Export/Import Risks at Alternative Stages of U.S. Grain Export Trade

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INTRODUCTION

U.S. grain shipments often involve long distances and several changes in ownership. Consequently, the price risk facing merchandisers presumably varies depending on location within the marketing channel and the effects of such factors as transportation, exchange rates, and local supply/demand. The general objective of this analysis is to measure the level and hedgeability of grain-price risk facing exporters as well as importers at different stages of the marketing process.

Results of a survey conducted by the United States Department of Agriculture [Caron (1985)] indicate that the largest "exporting" risk perceived by U.S. grain merchandisers is caused by changes in the flat price of grain. The largest "logistical" risk is associated with ocean charters. However, many questions arise from this type of survey response. For example, how does flat-price risk at export ports differ from that at inland locations or at import locations in terms of level and hedgeability? What is the effect of ocean charters on grain-price risk? To what extent can freight futures and exchange-rate futures be used to mitigate the risk facing exporters or importers? These types of questions are addressed here.

The specific objectives of the study are: (1) to measure the price uncertainty perceived by exporters and importers of corn and soybeans at different locations within the marketing channel between Illinois and Rotterdam; (2) to distinguish the level and factors underlying the uncertainty facing exporters versus importers; and (3) to estimate the extent to which the uncertainty can be reduced through small portfolio diversification, and consequently, to estimate the "effectiveness" of grain, exchange-rate, and ocean-freight futures to exporters and importers at different locations.

Numerous studies have focused on price risk associated with agricultural export/import markets. The use of U.S. futures markets by foreign countries to abate commodity price risk has been the focus of many analyses [e.g., Ouattara, Schroeder, and Sorenson (1990); Thompson (1985)]. Others have emphasized the measurement and abatement of exchange rate risk facing offshore exporters and importers [e.g., Braga and Martin

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(1990); Thompson and Bond (1987)]. Recently, Braga and Martin (1991) examined the potential to hedge the European Community's variable levy risk associated with corn and wheat.

The focus of the present analysis is on price-risk change in the corn and soybean export marketing channel caused by spatial differences. Price uncertainty is measured here as a function of the difference between expected and realized outcomes. Uncertainty is estimated under different assumptions about the portfolio of commodity and futures instruments. In general, the results indicate that the price uncertainty caused by the transoceanic shipments is difficult to abate, and that the risk structure implies a strong incentive for sales between importers and exporters to occur at the export port as opposed to inland locations or import ports. It is suggested that the need for price-spread futures of export–import grain prices be considered.

The methodology and data are described in the next two sections. The results are then discussed, and the final section offers some concluding remarks.

PROCEDURE

Corn and soybean shipments from Illinois to Rotterdam during 1981–1989 are considered. It is assumed that the exporter can sell grain at either Illinois, the Gulf, or Rotterdam. The sources of price uncertainty facing the exporter at each location are:

Location	Source of Price Uncertainty
Illinois	Illinois grain price
Gulf	Gulf price, barge rate
Rotterdam	Rotterdam price, barge rate, ocean-vessel rate

Price uncertainty facing the exporter who sells in Illinois is associated only with the future Illinois price. At the port stage (Gulf), the uncertainty is measured as a function of future Gulf price and the cost of transporting grain from Illinois to the Gulf (barge rate). Likewise, at the import site, the uncertainty is associated with the Rotterdam price and transport costs.

The importer's purchasing scenarios are defined as:

Location	Source of Price Uncertainty
Illinois	Illinois price, barge rate, ocean rate, exchange rate
Gulf	Gulf price, ocean rate, exchange rate
Rotterdam	Rotterdam price, exchange rate

The importer must pay the location's grain price plus transportation costs. All payments are made in U.S. dollars, meaning that the importer also faces exchange rate uncertainty.

Two time periods are considered: January, 1981 to June, 1985 and July, 1985 to December, 1989. The nine years of 1981–1989 are divided into the two 4.5-year periods because trading of ocean-freight futures at the Baltic International Freight Futures Exchange (BIFFEX) in London began on May 1, 1985.

Uncertainty Estimates

Uncertainty is defined here as the variance (or standard deviation) of the difference between expected and realized outcomes.[1] For a given commodity (c), location (l), time period (i), hedging scenario (h), and transaction period (t), the price uncertainty can be described as:

$$\mathrm{VAR}(P_{cliht} - {}_{t-1}E[P_{cliht}]) \tag{1}$$

where VAR is the variance operator, P is the realized outcome; $c = 1,2$; $l = 1,2,3$; $i = 1,2$; $h = 1,2,\ldots,n$, where n depends on values of l and i; $t = 1,2,\ldots,27$ for $i = 1(1981–1985)$ and $t = 1,2,\ldots,28$ for $i = 2(1985–1989)$; and ${}_{t-1}E[P_{cliht}]$ is the expectation of P_{cliht} at time $t - 1$. Realized and expected outcomes are estimated in eight-week intervals (transaction periods) to account for the approximate time it takes to transport grain from interior U.S. to Europe; i.e., about six observations per year.

For the *exporter,* the *unhedged* price outcome (P_t) for a given commodity at each location is calculated as:

$$\text{Illinois:}\quad P_t = IL_t \tag{2}$$

$$\text{Gulf:}\quad P_t = GF_t - BR_t \tag{3}$$

$$\text{Rotterdam:}\quad P_t = RT_t - OC_t - BR_t \tag{4}$$

where IL is the commodity price in Illinois; GF is the commodity price at the export port (Gulf); BR is the barge rate of transportation for grain shipments from Illinois to the Gulf; RT is the commodity price at Rotterdam; and OC is the ocean rate for the Gulf-to-Rotterdam shipment. All prices and rates are in U.S. cents per cwt.

The outcomes estimated by eqs. (2)–(4) represent a "net price" received by an "exporter" who originates the commodity in Illinois and sells the commodity at either the origination point [eq. (2)], the Gulf [eq. (3)], or Rotterdam [eq. (4)]. This net price clearly does not include all costs. For example, handling costs and the trucking cost from the Illinois elevator to the river are not included. These other costs, however, are presumably close to constant (or deterministic) over an eight-week period and therefore add little uncertainty.

The *hedged* price outcome for the *exporter* is:

$$HP_t = P_t + b_1(F_{t-1} - F_t) + b_2(O_{t-1} - O_t) \tag{5}$$

where P_t is defined by either (2), (3), or (4); HP_t is the realized outcome when other instruments (futures contracts) are used to form a small portfolio; F_t is the commodity futures price at time t; O_t is the ocean freight futures price; and b_1 and b_2 are the number of short positions per cash position (hedge ratio) held in commodity futures and ocean futures, respectively. When the selling location is Illinois or the Gulf, $b_2 = 0$. Other values of b_1 and b_2 are defined later.

[1]A reviewer correctly noted that, because of the higher price levels for soybeans versus corn, percentage deviations may be a more appropriate measure. This is true but other considerations such as the distribution of the deviations (e.g., normal versus lognormal) and the focus of study are important. This study is concerned with a short-hedge transportation situation. The handling and transportation costs for soybeans are usually the same as those for corn and thus risk caused by spatial differences are based on similar cost levels. Moreover, based on past experiences with these types of measures, the use of percentage deviations would have little impact on the qualitative results and conclusions.

For the *importer,* the *unhedged* price outcome at each location is:

$$\text{Rotterdam: } IP_t = RT_t * SE_t \tag{6}$$

$$\text{Gulf: } IP_t = (GF_t + OC_t)SE_t \tag{7}$$

$$\text{Illinois: } IP_t = (IL_t + BR_t + OC_t)SE_t \tag{8}$$

where SE_t is the exchange rate in Deutsche marks (DM) per U.S. dollar, and the price outcome, IP_t, is in DM units. It is assumed that the importer can receive the commodity at either Rotterdam [eq. (6)], the Gulf [eq. (7)], or Illinois [eq. (8)].

The *hedged* price outcome for the *importer* is:

$$\begin{aligned} IHP_t = {} & IP_t + b_1(F_{t-1} - F_t)SE_t + b_2(O_{t-1} - O_t)SE_t \\ & + b_3(E_{t-1} - E_t)_{t-1}E[IP_t]/E_{t-1} \end{aligned} \tag{9}$$

where IP_t is defined by either (6), (7), or (8); and E_t is the exchange rate futures in DM/$. The last term in (9) contains ${}_{t-1}E[P_t]/E_{t-1}$, which determines the number of dollars hedged under a full hedge (i.e., when $b_3 = 1$).

Expectation Estimates

The measurement of uncertainty [eq. (1)] requires expectations of (2)–(9). For (2)–(4), the expectation of P_t is estimated as the sum of the expected values of each term on the right hand side. The expectation of (4), for example, is the expected (forecasted) Rotterdam price minus the expected ocean rate minus the expected barge rate.

One general procedure is used to estimate the expectation of commodity prices at each location, exchange rate, and ocean rate. This approach is based on price spreads between futures contracts. Price spreads reflect the market's estimate of the equilibrium return for holding a long position in the underlying cash good or service. Therefore, under the assumption of unbiased futures, the futures spread provides a market estimate of the expected change in spot price.

The expected change in spot price used here is based on the nearby and next nearby futures prices. At time t, the annualized rate of return (r) implied by the next nearby price minus the nearby price is calculated. The expected spot price for time $t + 1$ is then found by

$${}_tE[S_{t+1}] = S_t e^{rd}$$

where S_t is the spot price at time t; e is the exponential function; and d is 56/365, the annualized time between t and $t + 1$.

Although a futures market does not exist for barge freight, a similar procedure to that described above is used to estimate expected barge rates by using information from the St. Louis Merchants Exchange Call Session for southbound barge-grain freight. Forward rates resolved at the Call Session also provide a market estimate of expected rate changes. Hauser and Buck (1989, p. 11) use this information to estimate the market's expectation of rate seasonality. The resulting seasonality indices are used here to find expected barge rates by adjusting the current barge rate forward according to the appropriate index.

Since trading in ocean-freight futures did not begin until mid-1985, the market's implied rate of change in ocean rates can not be calculated for the 1981–1985 period. Therefore, a naive expectation model is assumed for ocean rates for 1981–1985. That is, the ocean rate in period t is the expected rate for period $t + 1$.

The sum of individual variable expectations yields the expectation of (2), (3), or (4), representing the expectation of unhedged price. The expectation of (5) is the expectation of hedged price. It is assumed that the futures price is the agent's unbiased expectation of futures price; e.g., ${}_{t-1}E[F_t] = F_{t-1}$. Consequently, the expected hedged outcome corresponding to (2)–(4) is equal to the respective expected unhedged outcome. In other words, the expected net price of a particular hedged scenario is the same as the expected net price when not hedging.

Eqs. (6)–(8) include products of variables, and thus expectation estimates must consider covariances. It is assumed here that the exchange rate (SE_t) and other prices (*RT*, *GF*, *IL*, *BR*, *OC*) are independent. Therefore, expectations of (6)–(8) are found by simply inserting the expected values of each variable into the equations. The expected hedged price [eq. (9)] is again equal to the expected unhedged price.

Note that all expectations (except 1981–1985 ocean rates) are based on market signals; i.e., temporal bases determined by the market. This type of model is chosen for several reasons. First, the method provides a market-determined expectation which is more general than an individual researcher's econometric or time-series forecast. Second, the expectation can be easily observed and used by the hedger. Third, Hauser, Garcia, and Tumblin (1990) find that this market-signal model often performs as well as or better than regression models in predicting Illinois soybean bases.

Hedge Ratio Estimates

Hedge ratios (b_i values) for (5) and (9) are based on either a "full" hedge or an "optimal" hedge. Under full hedging, b_i is one. The optimal hedge ratio is based on Myers and Thompson's approach of first specifying futures and cash price determination processes, and then using the errors from these processes to estimate the variances needed to calculate the ratio.

The assumptions underlying the agent's expectation models are used also to specify the price determination models for cash and futures prices. Under the unbiased-futures assumption the general model is [Myers and Thompson (1989, p. 863)]:

$$p_t = X_{t-1}\alpha + u_t \tag{10}$$

$$f_t = f_{t-1} + v_t \tag{11}$$

where p_t is the cash price, f_t is futures price, u_t and v_t are serially uncorrelated errors, and X_{t-1} is a vector of variables which help predict p_t. The generalized optimal hedge ratio estimator is the OLS estimate of δ in:

$$p_t = \delta\Delta f_t + X_{t-1}\alpha + e_t \tag{12}$$

For the present analysis, (12) is estimated under the assumption that X_{t-1} is equal to the expected price outcome and that more than one type of futures instruments (commodity, ocean, and exchange) can be considered, depending on the scenario. For example, the OLS specification used to find optimal hedge ratios for soybean futures and ocean-rate futures for the exporter selling at Rotterdam is:

$$P_t = b_1\Delta F_t + b_2\Delta O_t + {}_{t-1}E[P_t]\alpha + e_t \tag{13}$$

where P_t is defined by (4), F_t is the soybean futures price, and O_t is the futures price for ocean freight.

The optimal ratios for the importer are found in the same fashion. For example, for the importer who buys at Illinois, the optimal hedge ratios are determined by:

$$IP_t = b_1\Delta F_t SE_t + b_2\Delta O_t SE_t + b_3\Delta E_t({}_{t-1}E[IP_t]/E_{t-1}) + {}_{t-1}E(IP_t]\alpha + e_t \quad (14)$$

where IP_t is defined by (8). Note that the first difference terms are now converted to DM units and that the number of units hedged in the exchange rate market is ${}_{t-1}E[P_t]/E_{t-1}$. An alternative specification is to set this term to one, allowing the regression coefficient, b_3, to represent the number of units hedged. However, the specification of (14) is chosen to provide consistency between full hedge ($b_3 = 1$) and optimal hedge results, and because the hedge units must be determined a priori in practice.

Regression eqs. (13) and (14) are altered, depending on the scenario being considered. The scenario defined by an importer who buys at Rotterdam, for example, does not obtain a position in the ocean-freight market and thus b_2 of (14) is not estimated. Other scenarios involve other locations, the use of only commodity futures, and perfect foresight of barge and ocean rates.

The measurement of price expectations and outcomes considers only quoted "private-market" prices. For example, the variable levy on corn imposed by the European Community is not considered. Consequently, the results may overstate the risk facing the private importer of corn, but may not overstate the risk facing both the importer and the Community. The general purpose here is to measure the market risk level and ability to reduce this level through hedging before price-enhancement and risk-reduction transfers are imposed by the public sector.

DATA

Corn and soybean cash prices are from the Illinois Market News Service. For confidentiality reasons, the exact location of the elevator used for this study cannot be identified; however, the elevator is approximately 20 miles from the Illinois River in central Illinois. Closing futures prices for corn and soybeans are from either CBOT tapes or *The Wall Street Journal.* Gulf prices are from *USDA Grain and Feed Market News.* Barge rates are those reported in Midco Commodities' *Merchandisers Fact Sheet.* Rotterdam prices are from *Oil World.* Exchange spot rates and futures are from the *CME Yearbook* and *The Wall Street Journal.*

Two sources of spot rates for ocean freight are used. The first set of rates is provided by the USDA. These rates are published by Maritime Research, Inc. Only rates for 40,000–60,000–metric-ton shipments are used. These data extend over the entire 1981–1989 period of study. The second set of rates are conversions of the BFI spot index for Gulf–Rotterdam grain shipments reported in the *Journal of Commerce.* The BFI futures index (converted to ¢/cwt.) is from the *Journal of Commerce.* All BFI data are from July, 1985 to December, 1989.

Thursday prices and rates are used when possible. If Thursday prices are not available, Wednesday prices are used. However, the 1981–1985 ocean rates represent weekly averages, and barge rates are midweek estimates.

RESULTS

Table I presents the 1985–1989 price uncertainty results for the exporter. At the first stage of the marketing channel (Illinois), three scenarios are considered for each crop—(1) unhedged (open) sale; (2) full hedge (hedge ratio = 1); and (3) optimal hedge.

The variance estimates in the OPEN column is the variance of the difference between expected and realized price when the futures market is not used. The variances under the HEDGE column apply to this difference when futures contracts are included. The "hedge effect" statistic measures the reduction in price uncertainty resulting from adding the futures contract(s); i.e., it is equal to 1 – (HEDGE variance/OPEN variance).

For soybeans at Illinois, the open variance of 7730 is reduced to 615 through full hedging. The optimal hedge (HR = 0.945) yields virtually the same hedge variance as the full hedge. For corn at Illinois, the open variance of 1513 is much smaller than the open soybean variance of 7730, indicating that price uncertainty based on expected minus realized prices is much smaller for corn than for soybeans. However, the hedge variances for corn are about the same as for soybeans. Consequently, the hedge effect is much smaller for corn than soybeans (about 0.62 for corn versus 0.92 for soybeans). This comparison illustrates an important caveat for hedging effectiveness studies. The hedge-effect statistic is analogous to the R^2 measure of hedging effectiveness from regressions of cash on futures [e.g., Ederington (1979)]. However, if differences in the variance of the dependent variable are large, comparisons of hedging effectiveness estimates (R^2 values) are meaningless [Lindahl (1989)]. Likewise, comparison of the hedge-effect statistics in Table I across scenarios with different open variances should be done with care. A more meaningful comparison across different open-variance scenarios is with the hedge variances. (This is similar to comparing the mean-squared error of traditional hedging effectiveness regressions.) For example, the fact that the hedge variances for corn and soybeans at Illinois are about the same suggests that price uncertainty across these crops at Illinois is about the same even though "hedging effectiveness" is much larger for soybeans.

The Gulf results in Table I indicate that price uncertainty facing the exporter does not increase as grain moves through the marketing channel from Illinois to the Gulf. The open and hedge variances for the Gulf are slightly lower than for Illinois for both corn and soybeans. In other words, the Gulf price does not present more price uncertainty than the Illinois price in either the unhedged or hedged situation.

Another scenario examined for the Gulf measures the remaining price uncertainty after the uncertainty caused by fluctuating barge rates is removed. This is done by assuming that the realized barge rate is the expected barge rate; i.e., perfect foresight in barge rates. The purpose of this scenario is twofold: (1) to get an idea of the amount of risk reduction possible through forward contracting barge freight; and (2) to provide a means for comparing risk across transport modes (barge versus ocean vessel). The hedge-variance reduction caused by perfect barge-rate forecasts is about 30% in each case. The results of perfect ocean-rate forecasts are discussed below.

The exporter who sells at Rotterdam faces uncertainty about commodity price, barge rate, and ocean rate. For soybeans during 1985–1989, the open variance at Rotterdam (7235) is less than the open variance at the Gulf (7696). However, the full-hedge variance at Rotterdam (1112) is considerably higher than the full-hedge variance at the Gulf (610). The optimal hedge variances are also much different (930 versus 585). These results suggest that as soybean marketing moves from the Gulf to Rotterdam, the level of total price uncertainty does not increase; however, the amount of this total uncertainty that can be eliminated by using futures contracts decreases.

The use of ocean-freight futures is of little help in reducing the 1985–1989 soybean price uncertainty. This ineffectiveness is reflected in the t-statistics of the optimal hedge ratios, and by the fact that the optimal hedge variance when using both soybean and ocean futures (930) is virtually equal to the optimal hedge variance when using only

Table I
1985–1989 PRICE UNCERTAINTY FACING ILLINOIS EXPORTER

	Soybeans					Corn				
	Hedge Ratio[a]		Variance[b]			Hedge Ratio		Variance		
	FUT	OCN	OPEN	HEDGE	Hedge Effect[c]	FUT	OCN	OPEN	HEDGE	Hedge Effect
Illinois										
HR = 1	1	—	7730	615	0.920	1	—	1513	581	0.616
Optimal	0.945 (17.32)[d]	—	7730	597	0.923	0.935 (6.33)	—	1513	577	0.619
Gulf										
HR = 1	1	—	7696	610	0.921	1	—	1416	485	0.657
Optimal	0.943 (17.42)	—	7696	585	0.924	0.937 (6.94)	—	1416	481	0.660
HR = 1, E[B] = RB[e]	1	—	7382	433	0.941	1	—	1351	346	0.744
Opt, E[B] = RB	0.935 (20.89)	—	7382	400	0.946	0.972 (8.50)	—	1351	345	0.745

Rotterdam										
HR = 1	1	–1	7235	1112	0.846	1	–1	1918	658	0.657
Optimal	0.890	0.119	7235	930	0.871	0.957	–1.777	1918	626	0.674
	(12.66)	(0.14)				(5.99)	(–2.47)			
HR = 1, E[O] = RO	1	–1	7103	1114	0.843	1	–1	1709	523	0.694
Opt, E[O] = RO	0.895	0.879	7103	810	0.886	0.991	–1.002	1709	523	0.694
	(13.65)	(1.08)				(6.78)	(–1.53)			
HR = 1, Only FUT	1	0	7235	1029	0.858	1	0	1918	788	0.589
Opt, Only FUT	0.889	0	7235	931	0.871	1.029	0	1918	787	0.590
	(13.01)					(5.97)				

[a]Hedge ratio for commodity futures (FUT), or ocean freight futures (OCN); equal to one (HR = 1), or determined by regression (Optimal).

[b]Variance of differences between expected and realized outcomes without using futures (OPEN) and with futures (HEDGE).

[c]1–(HEDGE variance/OPEN variance).

[d]t-Statistic from optimal hedge regression.

[e]E[B] = RB: Perfect foresight in barge rates. E[O] = RO: Perfect foresight in ocean rates.

soybean futures (931). Furthermore, the optimal ocean hedge ratio (0.119) implies short hedging ocean freight in a situation which one would expect the covariances to lead to a long hedge.

Perfect expectations of ocean freight do not reduce the Rotterdam hedge variance for soybeans. (The slight increase is explained below with a more pronounced case.)

There are two important factors determining whether ocean-freight hedging will reduce price uncertainty as defined here. The first factor is the correlation between the Rotterdam–Gulf price spread and ocean-freight rate. The second factor is the "hedging effectiveness" of the freight futures market. Table II presents simple correlation coefficients for price spreads and freight rates. Weekly data are used, and correlations are estimated annually. The ocean rate correlations with the soybean spread vary from –0.220 in 1983 to 0.738 in 1982. The correlations for ocean rates and corn spreads tend to be higher than the correlations for soybeans. In general: (1) the ocean rate correlations vary considerably from year to year; (2) they are lower than what might be expected in an "integrated" market; and (3) the corn correlations are generally higher than the soybean correlations. There are many possible explanations for these general results. The Rotterdam price is being determined by many grain flows (not just U.S.–Rotterdam), and other economic and political factors; ocean rates are determined within a very competitive industry which can serve many different markets; and it is not clear that integration in a competitive market implies high correlation [Faminow and Benson (1990)]. Thus, the corn versus soybean results may reflect the fact that relatively little corn was shipped to Rotterdam during the 1980s. Although further work is being done on these issues, the simple correlation coefficients reveal one reason why the soybean price uncertainty at Rotterdam is not reduced through hedging ocean freight. Another reason is reflected by the regression fit of ocean spot-rate changes on ocean futures-rate changes. Using the 27 eight-week-interval prices for 1985–1989, this regression has a slope coefficient of 0.83 and an R^2 of 0.35. This R^2 (one measure of hedging effectiveness) may underestimate hedging effectiveness of alternative time periods and/or selective hedging techniques; however, its low value for the data used here to measure price uncertainty indicates that the contract may not provide much help in reducing the portfolio variance being studied.

Returning to Table I, both the open and hedge variance for *corn* at Rotterdam are higher than the respective variance at the Gulf. However, the hedge variances (658 and 626) are at about the same level as the Illinois hedge variances for corn (581, 577) and soybeans (615, 597). Thus, the results at the Rotterdam level suggest that the uncertainty for corn is higher than at the Gulf, but much closer to the uncertainty at Illinois than soybeans. The sign of the optimal ocean-freight hedge for corn is negative, as expected, but much larger in absolute terms than a full hedge. With perfect foresight of ocean rates, the optimal hedge variance is equal to the full hedge variance. And, unlike soybeans, the hedge variance increases by about 20% when only commodity futures are used in the hedge.

Table III presents the exporter results for 1981–1985. For this period, however, the use of ocean-freight futures cannot be considered. The general implications of Table III are similar to those of Table I. The hedge variances for soybeans decrease slightly from Illinois to the Gulf, and then increase by more than twofold from the Gulf to Rotterdam. For corn, relatively small increases in hedge variances occur at each stage.

Note that the variances associated with perfect ocean-rate forecasts are slightly larger than the other Rotterdam variances. Since the variance is of the difference between

Table II
SIMPLE CORRELATION COEFFICIENTS
FOR PRICE SPREADS AND FREIGHT RATES

	Rotterdam–Gulf Spread with Ocean Rate			Gulf–Illinois Spread with Barge Rate		
		Soybeans	Corn		Soybeans	Corn
	n[a]	ρ	ρ	n	ρ	ρ
1981	36	0.639	0.766	52	0.786	0.874
1982	45	0.738	0.819	52	0.747	0.662
1983	37	–0.220	0.026	52	0.814	0.810
1984	38	0.184	0.549	52	0.649	0.801
1985F[b]	13	0.239	0.727	21	0.556	0.849
1985L	31	0.058	0.638	31	0.515	0.681
1986	53	0.076	0.206	53	0.822	0.837
1987	52	0.375	0.265	52	0.668	0.770
1988	52	0.075	–0.162	52	0.705	0.731
1989	52	0.641	0.363	52	0.697	0.904
Average		0.281	0.420		0.696	0.792

[a]Number of observations (weeks) used; for 1981–1985F, observations for ocean rates did not exist for every week.
[b]1985F: January–May, 1985; 1985L: June–December, 1985.

expected and realized prices, it can be broken into three components (or more if one wants to consider the components of the realized and expected price calculations): (1) variance of realized price; (2) variance of expected price; and (3) two times the covariance between realized and expected prices. The covariance term increases slightly under perfect foresight, decreasing the overall variance. However, the variance of expected price increases in each case, causing a small but net increase in the overall variance. The important point here is that the covariance effect is not large (nor dominant) because of the rate/spread and hedging factors discussed earlier.

Table IV presents the 1981–1985 and 1985–1989 results for importing scenarios. Variance units are Deutsche marks. Comparable variances (standard deviations) to those of the exporting scenarios are presented below. The 1985–1989 variance results in the top half of Table IV indicate that soybean price uncertainty at Illinois under a full hedge (2441) is equal to the corn variance (2440). At the next stage (Gulf), the hedge-variance drops for both corn and soybeans, and then the variance increases at Rotterdam. The hedge variance for corn at Rotterdam is less than the Illinois variance, while the hedge variance for soybeans at Rotterdam is considerably more than the Illinois variance.

Ocean futures seem to fit their expected role better in the importer scenarios than in the exporter scenarios. Positive hedge ratios (long hedging) are as expected, and are close to one for corn. However, the statistics for the OCN hedge ratios relative to the FUT and EXC ratios suggest again that the amount of uncertainty reduction obtained through freight hedging is low.

Hedges in exchange-rate futures cause large reductions in price uncertainty. The importance of exchange hedging is implied by the EXC t-statistics, and illustrated further in the 1985–1989 Rotterdam scenario where the portfolio with only the commodity

Table III
1981–1985 PRICE UNCERTAINTY FACING ILLINOIS EXPORTER[a]

	Soybeans				Corn			
	Hedge Ratio	Variance		Hedge	Hedge Ratio	Variance		Hedge
	FUT	OPEN	HEDGE	Effect	FUT	OPEN	HEDGE	Effect
Illinois								
HR = 1	1	8783	467	0.947	1	1689	441	0.739
Optimal	0.918	8783	397	0.955	0.909	1689	429	0.746
	(23.14)				(8.68)			
Gulf								
HR = 1	1	9473	406	0.957	1	1868	544	0.709
Optimal	0.956	9473	384	0.959	0.936	1868	538	0.712
	(24.53)				(7.98)			
HR = 1, E[B] = RB	1	9162	340	0.963	1	1562	373	0.761
Opt, E[B] = RB	0.942	9162	306	0.967	0.890	1562	355	0.773
	(27.06)				(9.36)			
Rotterdam								
HR=1	1	13,258	976	0.927	1	2032	590	0.710
Optimal	1.114	13,258	844	0.936	0.971	2032	589	0.710
	(19.19)				(7.91)			
HR = 1, E[O] = RO	1	13,491	1037	0.923	1	2183	660	0.698
Opt, E[O] = RO	1.121	13,491	885	0.934	0.995	2183	660	0.698
	(18.89)				(7.67)			

Table IV
1981–1985 AND 1985–1989 PRICE UNCERTAINTY FACING ROTTERDAM IMPORTER[a]

	Soybeans						Corn					
	Hedge Ratio			Variance		Hedge	Hedge Ratio			Variance		Hedge
	FUT	OCN	EXC	OPEN	HEDGE	Effect	FUT	OCN	EXC	OPEN	HEDGE	Effect
1985–1989												
Rotterdam												
HR = 1	1	—	1	42,433	4318	0.898	1	—	1	11,154	1742	0.844
Optimal	0.841	—	0.989	42,433	3658	0.914	1.124	—	0.803	11,154	1585	0.858
	(10.79)		(10.78)				(8.59)		(5.98)			
HR = 1, Only FUT	1	—	0	42,433	21,669	0.489	1	—	0	11,154	4450	0.601
Opt, Only FUT	0.897	—	0	42.433	21,463	0.494	1.304	—	0	11,154	4033	0.638
	(4.87)						(6.63)					
Gulf												
HR = 1	1	1	1	41,172	1813	0.956	1	1	1	10,587	1494	0.859
Optimal	0.913	1.633	0.906	41,172	1385	0.966	1.059	0.863	0.875	10,587	1431	0.865
	(18.48)	(2.73)	(15.13)				(8.13)	(1.40)	(6.04)			
Illinois												
HR = 1	1	1	1	40,611	2441	0.940	1	1	1	11,005	2440	0.778
Optimal	0.919	1.728	0.889	40,611	1975	0.951	1.066	1.057	0.838	11,005	2369	0.785
	(15.55)	(2.42)	(12.05)				(6.36)	(1.33)	(4.24)			

(continued)

[a]See Table I footnotes for explanations of variables.

Table IV (continued)

	Soybeans						Corn					
	Hedge Ratio			Variance		Hedge Effect	Hedge Ratio			Variance		Hedge Effect
	FUT	OCN	EXC	OPEN	HEDGE		FUT	OCN	EXC	OPEN	HEDGE	
1981–1985												
Rotterdam												
HR = 1	1	—	1	126,456	6457	0.949	1	—	1	20,400	3574	0.825
Optimal	1.07	—	0.900	126,456	5891	0.953	0.956	—	0.833	20,400	3308	0.838
	(17.86)		(9.81)				(7.93)		(6.23)			
Gulf												
HR = 1	1	—	1	97,168	4043	0.958	1	—	1	18,162	3472	0.809
Optimal	0.904	—	0.904	97,168	3005	0.969	0.916	—	0.787	18,162	3011	0.834
	(21.10)		(13.57)				(7.95)		(5.96)			
Illinois												
HR = 1	1	—	1	89,808	5051	0.944	1	—	1	16,893	4828	0.714
Optimal	0.867	—	0.889	89,808	3276	0.964	0.897	—	0.682	16,893	3915	0.768
	(19.36)		(12.42)				(6.83)		(4.35)			

[a]See Table I footnotes for explanations of variables.

and commodity futures has a much larger hedge variance than the portfolio which also includes exchange-rate futures. Though not shown, the same uncertainty reduction is provided by exchange futures in the other import scenarios.

The bottom half of Table IV presents the 1981–1985 results. The same general patterns across location are revealed. However, a better perspective on the relative uncertainty across periods, crops, and locations is offered in Table V.

Table V reports standard deviations under optimal and full hedging. For the exporting scenarios, the standard deviation is simply the square root of the respective variance given in Tables II or IV. For the importer scenarios, the difference between realized and expected prices at period *t* are converted from Deutsche marks to dollars according to the spot exchange rate at period *t*. The standard deviation (SD) of these dollar differences are then calculated. The first pair of rows in Table V apply to the importer's purchase of the commodity (designated by I) or the exporter's sale (E) at Illinois. The second pair of rows apply to the Gulf, while the last two rows apply to Rotterdam.

Consider the four combinations of crops and time periods: corn, 1981–1985; soybeans, 1981–1985; corn, 1985–1989; and soybeans, 1985–1989. For each combination, the SD facing the *importer* is less for commodity purchases at the Gulf [GF + OCN (I)] than at Illinois [IL + BRG + OCN (I)]. For the *exporter,* a decline in SD occurs for three of the combinations, but not for corn 1981–1985. The decline facing the exporter, however, is not large relative to the decline facing the importer. (Indeed, three of the eight exporter cases have reductions of only 0.3, 0.2, and 0.1.) From solely a price uncertainty standpoint, the general results of the first two pairs of rows suggest that there is more incentive for the commodity transaction to take place at the Gulf than at Illinois. At the Rotterdam level, the soybean SDs increase considerably for both the importer and exporter. Therefore, the price-uncertainty incentive is clearly to buy and sell at the Gulf as opposed to Rotterdam. For corn, the SDs increase from the Gulf to Rotterdam, but the increases are small compared to the soybean SDs.

CONCLUDING REMARKS

In general, the price uncertainty facing the exporter is about the same at the Gulf as at Illinois. For soybeans, the uncertainty then increases considerably at Rotterdam. The same general pattern holds for the importer, except that there is a relatively larger decrease in uncertainty when going from Illinois to the Gulf. The uncertainty facing both importers and exporters at Rotterdam is much larger than at the Gulf for soybeans, but not for corn.

The variance characteristics of the Gulf versus Rotterdam raise at least two questions worthy of further analysis. First, what are the fundamentals which cause the uncertainty at Rotterdam to be higher for soybeans than corn? The Gulf–Rotterdam trade in soybeans is much higher than corn for the period studied. Thus, law-of-one-price arguments might lead one to expect the Rotterdam–Gulf price spread for soybeans to be more of a function of transport costs than for corn. Yet, the correlation and uncertainty results imply the opposite, perhaps reflecting different competitive structures [e.g., Faminow and Benson (1990)].

The second, and more interesting implication, involves the possible development of markets which might help reduce the Rotterdam uncertainty. There has been some recent attention given to the feasibility of developing commodity futures exchanges in European countries. The preliminary implication of the present analysis suggests a possible need for such exchanges if the Rotterdam price is a good representation of present and developing cash markets. Another possibility implied by the uncertainty results might involve the trading of price spreads. Results of the present study are not meant to indicate whether

Table V
STANDARD DEVIATIONS FOR IMPORTER (I) AND EXPORTER (E) BY COMMODITY, PERIOD, LOCATION, AND HEDGING SCENARIO

	1981–1985				1985–1989			
	Soybeans		Corn		Soybeans		Corn	
	Opt	HR = 1	Opt	HR = 1	Opt	HR = 1	Opt	HR = 1
IL + BRG + OCN (I)	23.6	28.3	23.6	26.0	23.0	25.6	25.2	25.4
IL (E)	19.9	21.6	20.7	21.0	24.4	24.8	24.0	24.1
GF + OCN (I)	22.5	25.5	20.1	21.6	19.0	21.8	19.1	19.3
GF – BRG (E)	19.6	20.1	23.2	23.3	24.2	24.7	21.9	22.0
RT (I)	31.5	32.8	23.2	24.1	31.5	34.7	20.7	21.4
RT – OCN – BRG (E)	29.1	31.2	24.3	24.3	30.5	33.3	25.0	25.6

such a price-spread futures market would be successful. While the results do indicate that the Rotterdam uncertainty for soybeans is larger than at the Gulf, questions still needing some thought and analysis include: (a) is the increased uncertainty large enough to create trading interest?; (b) are there good trading fundamentals?; (c) is there sufficient volume potential?; (d) would it dilute other market trading?; and (e) can other routes (e.g., Gulf/Far East, PNW/Far East) be included within one contract? Price-spread futures have recently been introduced in other markets (e.g., cocoa and interest rates). Although it is not clear that this concept would work (or is needed) in grain trade, perhaps the best candidate would be associated with the export market.

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