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CONSIDERING HEDGERS' BASIS RISK IN DESIGNING AGRICULTURAL FUTURES CONTRACTS

Richard G. Heifner, Gerald E. Plato, and Bruce H. Wright

Successful futures trading requires the price of each maturing contract to converge to a single or narrowly defined spot price or index that is widely observed, closely related to relevant cash prices for a large number of hedgers, and not manipulatable. This condition is usually obtained by allowing delivery at contract maturity. However, the decline of central cash markets for agricultural commodities leaves few concentration points where product flows can be easily diverted from normal channels to futures delivery. Consequently, the futures exchanges have resorted to arrangements, such as multiple delivery points and cash settlement, that rely on more than one spot market. Better methods are needed for choosing among such arrangements.

Risk-shifting effectiveness is a major consideration in choosing among final settlement arrangements. The hedger's basis risk arises from two sources: (1) differences in location, quality, and time of delivery between the commodity being hedged and the commodity priced by the futures, and (2) pricing imprecision at the final settlement point(s)--either failure of futures and cash prices to converge due to delivery costs or imprecision in observing market clearing prices for cash settlement. This paper focuses on the first type of basis uncertainty, particularly that associated with differences in location. The objectives of the paper are to: (1) add to understanding about final settlement arrangements for futures contracts in commodities that are costly to transport and traded over space; (2) develop an optimizing method for determining final settlement arrangements that incorporates hedgers' risk; and (3) compare alternative final settlement arrangements for U.S. soybean futures.

We first identify factors that affect the success of futures contracts and consider how such factors might be quantified. Two procedures for comparing the performance of alternative final settlement arrangements are developed and applied to soybeans. The first procedure involves searching for the final settlement method that results in the smallest weighted sum of certainty equivalent losses from basis risk for all hedgers. We show that under certain assumptions this amounts to maximizing a weighted average of hedging effectiveness. The alternative procedure involves maximizing the expected open contracts held by risk-minimizing hedgers. Both procedures involve simulating futures prices historically for alternative final settlement arrangements and using the simulated futures prices in combination with observed cash prices to calculate minimum-risk hedge ratios and hedging effectiveness for each location. This approach differs from previous studies by focusing on price differences due to location, measuring uncertainty explicitly in terms of deviations from expectations, and aggregating hedging effectiveness and hedging volume across locations to provide criteria for choosing among settlement methods.

While the procedures used here are suited for comparing alternative delivery points or alternative pricing points for cash settlement, they are less well suited for comparing delivery with cash settlement because the simulated futures prices do not take into account pricing imprecisions at individual locations. There are several reasons to expect that such imprecisions may differ between delivery and cash settlement. Leuthold suggests that delivery brings more information to the market in the form of arbitrage opportunities than does cash settlement. Price manipulation may occur under either delivery or cash settlement, but one method may be more susceptible to manipulation than another. Paul (pp. 307-8) suggests that the amount of capital required to manipulate prices would be about the same for both final settlement procedures. Unfortunately, we have no good way to quantify pricing imprecision at individual points for final settlement methods that have not yet been tried.

Factors Affecting the Choice of Final Settlement Methods

In addition to being effective in shifting hedgers' risks, successful futures contracts must be attractive to speculators and not highly susceptible to manipulation. The models presented here focus on risk-shifting effectiveness. Before proceeding with their development, the possibilities for quantifying these other factors believed to affect futures contract success are briefly considered.

Speculators are attracted to futures contracts that exhibit relatively large price fluctuations and wide availability of information related to price. They are generally attracted to contracts where there is substantial hedging interest. We see no promising way to quantify the factors that make futures contracts attractive to speculators, apart from the factors that make such contracts attractive to hedgers.

Price manipulation occurs when one or a few traders manage to distort a futures price to their advantage. For example, manipulation occurs if a few long traders raise prices by controlling deliverable supplies. Cash-settled futures contracts might be manipulated by influencing the spot prices used in calculating the final settlement price. Susceptibility to manipulation may be lowered by adding delivery points or making delivery more convenient, by tightening position limits as contracts near maturity, or in the case of cash settlement, by increasing the number of cash prices used in determining final settlement prices.

Susceptibility to manipulation is not modeled here explicitly. However, it should be noted that risk-shifting effectiveness and lack of susceptibility to manipulation are related. A high correlation between changes in a cash price and the futures price not only implies an effective hedge, but also suggests that delivery may be relatively easy. Thus, contracts that effectively shift risks for many hedgers tend to be less susceptible to manipulation.

Conceptual Model

Two different approaches to the problem of selecting final settlement methods are considered here--an aggregate risk minimizing approach and a hedge position maximizing approach. The first approach involves choosing final settlement methods that minimize a weighted sum of the revenue variances that would occur with minimum-risk hedges at all locations. This is equivalent to summing certainty equivalent losses from revenue uncertainty under the assumption that risk aversion coefficients are the same for all hedgers at all locations. This approach seeks a socially optimal solution--one that minimizes total certainty equivalent loss.

The second approach involves maximizing the total of hedgers' positions in the contract under the assumption that hedgers at all locations use risk-minimizing hedges. Since open interest and the amount of commissions generated are positively related, this approach should be of interest to exchange members who wish to increase commissions generated.

The search for solutions under both approaches begins with the selection of a set of feasible final settlement arrangements and a sample of historical prices and quantities at the various locations. For each settlement arrangement a simulated futures price is calculated for each date in the sample based on observed cash prices. Minimum-risk hedge ratios and risk-shifting effectiveness are then calculated for each location. Weighted averages of hedging effectiveness and hedge positions are constructed using estimates of cash positions at each location as weights. The optimal solutions are those with largest weighted average hedging effectiveness or largest total open interest for risk-minimizing hedgers.

Risk is measured in terms of variance or mean squared deviation of hedgers' revenues from expectations. Let

(1) $\Delta P_{it} = P_{it} - E_{t-1}(P_{it}), \quad i = 1,2,\ldots n, \quad t = 1,2,\ldots T$

be the deviation in cash price from its expectation where P_{it} is the spot price at location i for period t and E_{t-1} is the period t-1 expectation of the expression in the parenthesis. Further, let

(2) $\Delta F_{mt} = F_{mt} - E_{t-1}(F_{mt}), \quad m \in M, \quad t = 1,2,\ldots T$

be the deviation in the futures price from its expectation where F_{mt} is the futures price for settlement method m in period t and M is the set of settlement methods. The deviation in revenue from its expectation is then

(3) $\Delta R_{mit} = \Delta P_{it} + h_{mi}\Delta F_{mt}, \quad m \in M, \quad i=1,2,3\ldots n, \quad t = 1,2,\ldots T$

where h_{mi} is the hedge ratio (negative) for settlement method m at location i. Minimum revenue variance hedge ratios are used in this analysis which are

(4) $h_{mi} = -Cov(\Delta P_i,\Delta F_m)/Var(\Delta F_m), \quad m \in M, \quad i = 1,2,\ldots n$

where Cov() signifies the covariance and Var() signifies the variance of the expression within parenthesis. The variance of revenue when the minimum risk hedge is used is

(5a) $Var(\Delta R_{mi}) = Var(\Delta P_i) + h_{mi}^2 Var(\Delta F_m) + 2h_{mi}Cov(\Delta P_i,\Delta F_m).$

Substituting from equation 4 for h_{mi} we obtain

(5b) $Var(\Delta R_{mi}) = Var(\Delta P_i) + Cov(\Delta P_i,\Delta F_m)^2/Var(\Delta F_m) -$

$2Cov(\Delta P_i,\Delta F_m)^2/Var(\Delta F_m)$

which can be written

(5c) $Var(\Delta R_{mi}) = Var(\Delta P_i) + h_{mi}Cov(\Delta P_i,\Delta F_m), \quad m \in M, \quad i = 1,2,\ldots n.$

A weighted sum of the revenue variances serves as a measure of the aggregate loss from basis risk

(6a) $L_m = \sum_i w\lambda_i Var(\Delta R_{mi}), \quad m \in M.$

(6b) $L_m = \sum_i w_i\lambda_i Var(\Delta P_i) + \sum_i w_i\lambda_i h_{mi}Cov(\Delta P_i,\Delta F_m), \quad m \in M.$

where the weights, w_i, represent total cash positions at each location and are as defined below and $\lambda_i<0$ is the coefficient of risk aversion at location i. Note that the first term in (6b) can be neglected when L_m is minimized over the alternative futures settlement methods because it does not involve the futures price. Therefore, finding the settlement method that minimizes L_m in (6b) is equivalent to minimizing

$$(7) \qquad L_m' = \textstyle\sum_i w_i \lambda_i h_{mi} \mathrm{Cov}(\Delta P_i, \Delta F_m),$$

over M. The hedging effectiveness of futures settlement method m at location i can be defined as the proportional reduction in revenue variance from hedging

$$(8a) \qquad V_{im} = [\mathrm{Var}(\Delta P_i) - \mathrm{Var}(\Delta R_{mi})]/\mathrm{Var}(\Delta P_i)$$

where V_{im} is the squared correlation between the cash price at location i and the futures price for settlement method m. Substituting from (5c) gives

$$(8b) \qquad V_{im} = -h_i \mathrm{Cov}(\Delta P_i, \Delta F_m)/\mathrm{Var}(\Delta P_i)$$

Thus, we can write (7) as

$$(9) \qquad L_m' = -\textstyle\sum_i w_i \lambda_i \mathrm{Var}(\Delta P_i) V_{im}, \qquad m \in M.$$

In other words, minimizing L_m' is equivalent to maximizing a weighted sum of hedging effectiveness over locations where the weight for each location is a the product of hedgeable stocks, the risk aversion coefficient, and price variance around its expectation. If risk aversion and price variance are about the same among locations, they can be neglected in seeking an approximate minimum risk solution.

Alternatively, to calculate total positions of risk-minimizing hedgers we use

$$(10) \qquad W_m = - \textstyle\sum_i w_i h_{mi}, \qquad m \in M.$$

Note that minimizing L_m' over M in (7) or (9) differs from maximizing W_m over M in (10) only in that each hedging ratio, h_{mi}, is multiplied by the product of λ_i and a covariance term $\mathrm{Cov}(\Delta P_i, \Delta F_m)$. Thus, the aggregate variance minimizing approach gives more weight to locations with large covariances than the hedging position maximizing approach.

Application of the Model

Applying the model involves five steps:

1. Calculate simulated futures prices for each date in the sample for each final settlement method.

2. Calculate preceding-period expectations and current-period deviations from preceding-period expectations for each cash and futures price series.

3. Calculate the covariance matrix of price deviations from expectations for all cash and simulated futures price series.

4. Calculate minimum-risk hedges for each location, each quarter, and each final settlement method using the covariance matrix of price deviations from expectations.

5. Calculate the weighted average hedging effectiveness and hedging volume for risk-minimizing hedgers.

Simulating Futures Prices

Three types of final settlement are considered: single point delivery or cash settlement; multiple point cash settlement; and multiple point delivery. With either single point delivery or single point cash settlement the final settlement price is set equal to the spot price at the delivery point

$$(11) \qquad F_{mt} = P_{jt}, \qquad t = 1,2,\ldots T$$

where F_{mt} is the futures price for settlement method m at time t, and P_{jt} is the observed spot price at the delivery point (location j) at time t.

For multiple point cash settlement, the final settlement price is a weighted sum of prices at two or more locations

$$(12) \qquad F_{mt} = \textstyle\sum_j a_j P_{jt}, \quad j \in J, \quad t = 1,2,\ldots T$$

where J is the set of locations included in the final settlement formula and a_j is the weight assigned to location j.

With multiple point delivery we assume that delivery occurs at the point where the commodity can be acquired by shorts at the lowest price, after adjusting for the discount or premium. This gives a final settlement price of

$$(13) \qquad F_{mt} = \mathrm{Min}_J(P_{jt} - d_j), \quad j \in J, \quad t = 1,2,\ldots T$$

where J is the set of delivery points allowed under settlement method m, d_j is the premium(+) or discount(-) for delivery at point j, and Min_J indicates a minimum over J of the expression in parentheses.

Simulating Price Expectations

The cash and futures price expectations needed for estimating the variances and covariances of price and revenue deviations from expectations are not directly observable. However, in an efficient market for a storable commodity this period's expectation of next period's price equals this period's price plus the carrying cost. Carrying costs consist mainly of interest on the commodity and the cost of binspace. We used observed futures price spreads as an estimate of carrying costs.

$$(14) \quad C_{t-1} = F_{t,t-1} - F_{t-1,t-1}, \quad t = 1,2,\ldots T$$

where C_{t-1} is expected carrying cost from t-1 to t, $F_{t,t-1}$ is the observed price in period t-1 of the futures contract that matures in period t, and $F_{t-1,t-1}$ is the observed price in period t-1 of the futures contract that matures in t-1.

The expected futures price for each settlement method was simulated as,

(15) $E_{t-1}(F_{mt}) = F_{m,t-1} + C_{t-1}$, $t = 1,2...T$, for all m,

where $E_{t-1}(F_{mt})$ is the expectation at t-1 of the settlement price at time t under method m and $F_{m,t-1}$ is the simulated maturing futures price under settlement method m at time t-1. Similarly, cash price expectations at all locations were simulated as

(16) $E_{t-1}(P_{it}) = P_{i,t-1} + C_{t-1}$, $i = 1,2...n$, $t = 1,2..T$.

Estimated Minimum-Risk Hedge Ratios

For each quarter a covariance matrix of price deviations from expectations is calculated which includes cash price deviations for each location and futures price deviations for each final settlement method. From these quarterly covariance matrices we calculate the minimum-risk hedge ratios and hedging effectiveness using equations (4) and (8) above.

Aggregate Losses Due to Risk and Aggregate Hedging Positions

Finally, the weighted sum of hedging effectiveness and expected total open interest were calculated for each quarter and each settlement method using equations (9) and (10) above. The hedging weights, w_{iq}, for each quarter are set equal to historical average stocks by quarter and location:

(17) $w_{iq} = \sum_y S_{iqy}/Y$, $q = 1,2,3,4$, $i = 1,2,...n$

where S_{iqy} is the quantity of stocks at location i in quarter q of year y, and Y is the number of years.

Stocks appear to be a good estimate of hedgeable long cash positions. To estimate hedgeable short cash positions, we considered using estimates of crushings and exports, but concluded that the relationships were too tenuous to use. Moreover, data for allocating crushings among states is incomplete and exports by port is not satisfactory for weighting exporters' positions because most exporters own the soybeans before the soybeans reach the ports. Hence, we did not construct separate weights for long hedging. This amounts to assuming that long hedging would be distributed among locations in the same proportions as short hedging.

Data

The state estimates of farm-level prices and total stocks used in the analysis are the least aggregative data available that provide a broad coverage of the U.S. soybean market. The prices are prices paid to farmers by first handlers at mid-month as reported at the end of the month by the USDA's National Agricultural Statistics Service (NASS). The price data are for 1971 through 1991 for 14 states which account for about 90 percent of U.S. stocks. Use of such prices for cash settlement would require earlier reporting. To estimate hedgeable quantities by state, end-of-month farm and off-farm stocks were summed for the same months using data for 1987 to 1991.

Within state price variation is lost by using state average prices. The effect of such aggregation on the estimated price correlations and resulting measures of hedging effectiveness is unknown. Less aggregative price and inventory estimates would likely improve the results. The Federal-State Market News Service reports elevator bid prices by areas within states for some states, but not all states are covered and some of the series are relatively short.

The terminal market prices used in the analysis are those reported by the USDA's Agricultural Marketing Service (AMS) for Chicago, Toledo, Minneapolis, Illinois processors, and the Gulf. Prices are for the 15th, or trading day nearest the 15th, for the same months and years as the farm-level prices.

Expected prices for equations (1) and (2) were calculated by adding an expected carrying cost derived from futures price quotations to the preceding quarter's cash price. March to June carrying costs were estimated using March to May futures price differences plus one half of the price differences from May to July futures. June to September carrying costs were estimated using July to September futures price differences plus the July to August futures price differences. September to December carrying costs were estimated using the September to November futures price differences plus one half of November to January futures price differences. December to March carrying costs were estimated using one and one half times the price differences between January and March futures prices. The futures prices used to estimate carrying costs were for the 15th or trading day nearest the 15th in each month.

Table 1 shows the average percent distribution of soybean stocks over the 14 states by quarter for 1987 through 1991. The percentages in table 1 served as weights for calculating cash settlement prices and for estimating overall hedging effectiveness. The quarterly stock distributions by state shown in table 1 were combined using 1991 total inventories by quarter for the 14 states to estimate overall hedging effectiveness and hedging volume. The 14-state inventory estimates for December, March, June, and September 1991 are 1483, 1072, 655, and 208 million bushels, respectively.

Table 1. Average Percentage Distribution of Soybean Stocks among 14 States by Quarter, 1987 through 1991.[1]

	Quarter			
	March	June	September	December
		...............Percent...............		
Arkansas	3.1	2.5	1.6	3.9
Illinois	22.0	21.3	21.6	21.5
Indiana	6.0	5.4	4.3	8.0
Iowa	24.6	26.7	29.0	22.7
Kansas	3.3	3.1	2.7	3.4
Kentucky	1.5	1.3	1.4	1.9
Michigan	1.5	1.3	1.2	1.6
Minnesota	14.4	16.3	17.3	12.0
Missouri	6.7	6.2	6.1	7.9
Nebraska	5.7	6.0	6.8	5.6
North Carolina	1.7	1.3	1.5	2.1
Ohio	7.3	6.8	5.3	7.0
South Carolina	1.1	1.0	0.6	1.1
Tennessee	1.0	0.8	0.8	1.4

[1] Column sums differ slightly from 100 due to rounding error.

Results for Cash Settlement Using State Farm-Level Prices

Two sets of results were obtained, both using NASS state farm-level prices to represent cash prices. The first set compares alternative cash settlement arrangements which use weighted averages of the state farm-level prices for settlement. The second set compares alternative cash settlement and delivery arrangements using terminal market prices for settlement.

Examples of estimated minimum-risk hedge ratios and hedging effectiveness for cash settlement using state farm-level prices are shown in table 2. The settlement price for these estimates is a weighted average price for all 14 states with each state weighted by its inventory. The minimum-risk hedge ratios were calculated using equation (4) and average slightly over one for all 14 states. The hedging effectiveness estimates for the major soybean growing states of Illinois, Iowa, and Minnesota range from 98.80 to 99.87 percent and average 99.63 percent. The corresponding estimates for Michigan, South Carolina, and Tennessee range from 90.02 to 98.60 percent and average 96.30 percent. The average hedging effectiveness for all 14 states is 99.1 percent which reflects the high correlations in price deviations from expectations among the states.

Estimates of average hedging effectiveness and total risk-minimizing hedging volume for cash settlement using state farm-level prices are presented in table 3. Results are shown for settlement based on single-state prices, and weighted and simple averages of prices for selected states. The single state results show advantages for using prices from a state in the major growing area--Illinois, Iowa, or Indiana--but virtually no differences between these three states. If settlement were based on Arkansas or North Carolina prices, the average hedging effectiveness would be about 3 or 6 percent less respectively. Although these differences in average hedging effectiveness seem small, they may be important when viewed in terms of the residual price variance after hedging.

Table 2. Example Hedge Ratios and Hedging Effectiveness for Selected States, Cash Settlement Based on 14-State Weighted Average Stocks.[1]

State	Quarter							
	March		June		September		December	
	Hedge Ratio	Hedging Effec-tiveness	Hedge Ratio	Hedging Effec-tiveness	Hedge Ratio	Hedging Effec-tiveness	Hedge Ratio	Hedging Effec-tiveness
Illinois	0.97	99.71	1.02	99.86	1.01	99.69	1.06	99.19
Iowa	1.01	99.80	1.00	99.87	0.98	99.84	0.99	99.45
Minnesota	1.01	98.80	0.99	99.77	1.01	99.72	0.96	99.87
Michigan	1.01	96.75	0.96	98.60	0.90	96.45	0.90	90.02
South Carolina	1.00	97.02	0.92	98.09	0.95	98.07	1.02	93.30
Tennesse	1.04	97.83	0.91	98.08	0.97	96.77	1.04	95.71

[1] Hedging effectiveness is the percent of the price variance eliminated by the minimum risk hedge.

Table 3. Average Hedging Effectiveness and Hedging Volume for Alternative Cash Settlement Formulas Using Prices Received by Farmers by State.

State Included in Calculating Settlement Price	Weighted Average Hedging Effectiveness	Risk Minimizing Hedging Volume
	Percent	Percent of Stocks
Single point		
Illinois	98.8	98.1
Iowa	98.8	100.4
Indiana	98.5	95.9
Arkansas	95.6	94.7
North Carolina	92.6	94.0
Weighted average		
Illinois and Iowa	99.0	99.8
Illinois, Iowa and Minn.	99.0	100.3
Illinois and Arkansas	98.8	98.1
Illinois and North Carolina	98.8	98.4
All 14 states	99.1	100.5
Simple average price		
Illinois and, Iowa	99.0	99.5
Illinois, Iowa, and Minn.	99.0	100.3
Illinois and Arkansas	98.2	97.5
Illinois and North Carolina	97.4	98.8
All 14 states	98.9	100.2

Aggregate hedging effectiveness is slightly higher when settlement is based on averages of state prices instead of on a single state price. It appears that a broadly based weighted average price provides the most effective hedge overall. The hedging effectiveness estimate based on weighting all state prices by their inventories was slightly higher than those using prices from the main producing states. The estimate from simple averaging of all state prices was slightly less than using prices from two or more of the main producing states.

Table 3 shows that the simple averaging of price from a low production state with the price from a major producing state can reduce overall hedging effectiveness. For example, the cash settlement price from the simple averaging of the Illinois and North Carolina prices resulted in lower overall hedging effectiveness then Illinois alone.

Table 3 also shows that inventory weighting of prices from a major producing state and a low inventory state does not reduce overall hedging effectiveness. For example, an inventory weighted cash settlement price using Illinois and North Carolina prices did not reduce overall hedging effectiveness.

Averaging the North Carolina and the Arkansas price with the Illinois price had little effect on hedging volume. Surprisingly, however, the simple averaging of the North Carolina and Illinois prices increased hedging volume slightly.

Results for Cash Settlement Using Terminal Prices

Estimates of average hedging effectiveness and total risk-minimizing hedging volume for cash settlement using various combinations of terminal prices are presented in table 4. If only one price is used for settlement, the Illinois processors price provides the most effective hedge. The Gulf price was least effective. Chicago, Toledo, and Minneapolis ranked virtually the same in hedging effectiveness, but Chicago gave the highest hedging volume. Slight improvements in hedging effectiveness occur when settlement is based on an average of two or more terminal prices.

The hedging effectiveness measures reported in table 4 are generally lower than those in table 3. The difference is partly accounted for by the imperfect correlation between terminal prices and farm-level prices within states and lack of exact correspondence in dates between the AMS and NASS price observations.

Results for Delivery at Terminals

Table 5 provides estimates of hedging effectiveness and volume for alternative combinations of delivery points. Included are results for single-point delivery and multiple-point delivery with all points at par and with two discount and premium systems. The single-point delivery estimates are identical to the estimates for single-point cash settlement shown at the top

Table 4. Average Hedging Effectiveness and Hedging Volume for Alternative Cash Settlement Formulas Using Terminal Prices.

Markets Included in Calculating Settlement Price	Weighted Average Hedging Effectiveness	Risk Minimizing Hedging Volume
	Percent	Percent of Stocks
Single point		
Chicago	95.3	94.5
Toledo	95.2	92.5
Minneapolis	95.3	93.2
Ill. processors	95.7	93.2
Gulf	93.5	85.3
Simple average price		
Chicago, Toledo	95.6	94.0
Chicago, Toledo, and Minneapolis	95.7	94.0
Chicago, Toledo, Minneapolis, and Illinois Processors	96.0	94.2
All 5 locations	96.0	93.1

Table 5. Average Hedging Effectiveness and Hedging Volume for Alternative Delivery Arrangements

Delivery Points	Weighted Average Hedging Effectiveness	Risk Minimizing Hedging Volume
	Percent	Percent of Stocks
Single point		
Chicago	95.3	94.5
Toledo	95.2	92.5
Minneapolis	95.3	93.2
Ill. processors	95.7	93.2
Gulf	93.5	85.3
All locations at par		
Chicago, Toledo	95.4	93.9
Chicago, Minneapolis	95.2	93.6
Chicago, Ill. Processors	95.8	95.4
All	95.4	94.0
Chicago at par, others at average differences[1]		
Chicago, Toledo	95.3	94.3
Chicago, Minneapolis	94.9	94.5
Chicago, Ill. Processors	95.8	95.4
All	94.6	92.0
Chicago at par, others at penalty differences[2]		
Chicago, Toledo	95.3	94.8
Chicago, Minneapolis	95.0	94.4
Chicago, Ill. Processors	95.8	95.5
All	95.3	93.8

[1] Average differences relative to Chicago are -$0.04 for Toledo, -$0.11 for Minneapolis, $0.05 for Illinois Processors, and $0.28 for the Gulf.

[2] Discounts equal 2 times the negative average price differences and premiums equal 1/2 times the positive price differences from Chicago.

of table 4. All of the hedging effectiveness estimates range between 94.9 and 95.8 except for single-point delivery at the Gulf.

The delivery point results show that adding delivery points may decrease hedging effectiveness. For example, having four non-Chicago delivery points resulted in slightly lower hedging effectiveness than the Chicago-Toledo combination for the par delivery case. Adding more delivery points may result in more frequent delivery at locations with abnormally low prices.

The estimates in table 5 suggest that changing the discounts and premiums would have little effect on hedging effectiveness and volume. The effect is small despite large differences in the frequencies of delivery at the various delivery points. Table 6 shows the delivery point frequencies for the alternative discounts and premiums used. For example, for the Chicago-Toledo combination the delivery frequencies were almost equal when discounts and premiums were based on average price differences. At par delivery three fourths of the deliveries were at Toledo reflecting the generally lower price at Toledo. Increasing the discount to 8 cents, twice the average price difference, resulted in only 19 percent of the deliveries at Toledo. Decreasing the premium for the Chicago-Illinois Processors combination to

Table 6. Delivery Frequencies at Alternative Locations with Par, Average Differences, and Penality Differences for March, June, September, and December, 1971-1991.

Delivery Points	Delivery Distributions				
	Chicago	Toledo	Minneapolis	Illinois Processors	Gulf
	--------Percent--------				
All locations at par					
Chicago, Toledo	25	75			
Chicago, Minneapolis	11		89		
Chicago, Ill. Processors	67			33	
All	4	19	74	2	1
Chicago at par, others at average differences[1]					
Chicago, Toledo	51	49			
Chicago, Minneapolis	58		42		
Chicago, Ill. Processors	48			52	
All	14	14	25	19	27
Chicago at par, others at penality differences[2]					
Chicago, Toledo	81	19			
Chicago, Minneapolis	87		13		
Chicago, Ill. Processors	55			45	
All	39	11	7	37	6

[1] Average differences relative to Chicago are -$0.04 for Toledo, -$0.11 for Minneapolis, $0.05 for Illinois Processors, and $0.28 for the Gulf.

[2] Discounts equal 2 times the negative average price differences and premiums equal 1/2 times the positive price differences from Chicago.

2 1/2 cents, one half the average price difference, increased the frequencies of Chicago delivery as did reducing the premium to zero for the par case.

A basic difference between cash and delivery settlement should be kept in mind when examining the results in tables 4 and 5. Cash settlement averages price distortions while adding a delivery point can avoid upward price distortions at the par delivery point by giving shorts an alternative place to deliver. However, adding a delivery point can pick up downward price distortions at the new delivery point.

Summary and Conclusions

The basis risks associated with location price differences for soybeans among 14 states were estimated for alternative futures cash settlement and delivery arrangements using quarterly observations of state farm-level prices and terminal prices for 1971 through 1991. Alternative settlement arrangements were compared in terms of average hedging effectiveness and relative volume of minimum-risk hedges. Each state was weighted by its stocks. This study differs from previous studies by focusing on location price differences, measuring price risks in terms of deviations from expectations instead of deviations from means, and aggregating hedging effectiveness across pricing locations.

The differences found in hedging effectiveness and hedging volume are relatively small reflecting the high correlations between price deviations from the preceding quarter's expectations at the various locations. The results indicate that overall hedging effectiveness and expected hedging volume would be reduced by basing cash or delivery settlement on prices outside the major producing area. However, hedging effectiveness and volume are relatively insensitive to the choice of delivery or cash settlement points within the major producing area. Moreover, using more than one price from the major producing area adds little to hedging effectiveness and volume.

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