FORWARD SHIPPING OPTIONS FOR GRAIN BY RAIL:
A STRATEGIC RISK ANALYSIS--SUMMARY
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Railcar allocation strategies have evolved dramatically since the 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 on 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 better logistics planning tools, but are challenged with the integration of grain merchandising and logistical decisions.

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 serve as cancellation penalties and discourage "phantom orders." The effect of these mechanisms are to segment shippers and cars allocated according to shipping priorities. Since then, CPRS, UP, CSX, and other major Class One rail lines have adopted certain features of auction-based rate and car guarantee programs. Transferability of these instruments provide 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 rail carrier in return for a negotiated fee and a number of guaranteed trips per month. Examples of longer term guarantees include the BN SWAP and CPRS GEEPs programs. These rail equipment supply packages generally consist of an annual contract for a monthly number of guaranteed car placements. These programs also have cancellation penalties for carrier and shipper non-performance. Shippers participating in these 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. Each has various penalties for cancellation and payments 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.

The report provides a summary of an extended study that analyzed grain shipping and merchandising strategies integrating 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

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

varying degrees of forward commitment and

their relationships with key elements of planning uncertainty for a model of a typical North Dakota grain shipper.[2]

MODEL DESCRIPTION

A dynamic stochastic simulation model was developed based on inventory management, transportation choice, and scheduling theory. 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 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 chooses strategies to maximize the expected net payoff each month by shipping in the month and market with the highest net payoff. 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.

Data: Sources and Behavior

Extensive data on basis values, farmer sales patterns, shipping costs and premiums and placement probabilities for different forward transportation mechanisms were assembled and analyzed as part of this project. Some of them are presented below.[3] The model was calibrated using values and market conditions in April 1996.

Estimates of grain purchases were derived to reflect a typical single origin shipper in North Dakota. Estimates for forward and spot purchases and beginning/ending stocks were derived from several sources as described below (Figure 1).
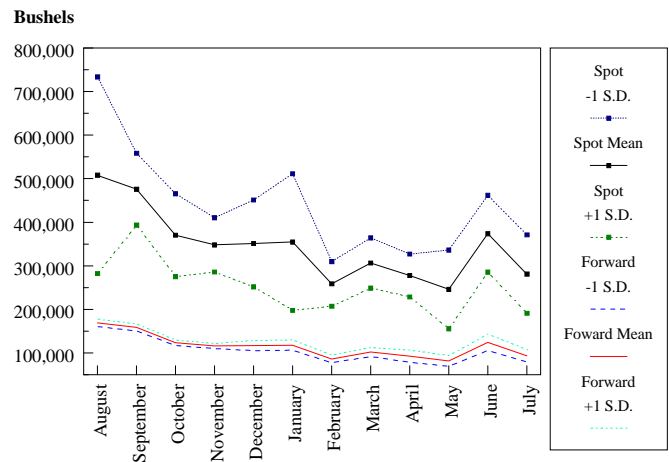

Figure 1. Estimate levels of forward contracted and spot deliveries to elevator..

Monthly purchases consist 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. 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.

Shipping Costs

Shipping costs were comprised of several elements. Burlington Northern 26-car tariff rate levels from Devils Lake, ND, to Minneapolis (MPLS) and Pacific Northwest (PNW) markets were used as of April 1, 1996 (Burlington Northern Tariff ICC-BN-4022 I).

Grain shippers face tariff rate uncertainty in addition to car placement uncertainty when making forward rail transportation plans. While longer-term guarantees, G^L, have tariff rate

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

[3]Greater detail is available in Priewe and Wilson (1997a).

uncertainty, use of shorter term guarantees, G^S, have both tariff rate (prior to bidding) 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.

Average monthly BN COTs values for 1993-95 were used to estimate distribution parameters for Short-term Guarantees (G^S)
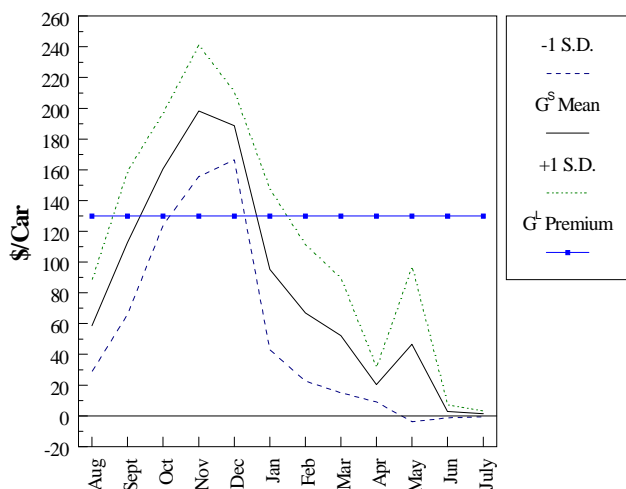

Figure 2. Short-term and Long-term Guarantee premiums (discounts).

(Figure 2). Average monthly COT premiums for 1995 were used in the base case to more accurately reflect the market situation for Spring 1996. 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 premium uncertainties in the model. All G^S are assumed to be purchased through the primary market.

Long-term Guarantees (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 2). These premiums are fixed, but the rate level is subject to the tariff rate at the time of shipment.

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.

Service Reliability Under Guaranteed Service Options. Service parameters for Short-term and Long-term Guarantees were established 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. Both sources noted a slightly greater likelihood of car placement for G^S over G^L due to the carrier performance incentives associated with the G^S instrument. Figure 3 shows these probabilities.
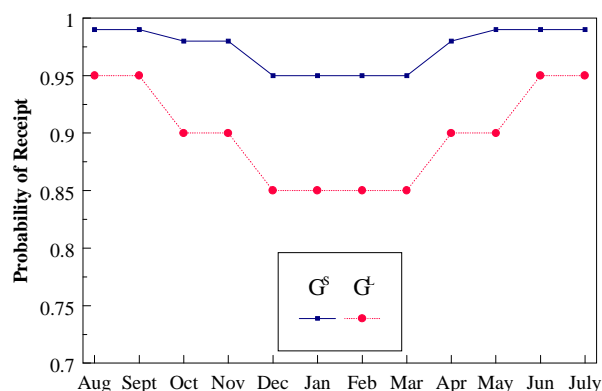

Figure 3. Shipper trade-offs for alternative rail strategies.

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

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cars under this option.

Shipping Demand

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

When there is a carry in the market $((P_{t+1} - P_t) > (i + E(\triangle S)))$ 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 intermonth 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 through the allocation process. Varying levels of long-term commitments (G^L) were evaluated as a strategic decisions. Any monthly shipping demand not met with G^L and general tariff cars are filled with short-term guarantees (G^S). Alternative shipping strategies considered in the analysis are presented in Table 1.

SIMULATION SCENARIOS AND RESULTS

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-

Table 1. Shipping strategies

| | G^L | | | |
Strategy	Trains/Month	% of Annual Volume Under G^L **	General Tariff	G^S
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.

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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 expected payoff decreases at an increasing rate. The maximum expected payoff was $582,085 with a shipping strategy of zero G^Ls (i.e., G^S Intensive). 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 expected payoff declines to $(248,335) with a G^L strategy of six unit trains per month. Results indicate a $541,880 reduction in total revenues on grain sales going from the payoff maximizing strategy to 100 percent coverage with longer-term guarantees. Total revenues on grain sales are affected by grain prices and the quantity shipped in a given month.

The relationship between payoff 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 4 illustrates the monthly shipping patterns in G^S and G^L
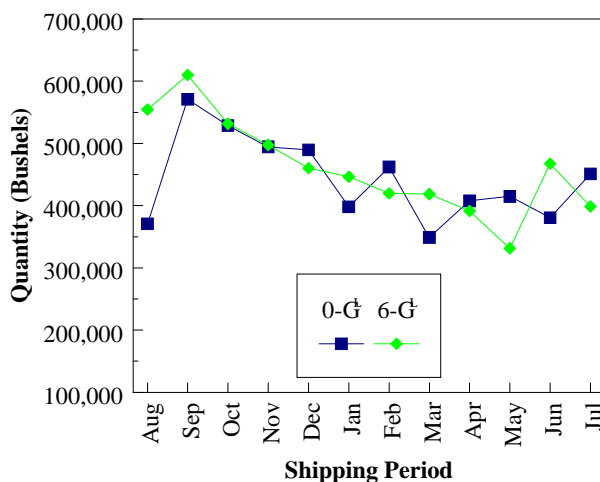
Figure 4. Relationship between shipping strategy and monthly shipments.

Intensive strategies. As illustrated, strategies using more G^L smooth out monthly shipments.

A second factor is that Shipper Cancellation Penalties (SCP) 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 5). Uncertainties in the level of grain supplies
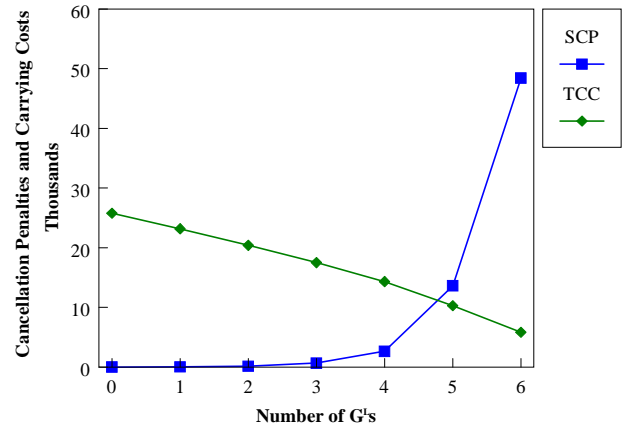
Figure 5. Relationship among Shipper Cancellation Penalties (SCP), Total Carrying Cost (TCC), and shipping strategy.

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.

Trade-offs between expected payoffs and risk are illustrated in Figure 6. 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
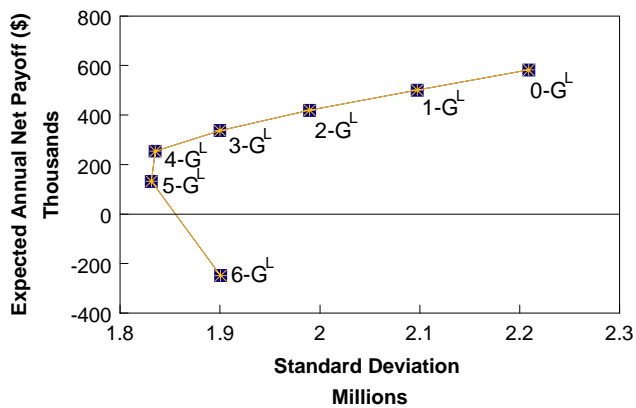
Figure 6. Shipper trade-offs for alternative rail strategies.

covered using 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, 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 and 4) carrying cost. A summary of results from sensitivity analyzes on key elements is presented. The effects of these variables on E(ANP) and risks are discussed with respect to the G^L and G^S Intensive strategy.

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). 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 adopts 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 payoffs and lower risk. Forward purchases 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 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. 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.

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.

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

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marketing participants are confronted with three logistical options: general tariff, short-term guarantees, and long-term guarantees. 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) strategies, the Payoff 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 Payoff. Such changes in the level of forward contracts, however, only affected Payoff 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. In any period, shippers must develop forward strategies that integrate grain trading and logistics strategies. Shippers need to make projections of future car requirements based on past trends in grain movements and projected market conditions. Coordination of expected grain purchases, sales, and shipping requirements results in increased profits and reduced risk. Grain shippers also need to accurately assess general tariff service

reliability when developing forward logistical strategies. In doing so, managers must integrate grain marketing and transportation decision planning. 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, a logistics strategy based on 100 percent shipping with general tariff allocation 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. Shipping strategies with 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.[3] 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.

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[3]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.

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 provide an assurance which reduces 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. 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.

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