in the standard deviation of E(ANP). Carrying cost, general tariff service reliability, and G^S premiums were less influential on the standard deviation of E(ANP). G^L premiums also had no impact on risk. These findings are consistent with the other evaluated shipping strategies. Figure 19 illustrates the relationship between the model's parameter values and the E(ANP) risk.

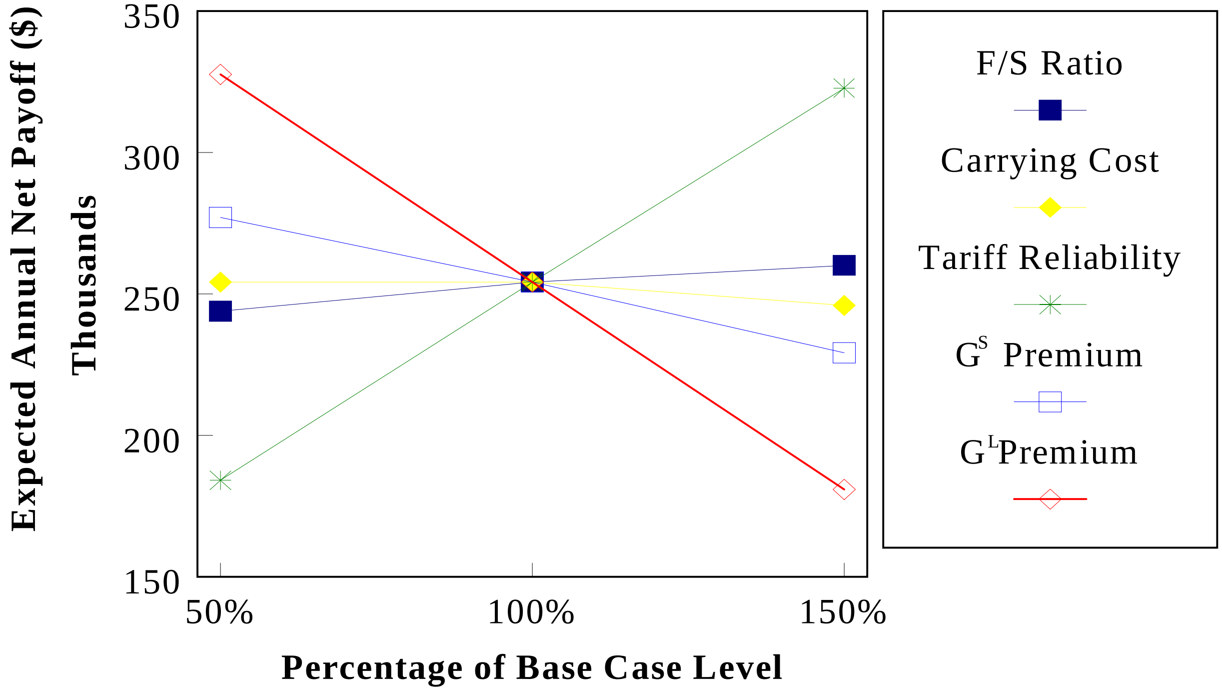

Figure 18. Sensitivity of Expected Annual Net Payoff to Changes in the Parameter Values for the G^L Mix Strategy.

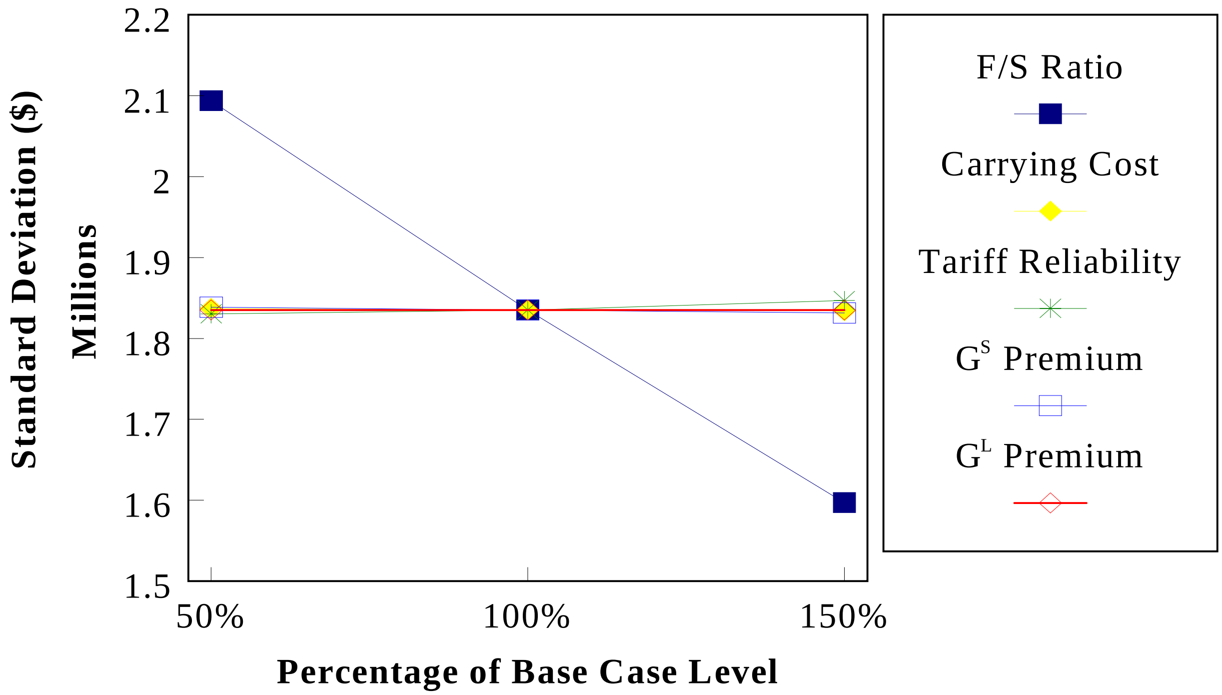

Figure 19. Sensitivity of the Expected Annual Net Payoff Standard Deviation to Changes in the Parameter Values for the G^L Mix Strategy.

G^L *Intensive Strategy*

Expected Value. The G^L Intensive strategy is defined as the 6 G^L shipping position in the base case. Under this strategy, the country elevator is assumed to have engaged in contracted deliveries of six 26-car unit trains per month. Residual shipping demand, if present, is filled with general tariff receipts and G^S. In the base case analysis, this strategy has the lowest E(ANP) level of - $248,335. This is due to the swings in shipping demand and high shipper cancellation penalties. Sensitivities revealed that G^L premiums had the greatest impact on E(ANP) for the G^L Intensive strategy. A 50 percent increase (decrease) in G^L premiums results in a $110,020 decrease (increase) in E(ANP).

The analysis suggests also that E(ANP) is influenced by the reliability of general tariff services and forward contracted delivery levels. A 50 percent increase (decrease) in general tariff service reliability results in a $77,290 decrease ($71,540 increase) in E(ANP). This inverse relationship with general tariff service reliability is due to the increase in shipper cancellation penalties. A 50 percent increase (decrease) in the base case level of forward contracted deliveries results in a $29,330 increase ($25,770 decrease) in E(ANP). The sensitivity of changes in forward delivery levels increases as the number of G^Ls increases. Figure 20 presents the results from this analysis on the G^L Intensive strategy.

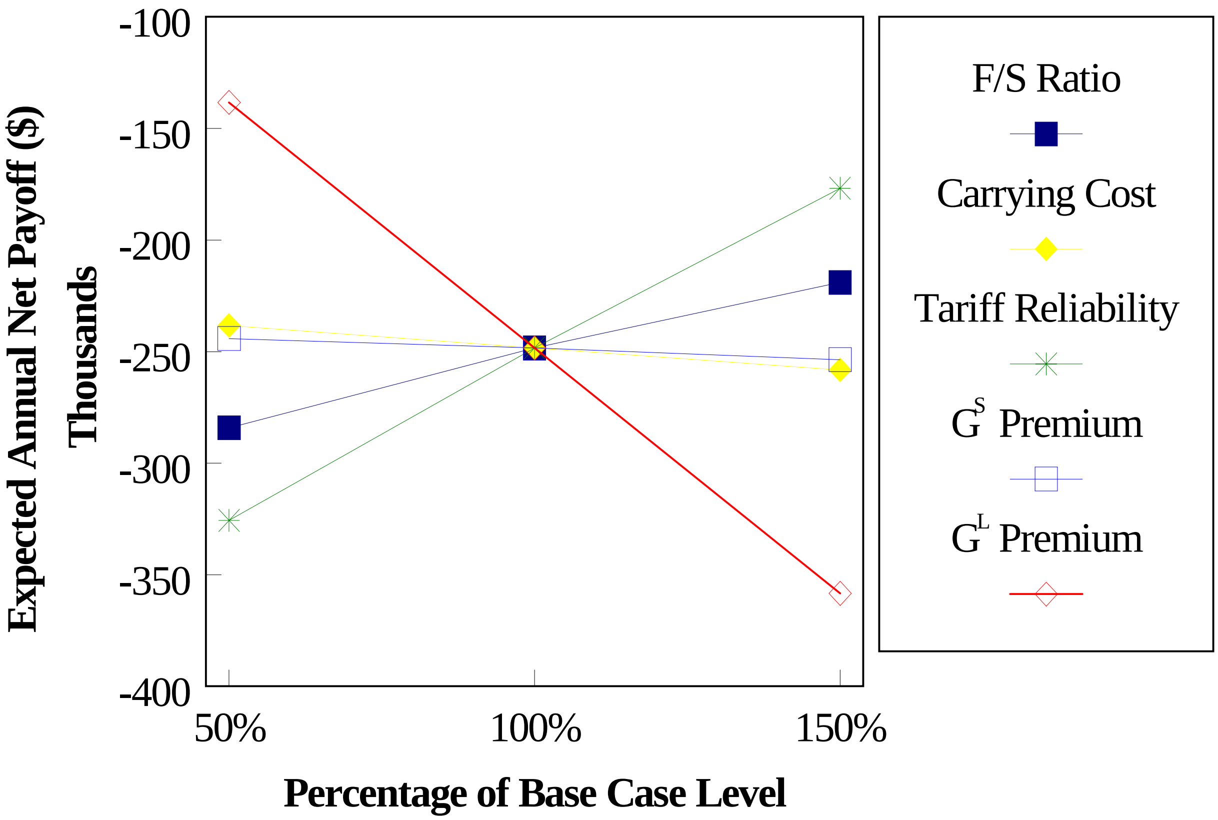

Figure 20. Sensitivity of Expected Annual Net Payoff to Changes in Parameter Values for the G^L Intensive Strategy.

Standard Deviation. Like the other cases, the standard deviation of E(ANP) for the G^L Intensive strategy is most responsive to the forward/spot delivery ratio. The base case standard deviation was $1,900,693. A 50 percent increase (decrease) in the base case forward delivery percentage for this strategy results in a $261,648 decrease ($278,231 increase) in the standard deviation of E(ANP). These findings suggest that greater levels of forward delivery commitments result in lower risk in Annual Net Payoff. The standard deviation of E(ANP) was relatively inelastic to carrying cost, general tariff service reliability, and G^S premiums. G^L premiums had no impact on the standard deviation of E(ANP). Figure 21 illustrates the impact that these elements have on the standard deviation of E(ANP).

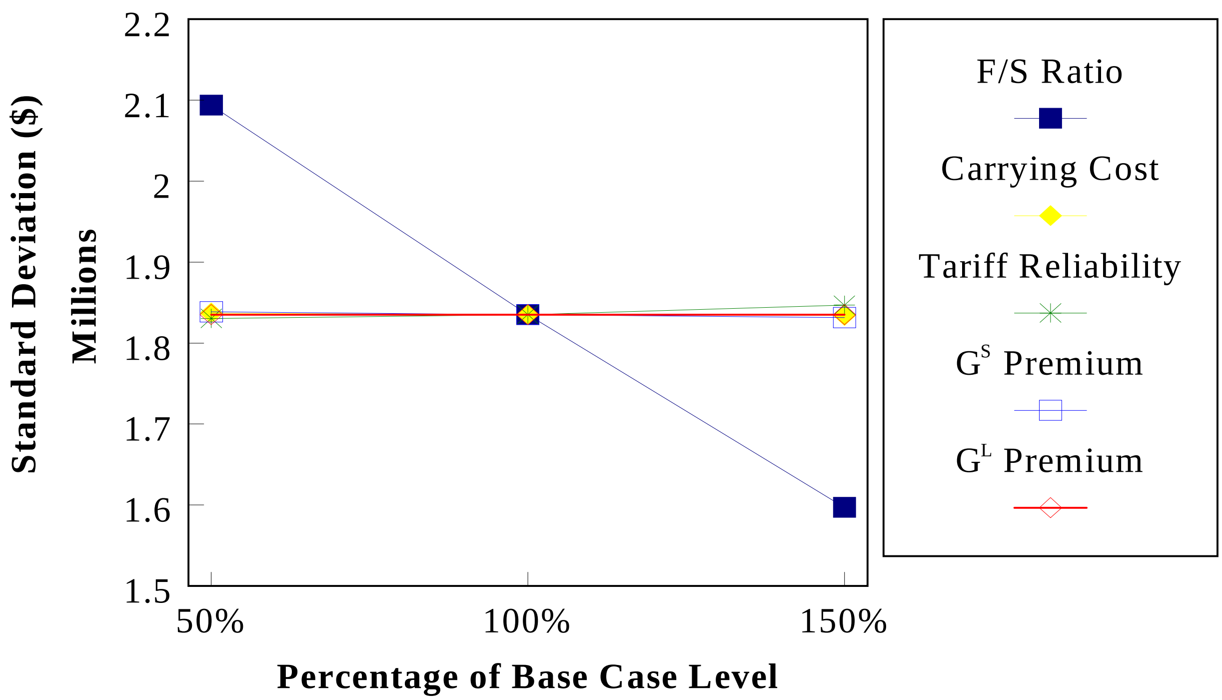

Figure 21. Sensitivity of the Expected Annual Net Payoff Standard Deviation to Changes in the Parameter Values for the G^L Mix Strategy.