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"The Effects of Commodity and Market Characteristics on Futures Basis Variability." (Paper presented at 1989 AAEA summer meetings)

S.J. Monson (FAPRI, University of Missouri) and Ronald W. Ward (University of Florida)

A cross commodity approach including storable and nonstorables was used to analyze the basis at constant periods from contract maturity. Various commodity and market characteristics that increase arbitrage potential were found to be significant in decreasing variability in the basis residual, thereby reducing basis risk.

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The basis is of critical importance in determining the risk reducing potential of using the futures market as a hedging device. Basis variability, which is the major source of financial risk to a hedged position, is a function of the correlation between prices in the spot and futures markets. The purpose of this research is to identify factors that influence the integration between the markets.

Theoretical models of basis determination have been developed to analyze the differences between cash and futures prices originating from the cost of storage (Brennan). In the present analysis, basis performance is gauged in terms of basis variability rather than absolute price differences between the markets. The relationship between the cash and futures markets is analyzed in the context of arbitrage, the competitive mechanism that integrates the two markets. Commodity and market characteristics which affect arbitrage potential can be expected to affect basis performance. The distinguishing feature of this research is that it involves a cross commodity approach, including both storable and nonstorable commodities, whereby differences among commodity characteristics account for different levels in the arbitrage potential.

Garbade and Silber (1983) examine the relationship between cash and futures markets for storable commodities and demonstrate that the degree of integration between these markets depends on arbitrage elasticity. Considering nonstorable commodities, Leuthold (1977) finds external factors common to the beef industry to influence the live cattle basis. Castelino and Francis (1982) identify several factors having an important effect on the structural relationship between cash and futures prices by examining the basis at a fixed time until maturity, across different storable commodities.

The present analysis extends Castelino and Francis' research by examining a larger cross section of commodities and including a broader range of factors that influence the basis. The objective is to identify and empirically verify which factors influence the integration between the cash and futures markets where the basis represents differences in product time and/or form. The time period from contract maturity is held constant so that the integration between the markets is a function of commodity characteristics rather than time-until-maturity. The model does not offer a means of determining price levels or actual basis values but rather assesses basis performance in terms of variability. The spatial dimension which influences basis patterns is not analyzed.

ARBITRAGE

Theoretically, a basis should equal the cost of transforming a commodity with respect to time, form or location. Misalignment between prices creates incentives to arbitrate across markets until basis levels are consistent with costs.[1] Hedgers represent potential arbitrators because they can deliver (or accept delivery) to fulfill a futures contract. While only a minute fraction of all futures contracts are exercised, it is the potential to arbitrate that integrates the two markets.

The most obvious limitation to arbitrage in the futures market is the inability to bring future supplies into the present. Other limitations to

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[1]Because it is impossible to bring future supplies to the present time period the adjustment potential is asymmetric and an inverted basis where the cash price exceeds the futures price may persist.

arbitrage may arise from commodity or market characteristics. Lack of liquidity or poorly defined contract specification in the futures market may lower the arbitrage potential (Ward and Schimkat). Other limitations may relate to inherent commodity characteristics and thus be independent of the institutional or market setting. For example, the time requirement necessary to transform feeder cattle to market weight restricts the ability to arbitrate between the feeder cattle spot market and a nearby fed cattle futures market. Alternatively, factors that enhance marketing or production flexibility improve the arbitrage potential.

Theoretically, when the arbitrage potential is high, the basis residual--defined as basis net of the corresponding transformation cost--tends to zero. The variability in the basis residual reflects the integration between prices and is the measure of basis performance used in the present analysis.

METHODOLOGY

A cross commodity approach was used to investigate the relationship between basis performance and commodity and market characteristics. The standard deviation of the basis residual SD(BR) was calculated conditioned on commodity (i), year (j) and season (k). The dependent variable was defined as $SD(BR)_{ijk}$ divided by the standard deviation of the spot price $SD(P)_{ijk}$ for the corresponding commodity, year and quarter. This denominator serves to cancel units, adjust for changing price levels and express basis variability or basis risk (the risk associated to a hedged position) relative to spot price risk (risk associated with an unhedged position.)

Exogenous variables include factors that reflect the trading process in the futures market, such as market liquidity and the hedging to speculation ratio, as well as variables that relate to each commodity's physical or market characteristics.

Three models of basis performance are defined corresponding to two, four and six months from maturity. All basis observations pertaining to a particular model correspond to futures contracts maturing as close as possible to the same length of time. By holding this time dimension constant, the integration between spot and futures markets is revealed as a function of commodity characteristics rather than a function of time-until-maturity.

DATA AND ESTIMATION PROCEDURE

Nine agricultural commodities over approximately a fifteen year period are included in the empirical analysis. Six of the commodities represent time transformations, that is, basis values that reflect commodity storage: corn, wheat, oats, soybeans, frozen pork bellies, and frozen concentrated orange juice. Form transformations of feeding out cattle and crushing soybeans into soybean oil and meal are also included.

For each commodity time series data were used to calculate the basis residual as the weekly averaged futures price minus the weekly averaged spot price minus the corresponding transformation cost, such as storage costs or finishing costs in the case of the cattle basis.[2] The data were then grouped by year and quarter prior to calculating the $SD(BR)_{ijk}$ in order to increase the number of observations and help control for changes in the price and cost levels that occur over time.

Exogenous data were based on yearly and in some instances quarterly data for the various commodities. Table 1. shows the mean values by commodity of

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[2] see author, dissertation, for details on cost computation and price series.

exogenous variables entering the models. Three degrees of perishability were specified: storable (grains), semi-storable (frozen pork bellies) and perishable (beef).

The explicit model specification including hypothesized signs is shown in (1): (1) SD(BR)/SD(P) = exp(a +

$$b_1 STX + b_2 ML + b_3 HR + b_4 IM + b_5 EX + d_1 P1 + d_2 P2)$$
$$(-) \quad (-) \quad (-) \quad (-) \quad (-) \quad (-) \quad (-)$$

SD(BR)/SD(P) = standard deviation of the basis residual normalized by the standard deviation of the cash price

STX = stock level$_{ijk}$ / mean stock level$_{ij.}$
ML = trading volume$_{ijk}$ / open interest$_{ijk}$
HR = hedged positions$_{ijk}$ / total positions$_{ijk}$
IM = imports$_{ij.}$ / total domestic consumption$_{ij.}$
EX = exports$_{ij.}$ / total domestic production$_{ij.}$
P1 = storable dummy variable
P2 = semistorable dummy variable
a = intercept corresponds to nonstorables

The functional form imposes the <u>a prior</u> assumption that variability in the basis residual must have some positive value regardless of the independent variable values since one would expect variability even under ideal conditions, as adjustments between markets in not instantaneous.

With the diversity among commodities in the analysis the exogenous variables were not expected to account for all cross sectional differences in the model. The assumptions concerning the error structure are as follows.

(2) $E(u_{ijk}) = 0$ i = commodity j,s = year k,t=quarter

(3) $COV(u_{ijk},u_{ist}) = 0$

(4) $VAR(u_{ijk}) = Za = Z^2a^2{}_i$

a_i = unknown multiplicative value (commodity specific)

A procedure similar to Glejser's (1969) approach was used to correct for heterscedasticity. The equations were estimated using OLS and the estimated residuals were then squared and regressed on commodity dummy variables in order to derive mean values of the estimated residuals pertaining to each commodity. These mean corrections (shown in Table 2) were then used to weight the regression equation so that the variance would be homoscedastistic.

(5) $\ln Y/ai = 1/ai + b_1/X_1/a_i + \ldots b_k X_k/a_i + V_i$

where $Y = SD(BR)/SD(P)$, $V = u_i/a_i$ and

(6) $VAR\ (V_i) + VAR\ (u_i/a_i) = \sigma^2 a^2{}_i/a^2{}_i = \sigma^2$

RESULTS

The weighted least square results are shown in Table 3 where each observation corresponding to a particular commodity is divided by the corresponding mean adjustment (a_i). The transformation does not lead to a respecification of parameters associated with the original variables (except for the intercept.) Because the parameter estimates for HR and STX were positive, squared terms for these variables were added to the specification since if $b_i > 0$, then the limit of X_i implies a second derivative greater than zero. Hence, the effects of X_i on Y would explode as X_i increased. Using this alternative of including a higher order form, the model still assures positive dependent variable values but allows for positive effects of HR and STX to occur at decreasing rates.

The overall fit of each of the three constant period to maturity (CPM) models is acceptable with adjusted R^2's in the two, four and six month models being .88, .89 and .87 respectively. In general the signs of the estimated parameters are as hypothesized.

The parameter estimate for exports (EX), defined as exports divided by total yearly domestic production, is negative and highly significant. The large firms that carry on highly centralized export activities act to increase the arbitrage potential because they have the incentive to use the futures market and devote significant resources to keep abreast of current situations in the spot and futures markets, which acts to improve integration between markets. The import variable (IM) was highly correlated (negatively) with exports and dropped from the model.

Market liquidity (ML), which reflects the ease of entry and exit in the futures market has a significant coefficient is all three models with each having the anticipated negative sign since a liquid market facilitates trading and enhances basis performance. The hypothesized sign for the hedging ratio (HR) was negative since a relative increase in hedged positions was expected to increase the arbitrage potential. As the parameter estimates for HR and HR2 in Table 3 reveal, the function initially increases then decreases in all three models. Simulation of the results suggest that only when a threshold level of the ratio of hedgers to speculators is reached (approximately .5) will an increase in the HR decrease variability in the basis residual.

Resolution of uncertainty about crop production brings about increased price volatility. This resolution of uncertainty and stock levels each follow seasonal patterns that are similar year after year. These two factors are contemporaneously correlated which causes the STX variable to confound the stock effect and the resolution of uncertainty effect. An increasing portion of the STX function results because the positive effect of uncertainty on price volatility dominates the negative effect that stock levels have on the variability of the basis residual. For stock levels not corresponding to the late summer months when the uncertainty effect is strong, the STX function is negatively sloped, revealing that increased stock levels benefit market performance by improving the arbitrage potential.

The mean level of variability in the basis residual was substantially greater for the nonstorable (cattle) as compared to the storable classification as shown in Table 4. This result was anticipated because holders of storable products have greater flexibility in timing their marketing than producers of nonstorables. As expected, this difference was much greater in the two month model than the six month model since there is no potential to arbitrate, that is, to complete the feeder cattle-live cattle transformation in the two month interval.

CONCLUSIONS

Commodity characteristic, including physical and marketing characteristics, influence variability in the basis residual that in turn influences the usefulness of the futures market as a risk shifting device. The arbitrage model offers a general approach to examining market performance under alternative conditions.

Changes in the economic environment which alter some of these commodity characteristics can be expected to affect market performance. For instance, government policy or exchange rates can affect exports which would be expected to change market performance. Alternatively, an increase in speculative interest in a futures contract may increase the volume of trading and market liquidity and therefore, be expected to enhance market performance. It may be possible to redefine a futures contract to be more useful to hedgers and thus improve the integration between the cash and futures markets. The results of the present analysis are useful in predicting how such changes might affect market performance.

Even commodity characteristics that appear to be intrinsic are subject to change as a result of changing technology. For instance, consider the effect that refrigeration and freezing has had on marketing flexibility for perishable commodities. Factors that improve a producer's marketing flexibility and control help reduce price risk whether a futures contract exists or not. If a futures contract does exist, then increased marketing flexibility can be expected to improve basis performance. One could expect to see new futures contracts as technological advances make this method of reducing price risk feasible. Alternatively, existing futures contracts may be discontinued as economic conditions change.

The present study represents a general approach to identifying broadly defined factors that influence basis performance. Further research is needed to ascertain how these factors effect producers' returns to hedging. Performance was gauged by the deviation of the basis from the transformation cost. This deviation may be asymmetric, that is, the likelihood of a narrow basis may be greater than a wide basis. This aspect of the distributional properties of the basis affects the potential returns to hedging depending on whether a hedge is long or short. In addition, the composition of long and short hedges pertaining to a futures contract could be expected to influence basis variability, as well as distribution.

Further research is also needed to analyze in detail the effect that the time until maturity has on basis variability and the returns to hedging. Such analysis would be useful to advising producers as to the best time to place a hedge. It would be beneficial to know what influences producers' decisions concerning whether or not to use the futures market. It would also be useful to know how the performance of the futures market is related to the percent of an industry that uses the market in hedging.

Table 1. Mean Values of Exogeneous Variables by Commodity Entering the Basis Residual Variance Model.

Commodity	Exports	Market Liquidity 2 mo	4 mo	6mo	Hedge Ratio
Corn	.26	.21	.16	.15	.73
Wheat	.61	.29	.22	.17	.57
Oats	.01	.19	.15	.13	.49
Soybeans	.39	.37	.23	.15	.52
Cattle	.004	.35	.28	.19	.37
Pork bellies	.001	.51	.35	.31	.12
FCOJ	.06	.12	.09	.08	.62
Crush	.26	.22	.14	.11	.62

Table 2. Heteroscedasticity Adjustment Coefficients.

Commodity (i)	Heteroscedasticity adjustment Coefficient (a_i)
Soybean crush	2.42
Corn	1.87
Wheat	1.03
Oats	2.46
Soybeans	1.36
Cattle	0.83
Frozen pork bellies	1.00
FCOJ	1.93

Table 3. Weighted Least Squares Estimates for the Basis Residual Variance Model After Correcting for Heteroscedasticity.

Variable	two month model	four month model	six month model
1/a	.71	-.89	-.45
	(1.48)[b]	(-2.11)	(-1.09)
EX/a	-3.27	-2.99	-4.05
→ (-7.98)	(-7.70)	(-10.05)	
ML/a	-3.44	-3.79	-2.41
	(-5.97)	(-5.84)	(-3.32)
HR/a	4.18	5.16	.61
	(1.62)	(1.95)	(.23)
HR^2/a	-3.59	-4.39	-1.26
	(-1.59)	(-1.95)	(-.54)
P1/a	-4.47	-4.50	-2.74
	(-7.43)	(-7.26)	(-4.36)
P2/a	-.67	-.83	-.02
→ (-1.47)	(-1.74)	(-.37)	
STX/a	1.27	3.07	1.99
	(2.13)	(5.10)	(3.20)
STX^2/a	-.68	-1.35	-.744
	(-2.90)	(-4.84)	(-2.55)
adjusted R^2	.88	.90	.87
F statistic	326.55	382.71	303.81
observations	412	396	409
d.f.	403	387	400

[b] T statistics shown in parentheses.

Table 4. Mean Levels of the Standard Deviation of the Basis Residual Corresponding to Alternative Classifications of Storability.

	two month model	four month model	six month model
Storable	.023	.005	.041
Semistorable	1.044	.179	.629
Nonstorable	2.040	.410	.640

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