Delivery Systems Versus Cash Settlement in Corn and Soybean Futures Contracts

by

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The economic function of a futures market is performed efficiently only when a high level of competition exists among the participants. If one or more traders are able to manipulate the market through the size of the position held, then futures prices may no longer reflect supply and demand conditions for the commodity or the financial instrument being traded. The prevention of "squeezes" or "corners" has been of major concern for futures institutions. At the heart of such distortions lies the type of settlement system associated with the futures contract. Hence, it is important to understand the effects of current and alternative contract specifications involving settlement at expiration.

This paper investigates the impact of settlement terms on the hedging effectiveness of two commodity futures contracts, the Chicago Board of Trade corn and soybean contracts. We focus on the effects of changes in the delivery locations and delivery differentials on price risk reduction for hedgers located at non-delivery markets. The multiple delivery issues are explored in the context of a futures pricing model allowing for a delivery option to be embedded in the futures price.

A general objective of the study is to analyze the present delivery system, alternative physical delivery systems, and cash settlement systems relative to each other. The specific objectives are to: (1) assess and compare the feasibility of alternative settlement delivery systems for corn and soybeans; (2) develop a method for estimating weights in a cash settlement index that minimizes basis risk; the value of the weighing scheme will be assessed relative to simple-average weights; and (3) construct an index where locations of the underlying prices are randomly selected in a manner which attempts to maintain a "consistent" index while inhibiting manipulation incentives. The following five sections provide a description of the theoretical framework, the settlement alternative considered, the methods used, the hypotheses tested and the data. The results of the simulation model for the corn and soybean contracts are presented in section VI. A summary of the main results and the implications of this study conclude the paper.

I. A Model of Futures Pricing with a Location Option

The delivery option plays an important role in the valuation of the futures price when the contract allows for such a flexibility. Expanding on previous work by Margrabe (1978) and Johnson (1987), Boyle (1989) shows that the price of a futures contract that allows delivery of several assets from an acceptable set of n assets equals the value of a call option on the minimum value of the n assets, with a strike price of zero.

In the case of three deliverables, the estimated value of the futures price is:

$$(1) \qquad F_t = e^{rT} \sum_{i=1}^{3} P_{it} \, N_3(d_{ij};\, d_{ik};\, \rho_i) \qquad i \neq j \neq k \qquad i,j,k = 1,2,3$$

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* The authors are Ph.D Candidate and Professor, Department of Agricultural Economics at the University of Illinois, Urbana-Champaign. This research was funded by a dissertation grant from the Chicago Board of Trade Educational Research Foundation. The authors would like to thank Phelim P. Boyle, Scott H. Irwin, Sarahelen R. Thompson, Raymond M. Leuthold and seminar participants at the University of Illinois Office of Futures and Option Research Workshop Series.

where:

$$N_3(d_{ij}; d_{ik}; \rho_i) = \int_{-\infty}^{+\infty} \int_{-\infty}^{d_{ij}} \int_{-\infty}^{d_{ik}} f(x,y,z)\, dx\, dy\, dz$$

$$\rho_i = \begin{bmatrix} 1 & -\rho_{iij} & -\rho_{iik} \\ -\rho_{iij} & 1 & \rho_{ijk} \\ -\rho_{iik} & \rho_{ijk} & 1 \end{bmatrix}$$

$$d_{ij} = \frac{\ln\frac{P_{jt}}{P_{it}} - \frac{1}{2}\sigma_{ij}^2 T}{\sigma_{ij}\sqrt{T}}$$

$$\rho_{iij} = \frac{\sigma_i - \rho_{ij}\sigma_j}{\sigma_{ij}} \qquad \rho_{ijk} = \frac{\sigma_i^2 - \rho_{ij}\sigma_i\sigma_j - \rho_{ik}\sigma_i\sigma_j + \rho_{jk}\sigma_j\sigma_k}{\sigma_{ij}\sigma_{ik}}$$

$$\sigma_i^2 = Var(\Delta \ln P_i) \qquad \rho_{ij} = Corr(\Delta \ln P_i, \Delta \ln P_j)$$

$$\sigma_{ij}^2 = Var(\Delta \ln \frac{P_i}{P_j}) = \sigma_i^2 - 2\rho_{ij}\sigma_i\sigma_j + \sigma_j^2 \qquad i \neq j \neq k \qquad i,j,k = 1,2,3$$

with f(x,y,z) being the trivariate standard normal density function, T the time to expiration, Var(·) the variance operator and Corr(·) the correlation coefficient between two random variables. As shown by equation (1), the valuation of the futures price involves the computation of a three-dimensional integral for the multivariate normal cumulative distribution. The trivariate normal distribution captures the fact that prices at deliverable locations are jointly determined. For a location, say market #1, to be the cheapest to deliver (over the entire range of prices taken by P_1), requires that P_1 must be less than P_2 (upper bound of integration d_{12}) and less than P_3 (upper bound of integration d_{13}) simultaneously.

Several futures contracts provide non-par pricing as a function of the delivery location. Delivery is allowed at the contract price at a specific point (commonly referred to as the par-location), say location A. The terms for non-par delivery (i.e. at any other location) are written in a way such that a short hedger who intends to deliver the commodity specified in the contract at an alternative location, say B, gets the contract price minus a discount if the delivery price at A is greater than that at B. If the delivery price difference is negative, then the short receives the contract price plus a premium. Given premiums or discounts, a slight modification in the futures pricing model described by equation (1) is needed. P_{it} is replaced by P'_{it} defined as:

$$(2) \qquad P'_{it} = P_{it} + \delta_i \quad with \quad \begin{cases} \delta_i < 0 \ , \ \delta_i = \textit{premium} \\ \delta_i > 0 \ , \ \delta_i = \textit{discount} \\ \delta_i = 0 \quad (\textit{par-pricing case}) \end{cases}$$

Almost all existing futures contracts providing for non-par pricing based on spatial differences have delivery terms specifying constant premiums and discounts. However, when commercial price differences are subject to structural changes, the constant adjustment may no longer reflect the intentions existing when the terms were written. An alternative to constant premiums/discounts is to allow the discount specification to vary over time as done in the cotton contract traded at the New York Cotton Exchange. The exchange can make regular adjustments depending on the behavior of cash price differences before each contract expiration. To account for such a variable adjustment in the discount, P_{it} in equation (1) is replaced by P''_{it} defined as:

$$(3) \qquad P''_{it} = P_{it} + \delta_{it} \qquad \delta_{it} = \sum_{j=1}^{t^*} \frac{1}{t^*}(P_{k,t-j} - P_{i,t-j})$$

$$\text{where} \begin{cases} \delta_{it} = \textit{moving-average adjustment} \\ P_{k,t-j} = \textit{lagged price at par location } L_k \in \Phi_I \\ P_{i,t-j} = \textit{lagged price at non-par location } L_i \in \Phi_I \\ [t^*, t] = \textit{span of moving-average horizon} \\ \Phi_I = \textit{set of delivery locations } L_i \\ i = 1,2,\ldots,I \end{cases}$$

II. Cash Index Construction

Several weighing schemes have been used and suggested when designing terms for contract settlement by cash. One approach used here reflects the information derived from the futures price simulations through the use of the cheapest-to-deliver probabilities (CTD probabilities). Some of the fundamentals of the market are reflected not only through prices at deliverable locations but also through the probability of a location becoming the cheapest at contract maturity. As suggested by Hauser, Chaherli and Thompson (1992), the average CTD probabilities over time might be used as weights in the price index. This type of index has one of the desirable features in a spot price index that an equally weighted index would not necessarily capture: the ability to reflect relevant information drawn from the dynamics existing in the spot markets. To illustrate such a weighing scheme, let the deliverable set contain three markets: market #1, market #2 and market #3. Equation (1) can be rewritten as:

$$(4) \qquad F_t = e^{rT}[P_{1t}w_{1t} + P_{2t}w_{2t} + P_{3t}w_{3t}] \qquad w_{it} = N_3(d_i\, , \rho_i) \qquad i=1,2,3$$

where each price is weighted with the probability that the commodity at the respective location will be the cheapest to deliver. $N_3(\cdot)$ is the trivariate cumulative normal distribution with arguments d_i, the vector of upper bounds and ρ_i the correlation matrix as defined in equation (1). The time dependent probabilities in equation (4) are averaged over time to give a mean CTD-probability for each respective price. Now define I^{CTD} as an index of spot prices such that:

$$(5) \qquad I_t^{CTD} = e^{rT}\,[P_{1t}\hat{w}_1 + P_{2t}\hat{w}_2 + P_{3t}\hat{w}_3] \qquad \hat{w}_i = \frac{1}{\tau}\sum_{k=0}^{\tau} w_{ik}$$

where $[0,\tau]$ is the time interval over which CTD probabilities are averaged. This index differs from indices that has been used in past cash settlement studies in that it uses information provided by a simulated physical delivery system but serves as a settlement price at the expiration of the contract. In the remaining of the discussion, this type of index will be referred to as a CTD-weighted-index to reflect the link between the CTD probabilities and the weights used in the index. Hauser, Chaherli and Thompson conjectured that if the simulated futures price and the CTD-weighted-index are highly correlated then there may be little gain by using an index weighted by the underlying probabilities over a delivery system which would include the same deliverable locations.

One major drawback behind the use of a cash settlement scheme may be the index's susceptibility to manipulation. If traders know that a particular cash price is used in the index, they may attempt to "punch the settlement price." To address the issue of manipulation, the following simulation was designed. A basket of prices from which locations are randomly drawn is used to construct an index. This index contains at any given time a subset of the original basket of prices. Though the set from which locations are pulled is known with certainty, the composition of the subset keeps changing in a random fashion. The expectations that a change in the cash location will affect the index take a different nature as more uncertainty is introduced in the system. If a trader is told that his/her strategy may fail because of the randomness in the way cash markets are picked, there would presumably be less incentive to make such an attempt because of the increased risk associated with the intended manipulation effort.

The procedure suggested is to remove randomly `k` prices from the index. This index, I_k^{Ran}, will be defined as:

$$(6) \qquad I_k^{Ran} = e^{rT} \sum_{n=1}^{N} \frac{1}{N-k} w_t P_t \quad s.t. \quad \frac{1}{N-k} \sum_{n=1}^{N} w_t = 1 \qquad k < N$$

This means that at any given time, only N-k prices are part of the index.

One potential drawback from the procedure presented above is that the effectiveness of the index may decrease as the number of randomly dropped prices increases because of the reduction in the degree of correlation between the index and the spot market prices. A different randomization procedure in the index is proposed to reduce the potential for manipulation but without necessarily reducing the effectiveness of the index. The key to such an improvement stems from the degree to which each major marketing region is composed of highly integrated cash locations. Suppose that we have `J` different regions with `$K_j$` prices in each area. The procedure would consist of pulling out of the index one single price from the set of `$K_j$` elements for each one of the `J` regions; i.e., a total of `J` locations are dropped. This index will reflect supply and demand conditions at each of the major areas with less potential for misrepresentation of major producing areas. Market participants would know that the index fairly represents, for example, the Ohio cash markets but they would not be able to perfectly detect which particular location is in the index. Because of the presumably high degree of correlation between markets within the same geographic area, this method may be an easily implemented solution to address the trade-off between effectiveness and manipulation.

III. Hedging Performance Evaluation

The typical hedging effectiveness measure (Ederington) is used to analyze the effectiveness of hedging decisions made by individuals for each of the settlement specifications discussed in the previous sections. Let π be the profit or loss from a hedge, h be the fraction of the cash position hedged and h^* be the risk minimizing hedge ratio. The measure of hedging effectiveness (HE) is defined as the difference between the variance of the unhedged position, $Var(\pi_{h=0})$, and the variance of the hedged position, $Var(\pi_{h^*})$, divided by the variance of the unhedged position:

$$HE = \frac{Var\,\pi_{h=0} - Var\,\pi_{h^*}}{Var\,\pi_{h=0}} = \frac{\sigma_{pf}^2}{\sigma_f^2\,\sigma_p^2} = R^2$$

$$\sigma_{pf} = Cov(\Delta P_t, \Delta F_{k,t}) \qquad \sigma_f = Var(\Delta F_{k,t}) \qquad \sigma_p = Var(\Delta P_t)$$

where R^2 is the coefficient of determination from the ordinary least squares regression of the change in the cash price on the change in the price of a futures contract expiring at time k:

$$\Delta P_t = a + b\Delta F_{k,t} + u_t$$

A futures price for a contract that expires in five weeks is simulated first. A second futures price for the same contract expiring in four weeks is also simulated. For our analysis, a trivariate distribution of cash prices is used to value the futures price (eq. 1). The correlation matrix is based on the previous thirty weekly prices. The interest rate, r, is equal to the storage rate of return implied by the nearby and next nearby futures prices. Given the series of synthetic futures prices, the HE regression is run using a log-log specification with one-week price differences; i.e.:

$$(7) \qquad \ln(\frac{P_{it}}{P_{it-1}}) = \alpha_{ij} + \beta_{ij}\ln(\frac{F_{jt}}{F_{jt-1}}) + \epsilon_{ijt}$$

where F_j is the settlement price based on one of the settlement processes defined above and P_i is a cash price at non-delivery location L_i. The same procedure is used to evaluate cash settlement indices by replacing the futures price, F, with the cash settlement index. Specifications are then ranked according to the level of R^2. The approach is similar to the one followed by Pirrong, Haddock and Kormendi (1991).

IV. Non-Nested Modeling of Settlement Specifications

The hedging effectiveness relationships have different settlement price specifications due to delivery differentials, delivery points, and nature of the settlement process. The relationships cannot be obtained from one another by imposing parametric restrictions and thus represent "non-nested" models. To assess the statistical differences of the hedging effectiveness regressions, a testing hypothesis approach is employed. The approach relies on the prediction of the model performance based on the data generation process (DGP) of cash prices. Suppose that the null hypothesis

$$(8) \qquad H_0: \ C_i = \alpha_0 F_0 + \beta_0 + u_0 \qquad E(u_0^2) = \sigma_0^2$$

is the true DGP for C_i (cash price at location L_i) where F_0 is the settlement price based on specification S_0. Another specification S_1 with settlement price F_1 is believed to generate the true DGP and is predicted on the basis of H_0:

$$(9) \qquad H_1: \ C_i = \alpha_1 F_1 + \beta_1 + u_1 \qquad E(u_1^2) = \sigma_1^2$$

These two models can be combined into the single model:

$$(10) \qquad C_i = (1 - \delta)\alpha_0 F_0 + \delta \alpha_1 F_1 + \beta + u$$

Since the slope coefficients in H_0 and H_1 cannot be estimated directly from (10), Davidson and MacKinnon (1981) suggest that the predicted value of C_i based on the model given by H_1 in (9) be used in (10) and then test whether δ equals zero. When H_0 is true, they show that the estimator of δ divided by its conventionally estimated standard error is asymptotically distributed as a standard normal N(0,1). The steps of this "J-test" are:

- *Estimate the regression* : $C_i = \alpha_1 F_1 + \beta_1 + u_1$

  Let : $\hat{c}_{i1} = \hat{\alpha}_1 F_1 + \hat{\beta}_1$

- *Estimate the regression* : $C_i = (1 - \delta)\alpha_0 F_0 + \delta \hat{c}_{i1} + \hat{\beta}_1 + u$

- *Test the hypothesis* $\delta = 0$

Note that when H_0 is being tested, H_1 is used to challenge the adequacy of H_0. If it happens that H_0 is rejected then it should not be argued that H_1 is the true model. To make a statement about the validity of H_1, the roles have to be reversed and the testing procedure carried out again.

V. Description of Data

The cash markets considered are Minneapolis, Chicago, Northern Illinois, Central Illinois, St. Louis, New Orleans, Toledo, Eastern Ohio, Western Ohio, Cincinnati and Kansas City. Cash bids for Northern Illinois, Central Illinois and St. Louis are from the Illinois Agricultural Marketing Service. Prices for Eastern Ohio, Western Ohio and Cincinnati were supplied by Dean Baldwin, Ohio State University (Baldwin and Dayton). Prices for Minneapolis, Chicago, Toledo, Kansas City and New Orleans are from USDA Grain and Feed Market News publications. These prices are based on a daily price survey of grain buyers at major commercial or production locations. For the USDA set of prices, the midpoint of the reported price range is used. Futures prices are from CBOT publications. A nearby futures price series is constructed by rolling over the contract before the beginning of the delivery period. All prices are Thursday prices from January 1981 through December 1991.

VI. Results

The following section presents and analyzes the hedging performance of various settlement specifications discussed previously. The four settlement methods are (a) multiple physical delivery with constant price differentials, (b) multiple physical delivery with variable price differentials, (c) cash settlement based on the cheapest-to-deliver probability weighing scheme, and (d) cash settlement based on random location weighing schemes. Each type of specification is evaluated separately with respect to changes in the settlement and then comparisons are made across specifications. The results for the testable hypothesis evaluation for a selected group of specifications are then presented in Section 2.

1. Hedging Effectiveness and Settlement Specifications

Given different specifications considered, the main questions in this study are:

(1) Which type of settlement terms yields the highest level of hedging effectiveness (multiple delivery or cash settlement specification)?

(2) How sensitive are estimates of hedging effectiveness to changes in the size of delivery differentials (discount/premium)?

(3) Which is the best set of delivery locations?

(4) How does the randomness in the index locations affect levels of hedging effectiveness?

(5) Are non-delivery locations affected in the same way by changes in settlement terms?

<u>Changes in Delivery Differentials</u>

Tables 1 (corn) and 2 (soybeans) show levels of hedging effectiveness at individual locations. For most of the locations, performances tend to be clearly related to the weights among delivery locations. For example, the larger the percentage for delivery potential in St. Louis, the higher the level of hedging effectiveness at Northern Illinois. These types of results confirm the intuition that any change in discounts will make one location better off at the expense of other locations. However, presumably the main concern behind optimal contract design is on the entire system's response to changes in delivery differentials. The mean performance (last column) varies slightly as delivery differentials change. For both corn and soybeans, the difference between the most effective and the least effective delivery specification does not exceed 2% in absolute terms.

The traditional specification for these two commodities yields the lowest level of hedging effectiveness. The current specification improves performance from 78% to 80% in soybeans and from 64% to 65% in corn. The statistical significance of these changes will be considered later. There are other specifications that have a potential to reduce even more basis risk in both contracts. Overall, changing the type of differential in St. Louis for corn, and adding the same location as a soybean delivery location seems to improve the contracts' hedgeability.

<u>Changes in Delivery Set</u>

The impact of changes in the delivery set on hedging performance is summarized in Tables 3 and 4 for corn and soybeans respectively. The most effective specification is selected for each delivery set. The first row

Table 1

Corn Hedging Effectiveness Under Alternative Settlement Specifications

CORN	Non Delivery Location					
	MIN	NIL	EOH	GUL	KCT	Mean
Traditional Delivery[1]	.53	.62	.67	.62	.62	.64
Current Delivery[2]	.59	.70	.63	.66	.62	.65
Most Effective Delivery[3]	.59	.76	.59	.72	.63	.66
Least Effective Delivery[4]	.56	.65	.66	.63	.61	.64
Variable Adjustment[5]	.57	.69	.61	.66	.60	.63
Most Effective Cash Index[6]	.62	.78	.69	.75	.72	.72
Least Effective Cash Index[7]	.55	.66	.72	.66	.65	.67
All Location Index	.68	.81	.75	.80	.78	.77
Random Index #1[8]	.62	.77	.71	.74	.74	.72
Random Index #2[8]	.54	.70	.67	.68	.71	.67
Random Index[9] #3	.58	.70	.65	.67	.67	.66

Notes:
Non delivery locations are: MIN = Minneapolis; NIL = Northern Illinois; EOH = Eastern Ohio; CIN = Cincinnati; GUL = Gulf; KCT = Kansas City. The mean column represents the average performance for eight non-delivery locations.

(1) The traditional delivery specification simulation uses the delivery set and discount adjustments in effect during the 1981-1991 period.
(2) This specification replicates the terms currently used for contract settlement.
(3) Specification simulated with an 8¢ discount at Toledo and a 10¢ premium in St. Louis. Delivery would occur approximately 75% of the time in St. Louis.
(4) Specification simulated with a 2¢ discount at Toledo and 3¢ premium in St. Louis. Delivery would occur 75% of the time in Toledo.
(5) The variable adjustment specification relies on a variable discount and premium adjustment process based on past price difference behavior.
(6) The highest level of hedging effectiveness for cash settlement is obtained with a cash index equally weighted with Chicago, St. Louis and Toledo prices.
(7) The least effective cash index has 75% of total weight given to Toledo.
(8) Random Index #1 has one single market dropped from a basket of eleven locations. Random Index #2 has two markets dropped.
(9) One price is dropped from each of three different geographical areas. See footnote 1 for exact composition.

Table 2

Soybean Hedging Effectiveness Under Alternative Settlement Specifications

SOYBEANS	Non Delivery Location					
	MIN	NIL	EOH	GUL	KCT	Mean
Traditional Delivery(1)	.71	.79	.80	.81	.76	.78
Current Delivery(2)	.73	.83	.79	.84	.76	.80
Most Effective Delivery(3)	.72	.83	.79	.84	.76	.80
Least Delivery Delivery(4)	.70	.79	.80	.81	.76	.78
Variable Adjustment(5)	.72	.82	.79	.83	.76	.80
Most Effective Cash Index(6)	.75	.85	.81	.84	.79	.82
Least Effective Cash Index(7)	.74	.82	.81	.84	.79	.81
All Location Index	.81	.89	.84	.89	.85	.87
Random Index #1(8)	.79	.87	.82	.87	.84	.85
Random Index #2(8)	.76	.84	.81	.84	.83	.83
Random Index(9) #3	.78	.86	.82	.85	.80	.83

Notes:
Non delivery locations are: MIN = Minneapolis; NIL = Northern Illinois; EOH = Eastern Ohio; CIN = Cincinnati; GUL = Gulf; KCT = Kansas City. The mean column represents the average performance for eight non-delivery locations.

(1) The traditional delivery specification simulation uses the a two point-delivery system with Toledo at an 8¢ discount.

(2) This specification replicates the terms currently used for contract settlement.

(3) Specification simulated with a 3¢ discount at Toledo and 11¢ premium in St. Louis. Delivery would occur approximately 50%, 25% and 25% of the time in St. Louis, Toledo and Chicago respectively.

(4) Specification simulated with a 2¢ premium in Toledo and 4¢ premium in St.Louis. Delivery would occur approximately 70%, 20% and 10% of the time in Toledo, Chicago and St. Louis respectively.

(5) The variable adjustment specification relies on a variable discount and premium adjustment process based on past price difference behavior.

(6) The highest level of hedging effectiveness for cash settlement is obtained with a cash index equally weighted with Chicago, St. Louis and Toledo prices.

(7) The least effective cash index is a two-market index where Toledo and Chicago hold 25% and 75% of total weight respectively .

(8) See Table 1.

(9) Idem.

in both tables shows the performance with multiple delivery based on constant differentials. Changing the composition of the current delivery set to that suggested by the CFTC (1991) does not seem to be a potential source for major improvement in hedging performance. There is, however, a small improvement in soybeans if the Gulf is substituted for Chicago as the third delivery location. Given the cost associated with the replacement of the contracts' existing delivery points and the extent of a potential increase in hedging effectiveness, these results tend to support Peck and Williams' viewpoint that a radically different delivery set lacks justification.

Changes in Nature of Delivery Differentials

Though the suggestion of varying the size of the discount/premium based on observed commercial differences has theoretical appeal, there is no empirical support for the adoption of a variable adjustment specification for either corn or soybeans. The fifth row in Tables 1 and 2 shows individual as well as average performances with a variable differential delivery specification. For most of the individual locations, constant differentials are more effective than variable differentials. Furthermore, no matter what delivery set is adopted, the variable differential specification does not yield levels of hedging effectiveness higher than the levels obtained with a constant differential as shown in Tables 3 and 4. Switching the settlement of the contract from constant to variable differentials may worsen the level of hedging effectiveness by up to 3% on average for a corn hedger at a non-delivery location. In soybeans, the change would not improve upon the current specification.

Given the estimated impacts of changing some of the terms in the physical delivery process, the next discussion focuses on changing characteristics of the weighing scheme for cash settlement. Changes in weight size and index composition are evaluated on an individual basis and on average. The two types of indices considered have weighing schemes based on CTD probabilities and on random composition.

Changes in Index Weight and Composition

The weights given to each market in a cash index often affect the hedging performance at individual cash markets. As seen in Table 1, the difference between the least and most effective index may be substantial not only for individual markets but also on average for corn. Table 2 on the other hand shows relatively small differences between the most and least effective soybean cash index when Chicago, St. Louis and Toledo prices are part of the index.

Modifying the composition of the index has small effects on the average level of hedging effectiveness. The last row in Tables 3 and 4 show the comparative performance of each of the three baskets of prices. For corn, Chicago-St. Louis-Toledo provides the highest performance, while for soybeans, the best specification with the Gulf market outperforms the best specification with the Chicago market by a narrow margin (84% vs. 82%).

Randomizing the Index Composition

The issue of manipulation is addressed by examining the performance of a set of indices with random locations. The bottom part of Table 1 shows the corn hedging performance of three indices from which locations are dropped randomly. The bench mark used is an eleven location index with known composition. The performance of the first index reaches the 72% level of hedging effectiveness on average. The performance drops by 5% as an additional location is dropped, confirming the intuition that hedging effectiveness may decrease with fewer prices in the index. However, as prices selected from three different marketing areas[1] are randomly dropped, a further "significant" decrease in hedging effectiveness is not evident. Index #2 and Index #3 yield a percent reduction in variance of 67% and 66% respectively. This may indicate that by carefully designing the sets from which prices are dropped, an acceptable level of risk reduction can be achieved without necessarily jeopardizing the manipulation inhibitor feature of the index. While the performance of Index #2 and Index #3 is similar, a significant drop (about 6%) in the performance arises between Index #1 and Index #2 or #3.

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[1] The three subsets are:

A: Northern Illinois, Central Illinois and St. Louis.

B: Western Ohio, Eastern Ohio, Toledo and Cincinnati.

C: Minneapolis, Chicago, the Gulf and Kansas City.

Table 3

Impact of Changes in Delivery Set on Corn Hedging Effectiveness

Delivery Set[(1)] / Settlement Type	Chicago St. Louis Toledo	Toledo St. Louis Central Illinois	Toledo St. Louis Gulf
Multiple Delivery Constant Adjustment	.66	.64	.66
Multiple Delivery Variable Adjustment	.63	.63	.64
Cash Settlement[(2)]	.72	.71	.72

Notes:
(1) The best settlement specification in terms of hedging effectiveness has been selected for comparison across delivery sets.
(2) Since no physical delivery is involved in cash settlement, the delivery set refers in fact to the composition of the index.

Table 4

Impact of Changes in Delivery Set on Soybean Hedging Effectiveness

Delivery Set[(1)] / Settlement Type	Chicago St. Louis Toledo	Toledo St. Louis Central Illinois	Toledo St. Louis Gulf
Multiple Delivery Constant Adjustment	.80	.81	.81
Multiple Delivery Variable Adjustment	.80	.81	.80
Cash Settlement[(2)]	.82	.83	.84

Notes:
(1) See Table 3.
(2) Idem.

The same type of indices are evaluated for soybeans in Table 2. Settling the contract at expiration with such an index appears to be effective. Pulling one single location from a set of eleven locations provides, on average, 85% reduction in futures basis risk. The other two random indices (one and two locations dropped) are slightly less effective than the previous index. Interestingly, pulling up to three markets from the index performs as well as the index with two markets dropped. Indeed, for several locations, Index #3 performs better than Index #2. These findings indicate that when designing a random index, the way markets are dropped from the index may be more important than the number of markets pulled out.

Settlement Specifications

In the previous discussion, comparisons of performances for the same type of settlement was done. On average, it appears that features such as the composition of the delivery set, the magnitude and nature of delivery differentials marginally affect hedging effectiveness for multiple delivery specifications. An important question that remains is whether cash settlement in the different forms considered in this study can outperform multiple-point physical delivery.

Comparisons of performance between physical delivery and cash settlement suggest that the latter provides a more effective device for hedging. An examination of Tables 1 and 2 indicates that cash settlement specifications based on a CTD probabilities perform slightly better than multiple delivery specifications in reducing basis risk at the locations considered. On average, cash settlement provides up to 6% more risk reduction than multiple delivery for any of the delivery sets for corn (Table 3). The difference for soybeans is only 2% when considering the current delivery set (Table 4). However, choosing an index with Toledo, St. Louis and the Gulf soybean cash markets yields 4% more risk reduction than the best multiple delivery specification.

The random indices provides the same kind of advantage over multiple delivery specifications. The random index performance suggests a trade-off between hedging effectiveness and manipulation. For corn, as more prices are dropped, the advantage of using this type of settlement diminishes. Nevertheless, the random index with three prices dropped provide as much hedging effectiveness as the most effective multiple delivery specification. For soybeans, the random indices tend to outperform both cash indices with CTD weights and multiple delivery specifications, regardless of the number of locations dropped .

Summary of Corn and Soybean Futures Basis Risk Simulations

Alternative means of settlement are evaluated from a hedging effectiveness standpoint for corn and soybean futures. The findings suggest that the size of price differentials as well as the composition of the delivery set have a slight influence on basis risk reduction levels at non-delivery locations. The results also indicate that a multiple delivery based on variable price differentials does not outperform schemes with constant price differentials. The expansion of the delivery set in soybeans leads to an increase in hedging effectiveness at non- delivery locations. The safety valve system previously in place yields the lowest level of risk reduction among all physical delivery specifications.

Comparisons of performance between physical delivery and cash settlement indicate that the latter provides a more effective hedging tool. The level of aggregation in the analysis determines whether the index weighing scheme and composition, price differentials, and the choice of delivery set are influential in determining levels of hedging effectiveness. With results disaggregated by market, the above parameters do play a role. However, as results are averaged or aggregated, the specifics of each type of settlement tend to have only a marginal impact.

The results of the analysis of cash settlement with a random location index suggest that the manipulation inhibitor scheme can provide levels of hedging effectiveness above the levels obtained with multiple delivery. However, a balance should be made between market security and economic efficiency.

2. Hypothesis Testing Results

Seven of the sixty three specifications are chosen for non-nested testing. The best specification from each class of multiple delivery specifications is used for evaluation. In addition to these three specifications, the simulated specification with the current delivery differentials (corn: 3¢ discount for Toledo and 7¢ premium for St. Louis; soybeans: 8¢ discount for Toledo and 8¢ premium for St. Louis) as well as the traditional specifications in effect until 1993 are examined. Two cash settlement specifications based on indices composed of Chicago, St. Louis and Toledo prices for the first index and Toledo, St. Louis and the Gulf for the second index represent the second type of settlement.

Percentage changes in cash prices at five non-delivery locations (Minneapolis, Northern Illinois, Western Ohio, Eastern Ohio and Kansas City) are the dependent variables and percentage changes in the simulated settlement prices for each of the seven specifications are the explanatory variables. Since there is no "true" null hypothesis, tests are performed by holding each specification hypothesis as null and testing it with respect to the other six specification hypotheses. A summary of these results is provided in Table 5 for corn and Table 6 for soybeans. These two tables show the number of markets for which the test is not rejected. For example, the entry in the second row and first column of Table 5 shows that the current settlement specification is not rejected in favor of the traditional specification in two of five markets. This of course does not mean that in the remaining three markets the traditional specification is preferred over the current settlement. Similarly, the entry in the transpose cell gives the number of markets for which the old settlement is not rejected in favor of the current settlement specification. These summary tables are divided into four regions representing four different types of comparisons:

(1) the upper-left region compares specifications with physical delivery terms;
(2) the upper-right region compares physical delivery (null hypothesis) to cash settlement (alternative hypothesis);
(3) the lower-left region compares cash settlement specifications to multiple delivery specifications;
(4) the lower-right region compares the two cash indices to each other.

Corn Contract Results

When cash settlement specifications are tested against multiple delivery specification (lower-left region), the results based on the R^2 as a measure of hedging effectiveness tend to be supported by the J-test. In more than 60%[2] of the pairwise comparisons, the model based on cash settlement is not rejected when tested against multiple delivery. In none of the cases is multiple delivery not rejected when compared to cash settlement (upper-right region).

The results from the multiple delivery comparisons (upper-left) do not significantly support one specification over the other four. The delivery settlement with the most non-rejection cases is the current specification. Though the index with Toledo-St. Louis-Gulf (TSG) has more non-rejection cases than its equally-weighted Chicago-St. louis-Toledo (CST) counterpart, it is difficult to favor one index over the other.

Among the four types of comparisons, the most distinguishing feature is the statistical difference between cash settlement and multiple delivery. Regardless of how the index is weighted, it tends to perform better than any of the multiple delivery specifications selected. Given the number of markets for which cash settlement is not rejected compared to multiple delivery, it is unlikely that this difference is due to chance.

Soybean Contract Results

The soybean results in Table 6 do not differ much from the general results of corn; i.e., cash settlement tends to be rejected less often than multiple delivery. There are no instances where multiple delivery is not rejected when tested against cash settlement as shown by the zero figures in the upper-right region.

Though it is difficult to conclude that a particular multiple delivery specification is superior over the other four, the best CST specification is not rejected for all five markets when tested against the current delivery specification. The former is also not rejected for three out of five markets when tested against the latter. The results given by the lower-right region tend to favor the TSG equally weighted cash index over the CST cash index.

Testing Hypothesis Result Summary

The higher level of hedging effectiveness obtained with cash settlement and reported in Section 1 is supported by the non-nested hypothesis testing procedure. When multiple delivery is used as the null hypothesis, it is always rejected in favor of both cash indices. This higher performance seems to be robust not only across model selection techniques used but also across commodities.

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[2] This figure corresponds to the thirty one cells out of fifty possible (five markets, five multiple delivery specifications and two cash indices) for which the J-statistic falls in the non-rejection region.

Table 5

Hypothesis Testing Corn Results with J-Test
Number of Markets with Non-Rejected Null Hypothesis

Row is Null Hypothesis Column is Alternative Hypothesis	Multiple Delivery					Cash Settlement	
	1	2	3	4	5	6	7
1		2	0	0	0	0	0
2	2		2	2	0	0	0
3	0	1		0	0	0	0
4	1	1	0		0	0	0
5	1	0	1	1		0	0
6	2	4	2	3	2		1
7	3	4	4	3	4	2	

Specifications Selected:
1: Traditional specification
2: Current specification
3: Best multiple delivery specification with Chicago-St. Louis-Toledo delivery set
4: Best multiple delivery specification with Toledo-St. Louis-Central Illinois delivery set
5: Best multiple delivery specification with Toledo-St. Louis-Gulf delivery set
6: Cash settlement index equally weighted with current delivery market prices.
7: Cash settlement index equally weighted with Toledo, St. Louis and Gulf market prices.

Table 6

Hypothesis Testing Soybean Results with J-Test
Number of Markets with Non-Rejected Null Hypothesis

Row is Null Hypothesis Column is Alternative Hypothesis	Multiple Delivery					Cash Settlement	
	1	2	3	4	5	6	7
1		0	0	0	0	0	0
2	2		3	0	0	0	0
3	1	5		0	0	0	0
4	0	0	3		0	0	0
5	0	0	1	0		0	0
6	4	4	3	0	2		1
7	3	4	4	2	4	4	

Specifications Selected:
1: Traditional specification (two delivery-point system with Chicago and Toledo)
2: Current specification (three delivery-point system)
3: Best multiple delivery specification with Chicago-St. Louis-Toledo delivery set
4: Best multiple delivery specification with Toledo-St. Louis-Central Illinois delivery set
5: Best multiple delivery specification with Toledo-St. Louis-Gulf delivery set
6: Cash settlement index equally weighted with current delivery market prices.
7: Cash settlement index equally weighted with Toledo, St. Louis and Gulf market prices.

Concluding Remarks

The goal of this study was to analyze the hedging performance of CBOT corn and soybean contracts under the traditional physical delivery system, alternative combinations of physical delivery systems, and cash settlement. A pricing model incorporating an explicit option is used to estimate futures prices under different settlement terms such as price delivery differentials and delivery locations. Also, the cheapest-to-deliver probabilities derived from various specifications of the delivery terms provide an alternative weighing scheme for cash settlement. The study expands on previous work by considering a framework where alternative multiple delivery specifications are compared to cash settlement specifications.

Another contribution of this research is in simultaneously addressing the issue of hedging performance and manipulation in cash settlement. An index where locations are randomly drawn from a set of terminal markets as well as country elevators is constructed with the purpose of inhibiting manipulation under cash settlement. The results suggest that such an index could provide a good measure of value and be difficult to manipulate.

One method for describing and assessing the performance of the different settlement specifications investigated in this study is to examine how effectively cash market participants at non-delivery locations can hedge their price risk. The results indicate that hedging effectiveness, when measured individually at non-delivery locations, responds to changes in delivery differentials as well as delivery locations. However, as results are aggregated over space, the changes in settlement specifications tend to affect hedging performance only marginally. Results also suggest that cash settlement provides slightly higher levels of hedging effectiveness than any type of multiple physical delivery. The cash settlement results are not very sensitive to either the weighing scheme or the composition of the index when performances are evaluated for the entire set of non-delivery locations.

With respect to the recent changes in the CBOT corn and futures contracts, changing the corn discount in Toledo and St. Louis does not cause a decrease in the levels of hedging effectiveness compared to the traditional specification. The addition of St. Louis as a soybean delivery location improves hedging performance at most non-delivery locations though it does not cause large changes.

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