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# Cost of Forward Contracting Hard Red Winter Wheat

**John P. Townsend and B. Wade Brorsen**

ABSTRACT

Two methods were used to estimate the cost of forward contracting hard red winter wheat. One hundred days before delivery, the estimated cost of forward contracting ranged from six cents/bu. to eight cents/bu. Thus, further evidence is provided that the cost of forward contracting grain is not zero.

**Key Words:** *Forward contracting, nonparametric regression, wheat.*

Agricultural producers have been encouraged by academics, lenders, and extension professionals to reduce price risk using futures markets or forward contracts. A key assumption of those advocating these methods of risk protection is that the costs involved are negligible. However, Lence has shown that considering even small hedging costs can lead to quite different hedging recommendations. Brorsen and Anderson found that only four of 49 extension marketing economists surveyed agreed that farmers who forward contract production receive a lower average price than those who do not. Similarly, only four believed that pre-harvest hedging strategies will not necessarily translate into higher average prices for producers (as opposed to selling at harvest). Given that the views of extension economists contrast with the limited empirical research showing forward contracting is costly (Brorsen, Coombs, and Anderson; Elam and Woodworth; Harris and Miller), there appears to be a need for further research on this issue.

The purpose of this article is to determine the average cost associated with forward contracting hard red winter wheat at an Oklahoma elevator. While the costs involved in hedging are widely acknowledged, the cost of forward contracting is not so obvious. Hedging costs consist of margins, liquidity costs, brokerage fees, and paperwork. Barkley and Schroeder's arguments suggest these fees are built into the basis bid offered by the elevator (since the elevator is now assuming the price risk from the producer). Since forward contracts lack the margin requirements and the marking-to-market feature of futures contracts, they have greater default risk and collection costs. Elam and Woodworth found that the net price received with forward contracts ranged from 18 cents per bushel less (at 10 months to delivery) to 2 cents per bushel less (1 month from delivery) than the net price from hedging.

The cost of forward contracting can be viewed as the expected difference between the cash price at harvest and the forward contract price. If so, it can be said that contracting is costly when the basis between the forward contract price and the futures at the time of delivery increases as delivery approaches. Brorsen, Coombs, and Anderson determined the costs of forward contracting wheat based

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on Gulf elevator basis bids. Gulf bids may underestimate the cost of forward contracting at a local elevator. Unlike Gulf elevators, local elevators face the risk of an increase in transportation costs, and they mostly contract with farmers so they are liable if the farmer does not fulfill the contract. On the other hand, Gulf elevators will most likely contract with other elevators rather than with farmers, so their cost of enforcing the contract may be lower. Since this article determines the cost of forward contracting wheat using Arkansas River terminal elevator basis bids rather than Gulf bids, the cost of forward contracting estimated here is expected to be higher than in Brorsen, Coombs, and Anderson.

Two techniques are used to estimate the cost of forward contracting: a parametric model using first-differences and a nonparametric-regression model. The nonparametric approach uses a seven-day moving average of daily forward basis (forward contract price—futures price) to estimate the weekly average of forward basis. Nonparametric techniques have the advantage of not imposing a specific functional form, but their estimates are expected to be less precise than correctly specified parametric models.

## Forward Contracting of Wheat

The formula for forward contract price received by the farmer is

$$F(t) = K(t) + B(t), \tag{1}$$

where $F(t)$ is the forward contract price at t days from delivery, $K(t)$ is the Kansas City wheat July futures price at t days from delivery, and $B(t)$ is the Arkansas River forward basis bid, also at t days from delivery. Note that since the elevator only accepts wheat via a contract, the forward contract price at time zero equals the cash harvest price ($C$), i.e., $F(0) = C$.

Therefore, if the cost of forward contracting at t days from delivery ($r(t)$) is defined as the expected difference between the cash harvest price and the forward contract price at t days from delivery, the following equivalencies hold:

$$\begin{aligned} r(t) &= E_t[C - F(t)] = E_t[F(0) - F(t)] \\ &= E_t[K(0) + B(0) - K(t) - B(t)] \\ &= E_t[K(0)] - K(t) + E_t[B(0)] - B(t) \end{aligned} \tag{2}$$

where the expectations are taken conditional to the information set at time $t$. Also, since futures prices are modeled as a martingale, the expectation of unobserved future values ($t = 0$) given present information is the present value, so $E_t[K(0)] = K(t)$, therefore:

$$r(t) = E_t[B(0)] - B(t) \tag{3}$$

Thus, the cost of forward contracting is measured as the expected change over time in the forward basis bids. Now let us assume a linear functional form[1] for the cost of forward contracting: $r(t) \equiv a_0 + a_1 t$. First realize that $a_0$ is zero since at delivery time, there is no cost of forward contracting. Then, replace this expression and rearrange terms in equation (3) so that we have $B(t) = E_t[B(0)] - a_1 t$. Similarly, $B(t - 1) = E_{t-1}[B(0)] - a_1(t - 1)$, so

$$B(t-1) - B(t) = a_1 + E_{t-1}[B(0)] - E_t[B(0)]. \tag{4}$$

Since the expected value of $E_{t-1}[B(0)]$, with respect to the information set at time $t$ is $E_t[B(0)]$, the term $E_{t-1}[B(0)] - E_t[B(0)]$ has zero mean and can be regarded as an error term.[2] Equation (4) suggests the forward basis process has a unit root. If this is the case, regressing *levels* of the forward basis against time to delivery could lead to spurious significance and biased parameter estimates. Brorsen, Coombs, and Anderson used levels and thus their parametric results may be biased.

The parameter $a_1$ is expected to be positive since barge rates in the area are highly variable and uncertainty about barge rates decreases

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[1] A higher-order polynomial can also be assumed, and is in fact tested in the Procedures section.

[2] Note that $E_{t-1}[B(0)]$ is itself a random variable since the expectation is taken with respect to the information set at the future time $t - 1$. Thus, $E_t[E_{t-1}[B(0)]] = E_t[B(0)]$.

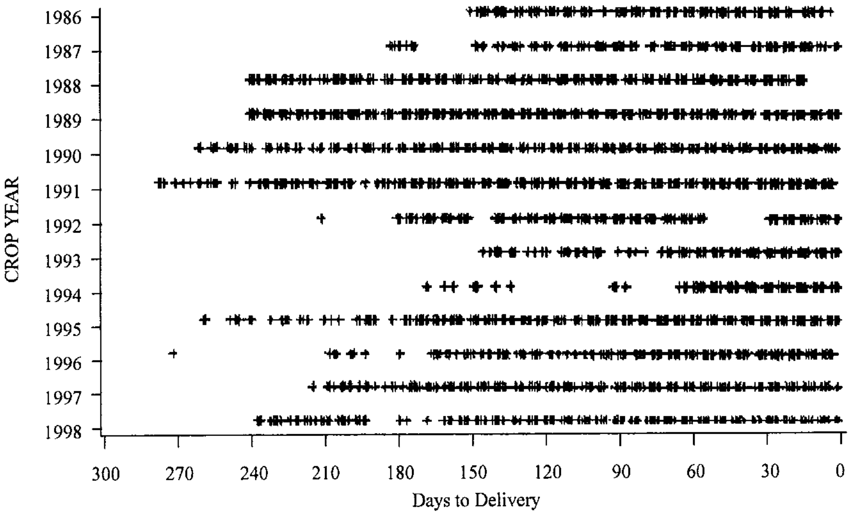

**Figure 1.** The days when an Arkansas River forward contract wheat price was quoted vs. days to delivery
Note: The days on which a price was quoted are marked with a plus.

with time to delivery. Barge rates at harvest have varied from 10.5¢/Bu. to 40.5¢/Bu. in recent years. The market for barges is illiquid and forward contracting of freight rates is not available. According to the elevator manager, his expectations about barge rates at harvest are $6/ton, but change as harvest nears. The $6/ton is his estimate of average barge rates in June. The elevator manager believes that no risk premium is included in the forward bids, but the data show that there is. Another argument in favor of $a_1$ being positive is that as harvest approaches, prices have less time to move against a producer and the producer has less incentive to default.

## Data

Data are Arkansas River (Catoosa, Oklahoma) forward contract bids for hard red winter wheat from 1986–1998. The data are available for every day a bid was offered by the elevator to the last delivery day. On many days, there was no interest in forward contracting and so no bids were offered. Prices are FOB Arkansas River for delivery in the last half of June.[3] The elevator is a terminal elevator and requires a contract on all grain delivered, so these bids become the spot price during the last half of June. Grain is generally loaded on barges rather than stored at the elevator since the terminal has little storage and charges for storage are high relative to local elevators. The terminal has one major competitor ten miles away, but also must compete with rail traffic and terminals farther down the river.

In addition to the terminal elevator's bids the data also include Kansas City July hard red winter wheat futures. Four observations were deleted because of either a limit move in the Kansas City futures or because a large move in the futures occurred and the reported bid did not immediately adjust. The elevator only quoted bids when there was some interest in forward contracting. Days when a bid was quoted are plotted in Figure 1. The first bids recorded in each year varied from 145 days before delivery in 1993 to 278 days before delivery in 1991.

Much theoretical work and applied work on "optimal" marketing strategies assumes hedging or forward contracting is done at planting. However, only during 1991 and one day in 1996 were prices even quoted at planting, so the data in Figure 1 do not support this assumption. Since seedbeds must be prepared and fertilizer applied before planting, the decision to plant wheat was made even earlier. The reader should be cautioned that this finding might not extrapolate to corn and soybeans. Corn and soybeans have a shorter growing season so elevators may be able to provide forward contracts at planting at a lower cost. Also, during this period, many producers may have been locked into planting wheat due to the now-defunct commodity programs. The critical decision point for producers may have been whether to take their cattle off the wheat in March and harvest a crop or to graze out the wheat.

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[3] Some years the elevator did not differentiate between the last and first half of June. In other years, a premium was offered for immediate delivery in early June. This premium was only offered for a few days.

The data for the parametric method includes all available one-business-day changes and no missing values are filled in. Many early bids were isolated with few or no bids following for long periods. For the nonparametric method, some missing values were eliminated by either deleting the isolated bids or filling in the missing values. The missing values were imputed to smooth the plot of the nonparametric regression, but the imputation is not a critical part of the analysis. The existing Arkansas River bids were regressed against the Gulf bids (Gulf prices should differ from the Arkansas River prices mostly by the expected cost of transportation between the two points), July Kansas City futures prices, crop year dummy variables, and the number of days to delivery. The $R^2$ of the regression used to impute the missing values was 0.998. Using the estimated parameters and available data, the missing river prices were predicted. These predicted values substituted 210 missing values in the data set. Then, the seven-day moving average could be calculated without any missing values in the plots. As Pindyck and Rubinfeld (pp. 220–221) discuss, the filling in of missing observations is an instrumental variables approach. Filling in the missing values made the plots smoother, but did not change any conclusions about the cost of forward contracting. Since no Gulf prices were available before January, any missing values before January had to be left as missing.

## Procedure

Both a parametric and a nonparametric method are used to estimate the cost of forward contracting. The nonparametric method has the advantage of not having to assume a functional form, while the stricter restrictions of the parametric model yield more precise estimates. The general function of the nonparametric model is

$$\text{forward contract price} = f(\text{time to delivery})$$

The nonparametric model used a seven-day moving average of the forward contract bids. The seven-day moving average was calculated first for each year and then averages were taken across years. A seven-day moving average was selected since it was unaffected by the missing data for weekends.[4] Although predictions from nonparametric regressions are generally biased since they tend to smooth peaks and fill in valleys (Hardle), they will still be less biased than parametric-method predictions. Finally, nonparametric predictions are consistent as long as the width of the window (the seven days here) decreases as the sample size increases.

Then the first differences model obtained in equation (4) was estimated (parametric method). A plot of the first differences suggested the error term was heteroskedastic, with the variance increasing as delivery approached. Thus, two estimation methods were considered. One assumed multiplicative heteroskedasticity on time to delivery, and the other was White's heteroskedasticity-consistent estimation. Also, a linear time trend was considered as a regressor, which corresponded to assuming that the cost of forward contracting was quadratic in time (replace $a_1$ with $a_1 + a_2t$). However, this term was not statistically significant so equation (4) was regarded as the true model.

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[4] Many kernels with declining weights have been suggested (Hardle). The nonparametric regression used calendar days rather than market days and so the alternative kernels would have given each year a different weight depending on where the missing values due to weekends happened to fall.

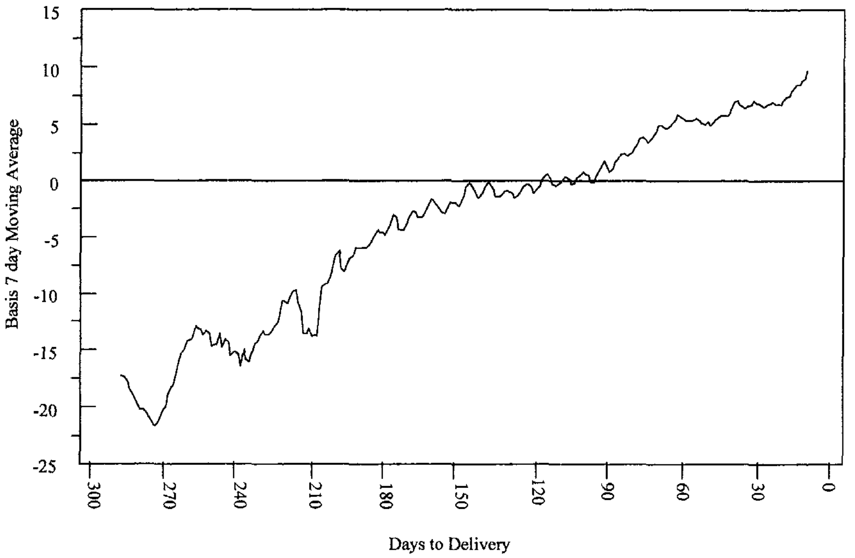

**Figure 2.** The 7-day moving average of Arkansas River forward basis vs. days remaining until delivery period ends

## Results

The nonparametric regression model is presented as a plot in Figure 2. The non-parametric regression shows the forward basis trending upward from roughly-20¢/bu. at planting to nearly 10¢/bu. at the end of June. Assuming futures prices are unbiased, this means that a producer forward contracting at planting would average 30¢/bu. less than a producer selling at harvest. The more distant forward basis bids are more variable, but this is likely due to few years having bids near planting. At 100 days before delivery ends, bids are around 8¢/bu. lower than at the end of delivery. Brorsen, Coombs, and Anderson estimated the costs of hedging hard red winter wheat to be 2¢/bu. Thus, as with previous studies, the costs of forward contracting estimated here are higher than the estimated costs of hedging. Elam and Woodworth also found large costs associated with forward contracting soybeans. Elam and Woodworth found a cost of forward contracting soybeans at 300 days to be 18¢/bu. and at 100 days approximately 4¢/bu. Brorsen, Coombs, and Anderson found at 100 days the nonparametric form yielded a cost of 4¢/bu. and the parametric form yielded a cost of 3 cents per bushel. The costs here are higher. Thus, the forward contracting costs implicit in Gulf bids do appear to underestimate farmers forward contracting costs.

The linear trend term in the first-differences model, which corresponds to the quadratic trend term in levels, was not statistically significant (t-value = 0.19). The Dickey-Fuller test statistic without the trend and dummies was −3.21. The 5% critical value is −3.86. Thus, this test could not reject the null hypothesis of a unit root. However, the Dickey-Fuller test with a trend and annual dummies included yielded a test statistic of −5.98 versus the asymptotic 5% critical value of −3.41 (Davidson and MacKinnon, p. 708), so the null hypothesis of a unit root could be rejected in this case. Since the unit root tests are fragile[5], we rely on the theory which says that a unit root is expected. The null hypothesis of interest is that the mean of the first differences is zero. The heteroskedasticity tests in SHA-

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[5] The finding of unit root tests being fragile is not unusual. Dejong *et al.* also find that Dickey-Fuller tests have difficulty distinguishing between unit-root processes and a trend stationary alternative. Linear and quadratic models with levels showed slightly lower, but still statistically significant costs of forward contracting.

ZAM all rejected the null hypothesis of homoskedasticity and so an adjustment was made for heteroskedasticity. The mean of the first-differences was 0.0817¢/day with a t-value of 2.08 using White's estimator. Using a multiplicative heteroskedasticity model that had annual dummies and days to delivery in the variance equation, the estimated mean was 0.0841¢/day with a t-value of 2.45. The first-differences model uses market days while the nonparametric model uses calendar days. Assuming five market days equal seven calendar days the cost of forward contracting 100 days before delivery would be 5.84¢ or 6.00¢ based on the parametric methods.

## Conclusions

While the costs of hedging are well documented, the costs of forward contracting are less researched because of the lack of data on forward contract prices. This study and other studies have now determined that the costs of forward contracting are substantially larger than the cost of hedging. Williams argues that futures markets exist partly because of having lower transaction costs than cash markets. The large costs of forward contracting could be due to a risk-averse elevator manager, monopsony power exercised by the elevator, or that producers do not always fulfill their contracts. If the costs merely reflect a risk of default[6], then elevators might not be making any extra profit on forward contracts. The assumption that producers make forward contracting decisions at planting appears to be incorrect, as indicated by the scarce number of bids offered earlier than 180 days to delivery, well after planting.

These findings also have important implications for extension programs and extension professionals. As Brorsen and Anderson found, most extension professionals believe that producers who use forward contracting do not receive lower average prices for their commodities than those who do not. This belief contrasts strongly with the empirical evidence. This suggests extension professionals should reevaluate the marketing advice they give producers. Forward contracting is more costly than many people realize.

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[6] Elevators do occasionally cancel a contract or part of it when the price rises. In these instances the elevator would be offering an option rather than a forward contract, but we choose to view this as a form of default.