NCCC-134
APPLIED COMMODITY PRICE ANALYSIS, FORECASTING AND MARKET RISK MANAGEMENT

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Suggested citation format:

Siaplay, M., K. B. Anderson, and B. W. Brorsen. 2007. "Using Basis and Futures Prices as a Barometer in Deciding Whether to Store Grain or Not." Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, IL. [http://www.farmdoc.uiuc.edu/nccc134].

Using Basis and Futures Prices as a Barometer in Deciding Whether to Store Grain or Not

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Paper presented at the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Marketing Risk Management
Chicago, Illinois, April 16-17, 2007

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The purpose of this paper is to determine the importance of the strength and weakness of basis and futures prices as barometers for producers to use in deciding whether to store or not. Basis is the single most important market signal for wheat producers to use when deciding whether to store or sell their wheat at harvest. While some models indicated low futures prices were a signal to store, results were fragile and inconsistent.

Key Words: basis, futures, storage, wheat.

Introduction

Purcell and Koontz (p.32, 1999) strongly advocate using "basis as a barometer" when making storage decisions because "it is the level of basis relative to cost of delivery that becomes important in the delivery process as actions are taken by producers holding short hedges or market arbitrageurs to ensure cash future convergence." While the theoretical argument is strong, the empirical research is more suggestive than conclusive.

Every year grain producers must decide whether to store grain or sell it at harvest. This decision is considerably complex and it is like a game of chance in which the probability of winning or losing changes each time the game is played (Heifner, 1966). The purpose of this study is to determine the importance of the strength and weakness of basis and futures prices in predicting returns to storage. Past studies have shown that grain markets are mostly efficient (Kastens and Schroeder, 1996; Tomek, 1997) and thus futures price level is not expected to be a signal. Both the price level and the basis are sometimes used as signals by extension economists and market advisors. The empirical research is inconsistent regarding whether basis and/or futures price level can be used as a signal to store or not (Zulauf and Irwin, 1998; Kastens and Dhuyvetter, 1999 Yoon and Brorsen, 2002).

Grain producers want to know if there are market signals that grain producers can use to a make harvest time store/sell decision. They desire rules of thumb that can be used to make decisions such as the marketing strategies presented in table 1. We propose to revisit this issue in the hope of providing a more definitive answer to the question of whether basis and/or futures price level can serve as a barometer of whether to store or not. This study is quite similar to Zulauf and Irwin (1998) as well as Kastens and Dhuyvetter (1999). However, our regression approach should lead to a more powerful test than the simulation strategies in past research and thus will more clearly show the usefulness of basis as a storage indicator.

First, the theory of the price of storage is presented to provide an understanding of inter-temporal price relationships between spot and futures prices. Theory suggests that futures price level should be a worthless signal, but the level of basis potentially has value as a storage indicator. Regressions of various measures of returns to storage are regressed against measures of the strength and weakness of basis and price levels. The data used are for wheat in Oklahoma. Misspecification tests are conducted to verify that underlying model assumptions hold. The model is then used to test hypotheses regarding the usefulness of basis and/or futures prices as a barometer when making a storage decision.

Theory

The theory of the price of storage was first proposed by Kaldor (1939) to explain the inter-temporal price relationship between spot and futures prices. Working (1949) viewed the returns to storage as being determined by the supply and demand for storage. Thus when wheat stocks are large, the demand for storage is large and the price of storage is expected to be relatively large. However, if wheat stocks are low, then the economic benefits/returns of storing wheat is small. Furthermore, the theory of the price of storage only holds for highly storable and continuous inventory commodities such as wheat (Brennan, 1958). Over the years, studies on the theory of the price of storage have evolved following Kaldor (1939) including: Telser (1958); Williams and Wright (1982); Benirschka and Binkley (1995); and Seamon, Kahl, and Curtis (2001).

The theory of the price of storage includes two different arguments. The first argument explains the difference between the spot and futures prices in terms of interest forgone in storing a commodity, physical storage costs, and convenience yield on inventory. This argument was shown in the works of Kaldor (1939), Brennan (1958, 1991); and Telser (1958). Under the second argument, Cootner (1960); Dusak (1973); Breeden (1980); and Hazuka (1984) show that the theory of the price of storage can be explained by dividing the futures prices into an expected risk premium and predicted future spot price (Fama and French, 1987).

Combining both arguments, we define the following variables that explain theory of the price of storage. Define F_T as the future price for delivery of a commodity and S_t as the spot price. The price of storage (basis) is defined as

(1) $$F_T - S_t = S_t R + W + P - C$$

where the basis $F_T - S_t$ is (the price of storage) at time *t* from holding a commodity until time *T*, $S_t R$ is the opportunity cost of holding stocks, W is the physical storage cost, P is the risk premium, and C is convenience yield.

While equation (1) relates the spot and futures prices, the key question that arises is "what does the theory of the price of storage say about basis and/or futures prices as a market signal?" The theory of the price of storage suggests that basis level can help producers to decide whether to store or sell their grain at harvest since the spot and futures prices should converge. Also, physical storage costs increase varies depending on the quantity of commodity stored. As more grain needs to be stored, it must be stored in higher costs facilities or locations. Moreover, convenience yield is an important element of basis and if convenience yields are high then returns to storage should be low as a signal for producers to sell their stocks.

One possible weakness of the above theory is that it assumes that producers are near the delivery point. For producers away from delivery points, basis may only reflect local conditions and thus might not be a strong indicator regarding storage decisions.

The concept of basis is important because it combines both the spot and futures prices, which reflects the current and expected demand and supply conditions, respectively (Leuthold and Peterson, 1983; Purcell and Koontz, 1999). In addition, if futures markets are efficient, futures prices cannot be used as a barometer by producers to decide whether to store or sell their grain. As Kastens and Schroeder (1996) the futures market is expected to be mostly efficient and thus futures price level should not help predict price changes. Alternatively, as Yoon and Brorsen (2002) explained, behavioral finance aspects such as overconfidence, anchoring, and regret by grain traders provide a possible theoretical reasoning to argue for mean reversion in futures prices.

Therefore, this study generates two testable hypotheses about the theory of the price of storage. The first testable hypothesis is that grain producers can use basis as a market signal to decide whether to store or sell their grain. The second testable hypothesis is that grain producers cannot use futures price as a market signal to decide whether to store or sell their grain.

Data

The commodity chosen is Oklahoma wheat. Oklahoma monthly average cash wheat prices are obtained from the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (NASS/USDA) from 1975-2005. Monthly average Kansas City Board of Trade (KCBT) December wheat contract prices are obtained from the KCBT for the same periods as the monthly average cash wheat price series. The daily commercial storage costs represent the physical cost of storage charged by elevators and the opportunity cost of interest. The commercial grain storage rates were obtained from Oklahoma Grain and Feed Association from 1975-2005. The monthly cost-of-carry loan interest rates were obtained from 1975-2005 Economic Research Service of the United States Department of Agriculture (ERS/USDA).

Procedures

The dependent variables considered are gross revenue; net gross revenue; basis change; and futures price change. The independent variables include: basis deviation; and futures price deviation. First, gross revenue is defined as the difference between the November and June cash price for each year from 1975-2005. Mathematically, gross revenue is expressed as

$$GR = P_T^C - P_t^C \tag{2}$$

where GR is gross revenue, P_T^C is the November cash price, and P_t^C is the June cash price.

Second, net revenue is defined as the difference between the gross revenue and the cost-of-carry for each year from 1975-2005. Net revenue is expressed as

(3) $$NR = GR - C$$

where NR is the net revenue, GR is the gross revenue, and C is the cost-of-carry which includes the physical cost of storage and the interest opportunity cost.

Third, basis change is the return to hedged storage as in Zulauf and Irwin (1998). It is defined as the difference between November and June monthly average December basis. Mathematically, basis change is expressed as

(4) $$BC = B_T^D - B_t^D$$

where BC is basis change, B_T^D is the November-December average basis, and B_t^D is the June-December average basis.

Fourth, futures price change is defined as the difference between November and June monthly average December futures price. Futures price change is expressed as

(5) $$FPC = P_T^F - P_t^F$$

where FPC is future price change, P_T^F is the November average futures price for December contract, and P_t^F is the June average futures price for the December contract.

Basis deviation is defined as the difference between monthly average December basis and the five year average basis. Basis deviation is expressed as

(6) $$BD = B_T^D - B_t^F$$

where BD is basis deviation, B_T^D is the June-December average basis, and B_t^F is the average June basis for the previous five years.

Futures price deviation is defined as the difference between monthly average December futures price and the five year average futures price. Mathematically, futures price deviation is expressed as

(7) $$FPD = F_T^D - F_t^A$$

where FPD is futures price deviation, F_T^D is the average December future price, and F_t^A is the five year average futures price.

The second step is to determine the relationship between the dependent variables (gross revenue, net gross revenue, basis change, and future price change) and independent variables (basis deviation and futures price deviation). A hypothesis drawn from this step is whether grain producers can use basis and futures prices as a signal to store or sell wheat at harvest.

Ordinary least squares regression models are developed for each dependent variable listed above and data are divided from 1975-1989 and from 1990-2005. The reason for separating the data into two time periods is to account for changes in government farm policy in 1990 (The Omnibus Budget Reconciliation Act) which allowed more planting flexibility for crop programs, crop loans, and less government involvement regarding crop storage incentives (Jones, Hanrahan, and Womach, 2001).

Using equations (6) and (7), gross revenue is regressed on basis deviation and futures price deviation as

$$Y_k = \gamma_0 + \gamma_1 BD_k + \gamma_2 FPD_k + \varepsilon_k \tag{8}$$

where Y_k is gross revenue at time *k*, BD_k is basis deviation at time *k*, FPD_k is futures price deviation, and ε_k is the error term.

The regression models presented in equation (8) are also developed for net revenue, basis change, and futures price change as dependent variables.

The third step is to conduct misspecification tests regarding error terms for all the regression models. The misspecification tests conducted are normality, homoskedasticity, autocorrelation, joint conditional mean, and joint conditional variance (McGuirk, Driscoll, and Alwang, 1993).

Omnibus test (K^2) is used to detect deviation from normality as a result of either skewness or kurtosis. This test and its corresponding null and alternative hypotheses are

$$K^2 = Z^2(\sqrt{b_1}) + Z^2(b_2) \sim \chi^2_2 \tag{9}$$

$$\mathrm{H}_0 = \mu \sim N \qquad \sqrt{b_1} = 0 \text{ and } \mathrm{b}_2 = 3 \tag{10}$$

$$\mathrm{H}_a = \mu \text{ not} \sim N \qquad \sqrt{b_1} = 0 \text{ and } \mathrm{b}_2 = 3$$

where K^2 is the omnibus test statistic, $Z^2(\sqrt{b_1})$ represents skewness and is approximately standard normal with mean zero and variance one, and $Z^2(b_2)$ represents kurtosis and is asymptotically standard normal.

Static homoskedasticity test is conducted using regression specification error test (RESET). Mathematically, the artificial regression equation is expressed as

(11) $$\hat{\varepsilon}_t^2 = \alpha + \Delta'\Psi_t + v_t$$

(12) $$H_0 : \Delta' = 0$$

$$H_a : \Delta' \neq 0$$

where $\hat{\varepsilon}_t^2$ is the predicted error term squared, Ψ_t is the RESET2 test, and v_t is the error term.

Autocorrelation test is conducted with an artificial regression as

(13) $$\hat{\varepsilon}_t = \beta'_0 X_t + \Lambda'\hat{\varepsilon}_{t-1} + v_t$$

(14) $$H_0 : \Lambda' = 0$$

$$H_a : \Lambda' \neq 0$$

where $\hat{\varepsilon}_t$ is the predicted error term, X_t is the independent variable, $\hat{\varepsilon}_{t-1}$ is predicted lagged independent variable, and v_t is the error term.

Conditional mean tests are conducted to test for parameter stability, functional form, and independence. Mathematically, the artificial regression is

(15) $$\hat{\varepsilon}_t = \beta'_0 X_t + \Gamma_P'\Psi_t^P + \Gamma_F'\Psi_t^F + \Gamma_I'\Psi_t^I + v_t$$

(16) $$H_0 : \Gamma_P = \Gamma_F = \Gamma_I = 0$$

$$H_a : \Gamma_P \neq 0 \text{ or } \Gamma_F \neq 0 \text{ or } \Gamma_I \neq 0$$

where $\hat{\varepsilon}_t$ is the predicted error term, X_t is the independent variable, Ψ_t^P represents the structural change using time trend, Ψ_t^F represent non-linearity using RESET 2 test, Ψ_t^I allows for temporal dependence, and v_t is the error term.

Conditional variance tests are conducted to check for static and dynamic heteroskedasticity. This test is based on the following artificial regression

(17) $$\hat{\varepsilon}_t^2 = \Gamma_P'\Psi_t^P + \Gamma_S'\Psi_t^S + \Gamma_D'\Psi_t^D + v_t$$

(18) $$H_0 : \Gamma_P = \Gamma_S = \Gamma_D = 0$$

$$\mathrm{H}_a : \Gamma_P \neq 0 \text{ or } \Gamma_S \neq 0 \text{ or } \Gamma_D \neq 0$$

where $\hat{\varepsilon}_t^2$ is the predicted error term square, Ψ_t^P allows structural change using time trend, Ψ_t^S allows the static heteroskedasticity using RESET 2, and Ψ_t^D allows for dynamic heteroskedasticity, and v_t is the error term.

In models where the normality assumption is violated, the nonparametric bootstrap method is used (Greene, Chapter 16, 2003). When the no autocorrelation assumption is violated, the model is estimated using maximum likelihood.

Results

Table 2 reports the parameter estimates for four different models from 1975-1989 and 1990-2005 where the dependent variables (basis change, future price change, and gross revenue) are regressed on basis deviation and futures price deviation. The regression results indicate that basis deviation is statistically significant only under basis change during 1975-1989. In addition, basis and futures price deviations are statistically significant during 1990-2005 except under basis change as well as futures price change for futures price deviation.

While the results in table 2 suggest that wheat producers may use basis and futures prices as market signals, our data has a large outlier of 212.7 futures price deviation in 1996 that may have distorted the results. Therefore, we re-estimated our models under the same period from 1990-2005 and deleted the data for 1996.

Table 3 presents the re-estimated models from 1990-2005 with 1996 data deleted. The results indicate that basis deviation is statistically significant under all models except under gross revenue, net gross revenue, and basis change with three independent variables. However, the futures price deviation is not statistically significant under all four models.

Tables 4 and 5 report misspecification tests conducted from 1975-1989 and from 1990-2005, respectively. The misspecification tests employed are: normality test (omnibus test), homoskedasticity test (Harvey and Godfredy LM test), autocorrelation test (Durbin-Watson test), joint conditional mean, and joint conditional variance. The results in table 4 indicate that we reject the null hypothesis of normality under gross revenue, net gross revenue, and futures price change models. In this case, nonparametric bootstrapping was employed when the normality assumption does not hold. Also, the conditional mean and variance are rejected under basis change model. In table 5, all misspecification tests fail to reject the null hypothesis of normality, homoskedasticity, no autocorrelation, joint conditional mean, and joint conditional variance.

Conclusions

The results show that basis and not futures price is a more consistent market signal for wheat producers to use when deciding to store or sell their wheat at harvest. This finding is important because while the theoretical argument is strong, the empirical research has been more suggestive than conclusive. Thus, these results answer our earlier research question, "Are there market signals that grain producers can use to make the harvest store/sell decision?" The answer is yes, basis can be used as market signals by wheat producers. But, unless a storage hedge is used, basis will be a very noisy signal.

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Table 1. Pre-harvest Market Signals and Marketing Strategies to Consider

Market Signal (Basis)	Price	Potential Strategies
Weak	Low	Store unhedged
Weak	High	Store and hedge
Normal	Normal	Stagger sales
Strong	Low	Sell & buy call option; Basis contract
Strong	High	Sell at harvest

Table 2. Parameter Estimates for Gross Revenue, Net Revenue, Basis Change, and Futures Price Change (1975-1989) and (1990-2005), Respectively

	Dependent Variable			
Variable	Gross Revenue	Net Revenue	Basis Change	Futures Price Change
1975-1989				
Intercept	-0.481	-0.299	15.976*	-0.609
	(0.26)	(0.13)	(9.08)	(0.26)
Basis deviation	-0.679	-0.707	-0.358*	-0.297
(BD_t)	(0.42)	(0.43)	(-3.07)	(0.36)
Futures price	-0.149	-0.157	0.022	-0.162
deviation (FPD_t)	(0.07)	(0.07)	(0.79)	(0.05)
R^2	0.33	0.49	0.64	0.19
1990-2005				
Intercept	23.680	19.614	22.562*	1.117
	(1.90)	(1.57)	(7.89)	(0.09)
Basis deviation	2.097*	2.106*	-0.376	2.472*
(BD_t)	(2.72)	(2.73)	(-2.13)	(3.23)
Futures price	-0.753*	-0.761*	-0.002	-0.751
deviation (FPD_t)	(-3.43)	(-3.47)	(-0.05)	(-3.44)
R^2	0.48	0.49	0.38	0.51

Notes: The figures in parentheses are *t*-statistics in basic change models, with an asterisk (*) indicating statistical significance at the 5% level. However, the figures in parentheses are *p*-value with the same significance level as that of the t-statistic for gross revenue, net gross revenue, and futures price change models. The *p*-value is calculated under these models when they were re-estimated using nonparametric bootstrap as result of normality assumption being invalid.

Table 3. Parameter Estimates for Gross Revenue, Net Revenue, Basis Change, and Futures Price Change (1996 data deleted)

	Dependent Variable			
Variable	Gross Revenue	Net Revenue	Basis Change	Futures Price Change
Intercept	33.888*	29.872*	24.560*	9.328
	(2.84)	(2.50)	(8.53)	(0.74)
Basis deviation	1.757*	1.767*	-0.442*	2.199*
(BD_t)	(2.53)	(2.54)	(-2.64)	(2.98)
Futures price	-0.322	-0.328	0.081	-0.404
deviation (FPD_t)	(-1.17)	(-1.19)	(1.23)	(-1.38)
R^2	0.35	0.36	0.37	0.43

Notes: The figures in parentheses are *t*-statistics for all models, with * indicating statistical significance at the 5% level.

Table 4. Misspecification Tests for Gross Revenue, Net Revenue, Basis Change, and Futures Price Change (1975-1989)

	Dependent Variable			
Variable	Gross Revenue	Net Revenue	Basis Change	Futures Price Change
Normality	16.294*	15.398*	0.013	15.694*
	(0.00)	(0.00)	(0.99)	(0.00)
(Omnibus test)				
Homoskedasticity	3.984	4.013	0.960	4.482
	(5.99)	(5.99)	(5.99)	(5.99)
(Lagrange Multiplier test)				
Autocorrelation	2.236	2.257	1.575	1.575
	(0.60)	(0.62)	(0.16)	(0.16)
(Durbin-Watson test)				
Joint conditional mean	1.030	0.950	7.970*	0.480
	(0.43)	(0.46)	(0.01)	(0.70)
Joint conditional variance	1.750	1.690	5.160*	1.710
	(0.24)	(0.25)	(0.03)	(0.24)

Notes: The figures in parentheses under normality test indicate significance *p*-value level at 5%. Under static homoskedasticity using Lagrange Multiplier as test statistic, the figures in parentheses are chi-square critical value at 5% significance level. The figures in parentheses indicated *p*-value under autocorrelation test using Durbin-Watson test at 5% significance level. Under the joint conditional mean and variance, the figures in parentheses are the F critical value at 5% significance level.

Table 5. Misspecification Tests for Gross Revenue, Net Revenue, Basis Change, and Futures Price Change (1990-2005)

	Dependent Variable			
Variable	Gross Revenue	Net Revenue	Basis Change	Futures Price Change
Normality	0.325	0.326	2.576	1.037
	(0.85)	(0.85)	(0.28)	(0.59)
(Omnibus test)				
Homoskedasticity	1.021	0.974	1.325	1.596
	(5.99)	(5.99)	(5.99)	(5.99)
(Lagrange Multiplier test)				
Autocorrelation	2.753	2.757	0.599	2.628
	(0.89)	(0.90)	(0.06)	(0.84)
(Durbin-Watson test)				
Joint conditional mean	3.410	3.460	1.730	2.910
	(0.07)	(0.07)	(0.24)	(0.10)
Joint conditional variance	0.020	0.020	0.720	0.290
	(0.99)	(0.99)	(0.58)	(0.83)

Notes: The figures in parentheses under normality test indicate the *p*-value at 5% significance level. Under static homoskedasticity using Lagrange Multiplier as test statistic, the figures in parentheses are chi-square critical value at 5% significance level. The figures in parentheses indicated *p*-value under autocorrelation test using Durbin-Watson test at 5% significance level. Under the joint conditional mean and variance, the figures in parentheses are the F critical value at 5% significance level.