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The Potential for Using Midwest Futures Contracts to Reduce Risk and Increase Storage Returns on Pacific Northwest Wheat

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Abstract

Procedures are developed for forecasting weekly cash prices for white wheat and the basis separating white wheat prices and Midwest futures prices. Forecast variances of each are supplied. A procedure is developed for choosing from among marketing options having uncertain outcomes. Operating results are simulated for the 1972/73-1977/78 storage seasons.

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The use of wheat futures in marketing wheat produced in the Pacific Northwest has historically been very limited. The major class of wheat produced there (white) is not deliverable against any of the wheat futures contracts currently traded and no consistent relation between cash white wheat prices and futures prices is evident. If changes in this relation were predictable, Pacific Northwest wheat producers and traders might profitably use wheat futures. This paper discusses results of research directed at determining if such predictability exists and how it might be used to increase white wheat storage earnings. The emphasis will be on uses most relevant in marketing wheat that has already been harvested.

Storage Decision Making in the Presence of Uncertainty

Wheat inventory holders must make decisions in the absence of exact information as to some of the outcomes. We assume that decision makers consider both expected returns and the dispersion of actual outcomes about expected returns from those decisions. We first examine how expectations and dispersion of outcomes from three decisions might be determined.

Sell Out Now

The expected return per bushel available to a decision maker from choosing this alternative is known with certainty to be the current cash price for white wheat.

$$E(R^S) = P_0^c \qquad (1)$$

In equation (1), R^S is return available from a sell out now decision; and P_0^c is current cash price.

Store Unhedged

The expected return from choosing to store wheat from the present to some later time period equals the expected cash price at time t,P_t^c, less the cost of storage from time 0 to time t, C_t^u.

(2) $$E(R^u) = E(P_t^c) - C_t^u$$

C_t^u includes elevator in and out charges, storage, and interest. It is assumed that C_t^u is known at the beginning of the storage period.

Attempts to model determination of within-season wheat prices are not likely to yield satisfactory results. But unquestionably, producers often do delay selling wheat inventories in anticipation of higher cash prices, and for our work a model is specified to represent a process producers might use in forming price expectations. At the beginning of the storage season, an initial forecast is made for price in every week of the storage season by multiplying the actual beginning price by a set of average historical ratios of price in each week to price in the beginning week of the storage season. In subsequent weeks, the entire set of remaining price forecasts is adjusted by adding to each a constant fraction of the difference between actual price in the current week and the most recent forecast of that price. The constant was chosen to minimize the average of the mean squared forecast errors over all possible forecast horizons in the 1972/73-1975/76 storage seasons.

In the analysis which follows, it is assumed that inventory holders may wish to hold wheat unhedged in anticipation of high cash prices in any one of several future time periods. However, for each of these, there is uncertainty as to the deviation of actual future price from its expected value, and this uncertainty is assumed to affect the choice whether or not to store unhedged. The cash price forecasting model was used to determine a mean squared forecast error for each possible forecasting horizon during the 1972/73-1975/76 storage seasons, and the square roots of these, $\hat{\sigma}^u_t$, were used as measures of the uncertainty attached to expected returns from holding unhedged for a period t weeks into the future.

Store Hedged

The return available to an inventory holder from storing his wheat from time 0 to time t hedged against any one of the six different futures contracts is equal to the current futures price of the j^{th} contract, $P^f_{0,j}$, plus the cash price at future time t, P^c_t less the price of the j^{th} futures at the time the contract is settled via offsetting futures purchase, $P^f_{t,j}$, less the cost of hedged storage, C^h_t, to time t. Hedged storage cost differs from cost of unhedged storage by the costs of futures trading.

(3) $$R^h_{t,j} = P^f_{0,j} + P^c_t - P^c_{t,j} - C^h_t$$

A more useful formulation of (3) is obtained by adding and subtracting cash prices at the beginning of the storage interval.

(3') $$R^h_{t,j} = P^c_0 + (P^f_{0,j} - P^c_0) - (P^f_{t,j} - P^c_t) - C^h_t \qquad j = 1, 2, \ldots, 6$$

The two parenthetical expressions in (3') define the basis in time 0, B_0, and time t, B_t, respectively. We thus rewrite (3') as (3").

(3") $$R^h_{t,j} = P^c_0 + B_{0,j} - B_{t,j} - C^h_t$$

The expected return associated with storing wheat and hedging it is subject to uncertainty because of the presence in (3") of the variable $B_{t,j}$, the unknown basis against contract j at future time t. Taking expectations of (3") yields:

(4) $$E(R^h_j) = P^c_0 + B_{0,j} - E(B_{t,j}) - C^h_t.$$

Decision making under a hedging strategy thus requires a procedure for forecasting expected basis and measuring the uncertainty attached to deviations of actual outcomes from their expectations.

At any time prior to delivery, the basis represents the price stockholders could expect to receive from holding stocks from that time to the delivery date, i.e., it represents the supply price for storage.

While the exact level of basis is determined by the simultaneous interaction of both supply and demand for stocks, the total supply is essentially fixed and known at any point within a storage season. Therefore, to a large extent, basis at any point within a storage season depends upon supply (stocks) at that time, so long as the commodity is deliverable.

But what about the relation between futures' prices of deliverable commodities and cash prices of nondeliverable commodities? A consistent relation can be derived if there is a consistent connection between cash prices of deliverable and non-deliverable commodities. White wheat does not substitute perfectly for deliverable classes of wheat, but it is a close substitute for soft red winter wheat (the deliverable class for Chicago contracts) and may be used in varying proportions in blends with hard red winter (the deliverable class for Kansas City contracts). Most actual substitution occurs in export markets, but existence of a <u>potential</u> for substitution serves to maintain an identifiable relation between prices of deliverable classes and prices of white wheat. The relation depends substantially on relative supplies of white wheat and deliverable classes of wheat. Thus, stocks play two roles in the determination of a white wheat basis for any particular futures. Stocks of deliverable classes serve to establish a relation between their cash and futures prices while relative stock levels serve to establish a relation between cash prices of white wheat and cash prices of deliverable classes.

But other factors also affect the basis. The possibility of delivery insures that convergence to some fixed and known level occurs, at least for deliverable commodities. For some non-deliverable commodities such as white wheat, the maturity basis, though not fixed, is at least determinate. Logically, the maturity basis should be influenced by stocks of white wheat and wheat of the deliverable class. Convergent processes of this type are often described well by difference equations.

The above considerations suggest that the white wheat basis at any time in a storage interval may be modeled as a function of stock levels at that time and basis at a prior point in time, equation (5).

$$B_{t,j} = a_{0,j} + a_{1,j}B_{t-1,j} + a_{2,j}S_t^W + a_{3,j}S_t^{R,i} + e_{t,j} \tag{5}$$

$i = 1, 2$

$j = 1, 2, \ldots, 6$

In equation (5), S_t^W is stocks of white wheat at time t; $S_t^{R,1}$ is stocks of hard red winter wheat at time t (used when the j^{th} contract is on the Kansas City market); $S_t^{R,2}$ is stocks of soft red winter wheat at time t (used when contract j is on the Chicago market); $e_{t,j}$ is an unobservable error; and a_{ij} are constants to be estimated.

To forecast basis several time periods ahead, it is also necessary to forecast stock levels. Because utilization rates are fairly consistent within a storage season, stocks at one time may be used to generate good forecasts of stocks at subsequent times. This suggests additional first difference relations to describe stock behavior during a storage season.

$$S_t^W = b_0 + b_1 S_{t-1}^W + V_t \tag{6}$$

$$S_t^{R,i} = c_{0i} + c_{1i}S_{t-1}^{R,i} + U_{it} \qquad i = 1, 2. \tag{7}$$

The above three equations were estimated by ordinary least squares using data for the 1972/73-1975/76 storage seasons.

Because equations (5) through (7) are difference equations in $B_{t,j}$, S_t^W, and $S_t^{R,i}$, respectively, they can be used to estimate the expected value of basis at <u>any</u> future time solely in terms of <u>known</u> basis and stocks in the <u>current</u> time period, plus constants which have been estimated through regression techniques. The procedure for doing so is straightforward, but the resulting forecasting equation is quite cumbersome and will not be presented here.

The same reduction procedure that leads to an estimate of the expected basis at any future time can also be used to represent actual basis at future times. In this case the future basis is given in terms of the same arguments listed above plus residuals to equations (5) through (7) associated with each time period from the present up to the time of the forecasted basis. Again, the actual result is cumbersome, but a conceptualization is displayed in equation (8).

$$B_{t+h,j} = h(a_{0j}, a_{1j}, a_{2j}, a_{3j}, b_0, b_1, c_{0i}, c_{1i}, B_{tj}, S_t^w, S_t^{R,i}, v_{t+k}, v_{t+k-1}, \ldots, v_{t+1}, u_{i,t+k}, u_{i,t+k-1}, \ldots, u_{i,t+1}, e_{t+k,j}, e_{t+k-1,j}, \ldots, e_{t+1,j}) \quad (8)$$

To avoid additional notation, let the symbols a_{rj}, b_r, c_{ri}, v_t, u_{it}, and e_{ij} in equation (8) stand for OLS estimates of corresponding true values. The variance of a forecast of actual basis, given initial stocks and basis, is the variance of h, and an approximation to this variance has been estimated. First h was approximated by the first order terms in a Taylor expansion about the OLS parameter estimates and the zero mean values of the error terms. Then the variance of this linear function of the random parameter estimates and errors was calculated by standard procedures using the estimated variances and covariances of OLS parameter estimates and estimated variances of residuals. The square root of the result, $\hat{\sigma}^h_{t,j}$, was used as a measure of the uncertainty attached to expected returns from hedging against the j^{th} contract for a period t weeks into the future.

Simulation Results

Simulation was used to assess financial outcomes on a per bushel basis from applying different decision making strategies to the marketing of white wheat inventories. In the first week of September, the inventory holder is assumed to have wheat in storage. He is presumed to assess expected returns from several alternative ways of marketing his wheat. He may sell at the current cash price, hold wheat unhedged in anticipation of selling in any future week through the end of April, or hold wheat hedged against any of six futures contracts (Kansas City or Chicago; December, March, or May) in anticipation of lifting the hedge and selling wheat in any week prior to contract maturity. He is assumed to make the choice that offers the maximum expected return net of all storage and futures trading costs. Forecasts of expected returns to each alternative marketing method and to all possible forecast horizons are assumed to be made in the manner described in the preceding section, using actual first week price, stocks, and basis.

If the inventory is not sold in the first week, the decision process is repeated in the second week. Forecasts are then made using new information that has become available: second week actual price, stocks, and basis. If the first week decision involved hedging, possibilities for switching to an unhedged position or to a hedge against a different contract are considered, along with appropriate costs. Note that even though the first week decision may have been, for example, to hold unhedged in anticipation of realizing a maximum return in the eighth week, this decision may be changed in the second week on the basis of newly available information and its implications for present and forecasted future returns. Note also that decisions involving hedging are made not merely to shift risk, but to pursue possible gains from forecasted favorable changes in the basis.

Simulation of the decision process is repeated at weekly intervals until the inventory is sold and a financial outcome is determined. Results are simulated using actual stocks, price, and basis data for the 1972/73-1977/78 storage seasons. Three combinations of marketing alternatives are simulated. In the first, the decision maker is permitted to choose only from among the various hedging alternatives or selling at the current price. In the second, the options include only holding unhedged positions or selling in the current market. In the last, the mixed strategy, all three options are permitted.

Nothing has been said to this point about how error expectations enter into the formulation of expected returns. Here, forecasts of cash prices and basis are reduced by some positive fraction of the standard deviation of those forecasts. The adjusted expected net price associated with unhedged storage is:

$$E^*(R_t^u) = P_0^c + E(P_t^c) - P_0^c - C_t^u - w(\hat{\sigma}_t^u) \tag{9}$$

where w is the discount factor. The adjusted expected net price associated with hedged storage for any futures is:

$$E^*(R_{t,j}^h) = P_0^c + B_{0,j} - E(B_{t,j}) - C_t^h - w(\hat{\sigma}_{t,j}^h). \tag{10}$$

The value of w depends upon decision makers' risk preferences, but results were simulated over a range of values. Obviously, as w increases, uncertain storage outcomes will be discounted so heavily that certain 'sell out now' expectations override.

Table 1 presents the net realized return, averaged across five values of the risk discount on a season by season basis, obtained under the three combinations of marketing alternatives. Comparisons with beginning-of-season returns and season weighted average returns are also presented. Returns associated with strategies involving futures trading exceed the unhedged storage only, beginning-of-season, and season weighted average net returns in most years and on an overall average basis.

Table 2 presents six-season average net realized returns and length of storage interval generated by the simulation at alternative values of the risk discount, for the three combinations of marketing alternatives. At the lower two levels of the risk discount, average net realized return associated with hedged

Table 1. Summary results of conditional hedged, unhedged, and mixed storage decision making, 1972/73 to 1977/78, and net realized return averaged by year across values of the risk discount from 0.0 to 0.4 with comparisons to beginning-of-season returns and season weighted average returns

Marketing Season	Average Net Realized Return Associated with Hedged Storage Strategy	Average Net Realized Return Associated with Unhedged Storage Strategy	Average Net Realized Return Associated with Mixed Strategy	Net Beginning-of-Season Return	Season Net Weighted Average Return Received
	($/bu)				
1972/73	2.13	2.07	2.13	1.88	2.29
1973/74	4.94	4.84	5.14	4.94	4.82
1974/75	4.38	4.95	4.77	4.36	4.35
1975/76	4.32	3.94	3.90	4.19	3.70
1976/77	3.32	2.92	3.03	3.25	2.75
1977/78	2.67	2.64	2.75	2.67	2.91
Average	3.63	3.56	3.62	3.55	3.47

Table 2. **Six-season average net realized return and average length of storage interval associated with conditional hedged storage, unhedged storage, and mixed storage decision making strategies at various values of the risk discount**

Value of (d)	Average Net Realized Return Associated with Hedged Storage Strategy	Average Storage Interval Associated with Hedged Storage Strategy	Average Net Realized Return Associated with Unhedged Storage Strategy	Average Storage Interval Associated with Unhedged Storage Strategy	Average Net Realized Return Associated with Mixed Storage Strategy	Average Storage Interval Associated with Mixed Storage Strategy	Average Net Realized Return--All Strategies	Average Storage Interval--All Strategies
	($/bu)	(weeks)	($/bu)	(weeks)	($/bu)	(weeks)	($/bu)	(weeks)
0.0	3.65	11.3	3.48	14.7	3.59	20.3	3.57	15.4
0.1	3.65	10.0	3.58	8.7	3.56	15.8	3.60	11.5
0.2	3.64	6.4	3.48	6.3	3.64	11.7	3.59	8.1
0.3	3.58	1.7	3.60	3.5	3.63	8.2	3.60	4.5
0.4	3.59	1.5	3.64	1.2	3.67	4.3	3.63	2.3
0.5	3.59	1.5	3.55	0.0	3.59	1.5	3.58	1.0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1.0	3.54	0.0	3.55	0.0	3.55	0.0	3.55	0.0

storage only is greater than that associated with either of the other two strategies, while at risk discount factors between .2 and .5 the mixed strategy yields average net returns equal to or greater than the other two strategies. For every strategy, the average length of storage interval decreases as the risk discount increases. Also, at every value of the risk discount, the average length of storage interval is greatest for the mixed strategy. The last two columns present average results for all three combinations of marketing alternatives with respect to six-season average net realized prices and length of storage interval.

Summary and Conclusions

Decisions to hedge an inventory, to hold unhedged, or to sell should be conditioned by both expected return and risk associated with each alternative. Forecasting efforts in this analysis were directed toward generating such expectations.

Operating results were simulated using actual data for the 1972/73-1977/78 storage seasons. Most of these years were ones in which within-season price variability was high by historical standards, and hence ones where forecasting and decision making was subject to great uncertainty. The forecasting models were estimated using a data set which did not include data from the last two of these seasons, and this provided some additional validation of the approach.

In the situation where conditional hedged storage is employed as the only storage alternative, the greatest returns on average are yielded when little or no weight is attached to risk. For the storage seasons simulated, the average returns to hedged storage at these low risk discount levels are greater than those yielded by any other storage strategy at the same risk discount levels. At the higher levels of discount for risk, the storage strategy which permitted both conditional hedged and conditional unhedged storage yielded higher returns to storage than did either of the other two strategies. In terms of average results, the strategy which permitted only conditional unhedged storage was inferior to both of the strategies which permitted conditional hedged storage.

All three storage decision making strategies yielded average returns greater than average beginning-of-season prices, thus yielding average positive net gains to storage. Similarly, all three strategies yielded average returns substantially above actual weighted average returns received in the seasons simulated. This suggests that, on the whole, the combination of forecasting methods, marketing options, and decision rules used in this analysis produced better financial results than the (unknown) forecasting methods and decision rules used in actual practice.

These results suggest a role for futures market transactions in marketing strategies for Pacific Northwest white wheat if decision makers can forecast prices and basis with about the same accuracy as yielded by forecasting mechanisms employed here. This would be true regardless of whether or not decision makers use the particular forecasting models developed in this research, or whether they use formal forecasting models at all.