FORECASTING THE NEARBY BASIS OF LIVE CATTLE

SHI-MIIN LIU
B. WADE BRORSEN
CHARLES M. OELLERMANN
PAUL L. FARRIS

Numerous articles have provided statistical models of cash-futures basis for live cattle [e.g., Ehrich (1972); Ivy (1978); Erickson (1977); Leuthold (1979); Naik and Leuthold (1988)] and for other commodities [e.g., Trapp and Eilrich (1991); Tilley and Campbell (1988)]. Researchers have generally found it more difficult to model basis as the futures contract approaches maturity. A better understanding of basis as the futures nears the delivery period is needed. This seems especially true in view of recent concerns about the delivery mechanism and lack of convergence revealed in studies by Peck and Williams (1991) and CBOT (1988), as well as interest in cash settlement [Kahl et al. (1989); Kimle and Hayenga (1991)].

This study seeks to forecast the live cattle basis during the month preceding contract delivery. Futures market variables believed to be associated with changes in the nearby basis are identified, their rela-

■ *Shi-Miin Liu is an associate professor at National Chung Hsing University, Taipei, Taiwan, and a former postdoctoral researcher in Agricultural Economics at Purdue University.*

■ *B. Wade Brorsen is a professor of Agricultural Economics at Oklahoma State University.*

■ *Charles M. Oellermann is an Attorney in Columbus, Ohio and former graduate student in Agricultural Economics at Purdue University.*

■ *Paul L. Farris is professor emeritus of Agricultural Economics at Purdue University.*

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tionship to the basis is examined and compared to alternative models, and out-of-sample forecasts based on these relationships are evaluated.

Past studies of the futures-cash price basis for live beef cattle have included several approaches and have yielded varying results. Ehrich (1972), examining the basis during the 2- or 3-month period before delivery, concluded that inventories play a key role. Ivy (1978) analyzed the basis between slaughter cattle cash prices at Guymon, Oklahoma, and the nearby live cattle futures contract price between 1973 and 1977 and found that the futures minus cash basis was related positively to the expected forward slaughter price and the supply of fed cattle in the Oklahoma region. His basis and price series, expressed in nominal terms, may have been positively associated partly because of an outside influence, inflation. Erickson (1977) developed two monthly models, one each for the nearby and 4-month-deferred bases. He considered the effects of slaughter levels, feeder steer prices, 1-month lagged cash price, cattle on feed, 1-month lagged futures/cash price ratio, and seasonal dummy variables. His models, with price data expressed in nominal terms, provided moderate explanation of basis variability.

Leuthold (1979) used a multiple regression model to explain variations in basis at various specified months prior to delivery. These were 0–1, 2–3, 4–5, and 6–7 months preceding the delivery month. His model related average monthly basis to monthly beef slaughter, price of corn, cash price of fed cattle, cash price of feeder cattle, cattle on feed in three weight categories, and seasonal dummy variables. For 2–7 months prior to futures contract maturity, this model explained 78 to 90% of the variation in live cattle basis between 1965 and 1977. However, the model explained only 26% of the variation one month prior to delivery. He concluded:

> The nearby basis is more random and difficult to explain. During delivery, items traded in the cash and futures markets become nearly interchangeable at the delivery point, and the difference between the prices reflects short run conditions including liquidity of the market.... Thus, it is not surprising that an economic model designed to depict shifting supply conditions cannot explain intertemporal price relationships during or very close to the delivery month. (p. 50)

In a later study, Naik and Leuthold (1988a) found considerable variability among correlation coefficients between cash and futures prices of cattle at Omaha during maturity months. Significant factors explaining the basis in the Naik and Leuthold study were lagged values of the basis, per capita income, and hog prices. They, along with added nonsignificant variables, accounted for 47% of the variation in the nearby basis.

Two futures market variables, the spread between the nearby and deferred futures contracts and open interest, are used in this study as an alternative to the cattle supply and demand variables and lagged basis used by Naik and Leuthold (1988a). Hauser et al. (1990) found that a measure similar to the spread used here provided a useful forecast of basis. Also, the spread variable may be preferred over lagged basis because the spread is unaffected by spatial price differences. The live cattle futures market has multiple delivery points and the futures prices reflect overall demand and supply situations. Non-nested hypotheses tests and out-of-sample forecasts are used to select among the alternative models. The four models considered include: spread and open interest, lagged basis, supply and demand variables, and a joint model which includes the other models as special cases.

THEORY

Because cattle are not storable, a standard model relating basis to storage costs, such as that used by Tilley and Campbell (1988) is not applicable. A similar model, however, is applicable. Naik and Leuthold's (1988b) model is a special case of the theoretical model used here. Assuming an efficient market with no transaction costs, the current futures price equals the expected cash price at delivery (i.e., the law of one price holds). The basis (futures-cash) prior to the delivery period for a par delivery point with no transaction costs is then the expected change in cash price. Thus, where transaction costs are zero:

$$\text{Basis} = E(\Delta \text{ cash price}) \tag{1}$$

Because transaction costs do exist for both buyers and sellers, the basis, due to arbitrage, is restricted to a range of

$$E(\Delta \text{ cash price}) + \text{cost of making delivery} \geq \text{Basis} \geq E(\Delta \text{ cash price}) - \text{cost of accepting delivery} \tag{2}$$

Thus, basis depends on both the expected change in cash price and cost associated with delivery:

$$\text{Basis} = g(E(\Delta \text{ cash price}), \text{delivery costs}) \tag{3}$$

Neither variable on the right side of the equation is directly measurable. Therefore, eq. (3) must be estimated as

$$\text{Basis} = f(x, y, \epsilon) \tag{4}$$

where x is a set of variables used to predict $E(\Delta$ cash price), y is a set of variables used to predict delivery costs, and ϵ is a random error variable. Naik and Leuthold (1988b) developed their model based on rational expectations. Naik and Leuthold's variables are one alternative to use for x. The general empirical model of this study includes the significant variables (per capita income and hog prices) from Naik and Leuthold (1988a) as a special case. Beef slaughtered, cattle and calves on feed and chicken prices are included also. The third alternative considered here is to use the spread between the nearby and deferred futures as an alternative to the lagged basis used by Naik and Leuthold (1988a).

FACTORS EXAMINED IN THIS STUDY

The joint model is

$$\text{LGBAS} = f(\text{LLGBAS}, \text{LGSLB}_{12}, \text{LGCCF}_{12}, \text{LGCHP}_{12}, \text{LGHGP}_{12}, \text{LGCPI}_{12}, \text{LLGSP}, \text{LGOI}_{12}) \tag{5}$$

Where:

LGBAS = log(FP) − log(CP). FP is the average futures price during the month preceding contract maturity. CP is the mean Texas–Oklahoma cash price for average choice steers during the month preceding contract maturity.

LLGBAS = lag of LGBAS.

Supply variables:

LGSLB_{12} = $\log(\text{SLB}_1) - \log(\text{SLB}_2)$. SLB is the number of beef cattle slaughtered commercially each month, United States, 1000 head. Subscripts 1 and 2 indicate lagged 1 and 2 months, respectively.

LGCCF_{12} = $\log(\text{CCF}_1) - \log(\text{CCF}_2)$. CCF is the number of cattle and calves on feed, 7 states, 1000 head. Subscripts 1 and 2 are indicators of the number of lagged months.

Demand variables:

LGCHP_{12} = $\log(\text{CHP}_1) - \log(\text{CHP}_2)$. CHP is the monthly farm price of young chickens. Subscripts 1 and 2 are indicators of the number of lagged months.

$LGHGP_{12} = \log(HGP_1) - \log(HGP_2)$. HGP is the price of barrows and gilts, seven markets. Subscripts 1 and 2 are indicators of the number of lagged months.

$LGPCI_{12} = \log(PCI_1) - \log(PCI_2)$. PCI is per capita income. Subscripts 1 and 2 are indicators of the number of lagged months.

Delivery cost variable:

$LGCPI_{12} = \log(CPI_1) - \log(CPI_2)$. CPI is the monthly Consumer Price Index (1964 = = 100). Subscripts 1 and 2 are indicators of the number of lagged months.

Futures market variables:

LLGSP = lagged LGSP. The lagged period is 2 months. LGSP = $\log(DFP) - \log(FP)$, where DFP is the average price for the 2-month-deferred futures contract. For example, if March is the observation month and April is the nearby contract, then DFP is the price of the June contract observed in March. LLGSP is, thus, the April minus the preceding February spread observed in the preceding January.[1]

$LGOI_{12} = \log(OI_1) - \log(OI_2)$. OI is the average monthly open interest of the nearby live cattle futures contract. Subscripts 1 and 2 are indicators of the number of lagged months.

In addition to the joint model, three subset models are considered. The subset models included the delivery cost variable and (1) futures market variables, (2) lagged basis, or (3) the supply and demand variables.[2]

Naik and Leuthold (1988a) used nominal prices and thus made no adjustment for inflation. The specification of the basis here uses percentage basis; and, thus, the basis is, in effect, deflated with the cash price.

Each of the four models are subjected to tests of misspecification and structural change. The specification test of White (1980) and the CUSUM test [Greene (1993, p. 217)] are insignificant in every case. Chow tests [Greene (1993, pp. 211–212)] from splitting the sample in half also reveal no significant structural change.

[1]Lagged 1-month spread variable in this case, the June minus the April value observed in the preceding February, is considered to contain less information than the lagged 2-month spread variable does because the two futures contracts involved in the calculation of 1-month lagged spread variable are more distant to the observed month.

[2]An additional lag of all variables was considered. The set of coefficients on the additional lagged variables was not significant and thus an additional lag was not included in the final model.

Since cash and futures prices have unit roots, the above specification implicitly assumes that cash and futures prices are cointegrated with a cointegrating regression that has a slope of one. Otherwise, the basis would not be stationary. Past tests of the cointegration of cash and futures prices have produced mixed results when the maturity of the futures contract is not held constant [Chowdhury (1991); Bessler and Covey (1991); Schroeder and Goodwin (1991); Djunaidi et al. (1993)]. But both Lai and Lai (1991) and Krehbiel et al. (1993) found cash and futures prices were cointegrated when maturity is held constant as it is here. The slope coefficient is 0.997. The null hypothesis that the basis is nonstationary is rejected using a Dickey–Fuller test (test statistic is −7.44, critical value −2.24).[3] The models used here are not error correction models. The basis is the error correction term. So, the models used here are trying to explain the error correction term.

The supply and demand variables and the futures market variables are both measures of the expected change in cash price. Non-nested hypothesis tests are used to test the null hypothesis that the futures market variables provide the best prediction, versus the alternative hypothesis that the intuitive supply and demand variables provide the best prediction. The non-nested tests used are the Wald test and the J-test [Davidson and Mackinnon (1981)].

The Wald non-nested test of the null hypothesis that the futures market variables and lagged basis contain all the information in the intuitive set of supply and demand variables, for example, corresponds to the joint F-test that all the coefficients for the intuitive set of supply and demand variables in eq. (5) are zero. Similarly, the null hypothesis that the intuitive set of supply and demand variables and lagged basis contain all the information in the futures market variables corresponds to the joint F-test that all the coefficients for the futures market variables in eq. (5) are zero. The J-test includes the predicted values of one model as an explanatory variable in another. The J-test of the null hypothesis then corresponds to the null hypothesis that the coefficient on the predicted value is zero.

EXPECTED DIRECTIONS OF INFLUENCE

The spread variable LLGSP and the lagged basis reflect the influence of intertemporal expectations in the futures market. According to Tomek and Gray (1970):

[3]The critical values are taken from Greene (1993, p. 565).

> The element of expectations is imparted to the whole temporal constellation of price quotations, and futures prices reflect essentially no prophecy that is not reflected in the cash price and is in that sense already fulfilled. (p. 373)

Although Tomek and Gray were referring specifically to inventory markets, a similar relationship may exist for nonstorables. A lagged 2-month-deferred futures price in excess of the lagged nearby futures price (i.e., a large value of LLGSP) means the future cash price would be expected to be above the current cash price, yielding an increased basis. If the lagged deferred contract price is below the lagged nearby futures price, a decreased basis would be expected. Therefore, a positive association between LGBAS and LLGSP is expected. Lagged basis should have a similar relationship.

The lagged open interest variable can be influential in that increased holdings of futures contracts could be associated with expected lower future supplies; so that a positive change in open interest would be expected to be associated with positive changes in cash prices. Thus, a negative association between LGBAS and $LGOI_{12}$ is expected.

The effects of the beef supply variables might differ, depending on whether they influence future cash prices or more recent cash prices more. If increases in current U.S. beef slaughter dampen current cash prices more than prices in the future, the basis would widen and a positive association would be observed between changes in lagged beef supplies and the basis. However, if future cash prices are influenced relatively more than current cash prices, an increase in supply would narrow the basis and an inverse association would be observed. Cattle and calves on feed would be expected to have a greater influence on future cash prices and, thus, more cattle and calves on feed would lead to a lower basis

Other things being equal, one would expect a decrease in hog prices to dampen more recent cash beef prices and thus widen the basis. As chicken prices move higher, substitution of beef for chicken would be favored and more recent cash beef prices would tend to rise. Therefore, an inverse association between lagged changes in both hog and chicken prices and the basis would be expected. Naik and Leuthold (1988a) found the basis increased as hog prices increased and as per capita incomes increased.

Rising delivery costs associated with inflation would seem to have some influence on decisions to avoid delivery. As eq. (2) shows, the effect of increasing delivery costs can be either positive or negative.

DATA

Six contract months (February, April, June, August, October, and December) of live cattle futures are traded. The data from each contract month from 1970 to 1986 (102 observations) are used to build the models, and the data from 1987 to 1991 (30 observations) are used to perform the out-of-sample forecasts. The futures price and open interest series are the daily opening price and open interest of the live cattle contract traded on the Chicago Mercantile Exchange (CME). The opening price is used because the futures market for live cattle opens at 9:05 A.M. and closes at 12:45 P.M. Thus, the opening price of futures contracts appears compatible with the price in the cash market.[4] Only three daily cash prices per week (Monday, Tuesday, and Wednesday) are included in calculating the monthly average since these are the most active trading days during the week. These series are from the Dunn and Hargitt Commodity Data Bank, Lafayette, Indiana. Monthly data for other variables used in this study are from various publications by R. M. Leuthold (University of Illinois).

OUT-OF-SAMPLE FORECAST

The out of sample time period of 1987–1991 yields 30 out of sample observations. Past research has often used fewer out of sample observations and has yielded statistically insignificant results. Granger and Newbold (1977, p. 307) explain how to calculate an optimal forecast when a log transformation is used on the dependent variable. The formula used is

$$\text{PBasis} = \exp(\widehat{\text{LGBAS}} + s^2/2) - 1 \tag{6}$$

where PBasis is the percentage basis (FP − CP)/CP, $\widehat{\text{LGBAS}}$ is the predicted value of LGBAS and s^2 is the forecast error [Greene (1993, p. 195)]. All forecast statistics are calculated in terms of the percentage basis.

Based on an equilibrium theory developed by Merton (1981), Henriksson and Merton (1981) propose a nonparametric statistic to measure models' market direction prediction ability. Assume M_t is market direction at time t, Z_t is forecast direction at time t, and A_t is the actual value at time t. M_t equals 1 if $A_t > A_{t-1}$, and equals 0 otherwise. Z_t is equal to 1 if $P_t > A_{t-1}$ and equal to 0 if $P_t \leq A_{t-1}$. Jackson et al. (1991) and McIntosh and Dorfman (1992) have used the Henriksson–Merton test of forecasting ability, although Jackson

[4]The closing prices of futures contracts were also used, and the results showed little difference.

et al. follow Breen et al. (1989) and base their test on asymptotic distribution theory.

The null hypothesis is that the model forecasts have no information value. To calculate the confidence level, c, of rejecting the null hypothesis, define the following for each forecast series:

N_1 = the number of observations with downward movement or no change $= T - \sum_{t=1}^{T} M_t$,

N_2 = the number of observations with upward movement $= \sum_{t=1}^{T} M_t$,

T = the total number of forecasts $= N_1 + N_2$,

n_1 = the number of correct forecasts of downward movement or no change $= \sum_{t=1}^{T}(1 - M_t)(1 - Z_t)$,

n_2 = the number of incorrect forecasts of downward movement or no change $= [\sum_{t=1}^{T}(1 - Z_t)] - n_1$, and

n $= n_1 + n_2$ = the number of forecasts of downward movement or no change.

The confidence level, c, is given by the formula [McIntosh and Dorfman (1992, p. 211)]:

$$c = 1 - \sum_{x=n_1}^{\min(N_1, n)} \binom{N_1}{x}\binom{N_2}{n-x} \Big/ \binom{N}{n} \qquad (7)$$

Merton recommends using a one-tailed test. For a one-tailed test with a confidence level of c, the null hypothesis of no information value is rejected whenever the desired significance level is greater than $1 - c$. The Henriksson–Merton confidence level is calculated for each of the four alternative models.

RESULTS

Table I shows the average basis by individual contract and for all contracts combined during predelivery months, 1970–1991. The averages for the June and August contracts are generally the lowest, the averages for April and December the highest. Considerable variability is apparent for all contracts. The basis is positive on average (implying futures is usually higher), but is often negative.

Four regression models are used in analyzing basis variations for all contracts combined (Table II). Model 1, which includes the futures market variables but not the supply-and-demand variables or lagged

TABLE I
Average Nearby Basis and Variability for Individual Live Cattle Contracts, 1970–1991

Contract Month	Number of Observations	Average	Standard Deviation	Range Minimum	Range Maximum
		dollars per hundred weight			
February	22	0.258	1.505	−2.350	3.710
April	22	1.027	1.333	−2.100	3.550
June	22	−0.355	2.389	−4.360	5.090
August	22	−0.605	1.953	−4.250	2.800
October	22	0.285	1.576	−2.120	3.580
December	22	0.910	1.724	−2.710	3.700
All	132	0.253	1.846	−4.360	5.090

basis, shows the high explanatory power of the spread variable. Also significant are the open interest and the delivery cost proxy, CPI. The results suggest that the basis decreases as delivery cost increases. Model 2, which includes only lagged basis and delivery cost, shows lagged basis has explanatory power similar to the two futures market variables. The power of the lagged basis in explaining the nearby basis is expected, since both basis series reflect conditions at the specific location of the cash price series. In Model 3, which includes the intuitive supply-and-demand variables but not the futures market variables or lagged basis, cattle and calves on feed is significant and inversely related to the basis. This finding is consistent with an increase in future expected supplies. For the demand side variables, chicken price is significantly associated with the nearby cattle basis while hog price is not. The signs suggest that both of the demand variables have more effect on prices for immediate delivery than on prices for future delivery.

In the joint model, the spread, open interest, and lagged basis variables are added to all other variables included in Model 3. The addition of the futures market variables and lagged basis increases the adjusted R^2 from 0.13 to 0.67. The lagged basis variable is highly significant in the joint model, and the spread and open interest variables are significant at the 5% level. The addition of the futures market variables and lagged basis also renders insignificant cattle and calves on feed, but chicken price is still significant.

The Wald non-nested tests reject the null hypothesis that the coefficients of the two futures market variables in the joint model are zero (F-value = 5.27) and that the coefficient of lagged basis is zero (F-value = 11.61). The Wald non-nested tests, however, fail to

TABLE II
Results of Nearby Cattle Basis (Futures-Cash) Regression Models, All Contracts Combined, 1970–1986

Explanatory Variables	*Model 1*	*Model 2*	*Model 3*	*Joint Model*
	Coefficients and *t* values			
Intercept	0.028[a]	0.013[a]	0.010	0.180[a]
	(6.85)	(3.73)	(1.36)	(3.39)
$LLGSP_{12}$	0.706[a]			0.313[b]
	(12.59)			(2.52)
$LGOI_{12}$	−0.024[b]			−0.025[b]
	(−2.56)			(−2.54)
$LLGBAS_{12}$		0.487[a]		0.301[a]
		(12.69)		(3.41)
$LGCPI_{12}$	−2.099[a]	−1.422[b]	−0.763	−1.551[b]
	(−3.95)	(−2.70)	(−0.87)	(−2.80)
$LGSLB_{12}$			−0.066	−0.019
			(−1.63)	(−0.73)
$LGCCF_{12}$			−0.157[b]	−0.025
			(−2.12)	(−0.53)
$LGCHP_{12}$			−0.123[b]	−0.078[b]
			(−2.47)	(−2.54)
$LGHGP_{12}$			−0.061	0.002
			(−1.43)	(0.06)
$LGPCI_{12}$			0.266	0.193
			(0.59)	(0.70)
F-value	55.97[a]	81.58[a]	3.38[a]	23.70[a]
Adjusted R^2	0.62	0.62	0.13	0.67
Non-nested tests[c]				
Model 1		2.82[a]	2.88[a]	5.27[a]
Model 2	3.65[a]		3.06[a]	11.61[a]
Model 3	2.32[b]	2.58[b]		1.58

The values in parentheses are *t*-statistics.
[a]Indicates significance at the 1% level.
[b]Indicates significance at the 5% level.
[c]The non-nested test statistics in columns 1, 2, and 3 are *T*-tests. The statistics in column 4 are Wald *F*-statistics.

reject the null hypothesis that the coefficients of the five supply and demand variables in the joint model are zero (*F*-value = 1.58) at the 5% level. Thus, the Wald non-nested tests indicate that the set of supply and demand variables do not contain information that is not contained in the two futures market variables and lagged basis. The *J*-tests, however, which are more powerful than the Wald tests find that the supply/demand variables do contain unique information. Both *J*-tests and Wald tests suggest that the futures market variables and lagged basis contain unique information.

The conclusions from the out-of-sample forecast statistics reported in Table III show that forecast results from all four models are remarkably similar. Even Model 3 which contains the supply and demand variables gives results comparable to the results of the other three models. The model with the two futures market variables alone has the highest root mean squared error, while the joint model with all explanatory variables has the lowest. The ratio of accurate forecasts is similar for all models ranging from 0.667 to 0.767. The model with lagged basis and the model with the supply/demand variables forecast direction well enough that the Henriksson–Merton test rejects the null hypothesis of no information value at the 0.05 level for these two models. The null hypothesis is rejected at the 0.15 level for all models.

CONCLUSIONS

In-sample tests show that the lagged spread and lagged basis both have considerable ability to explain movements in nearby live cattle basis. The lagged spread may be more generally applicable because, unlike the lagged basis, it is not tied to a specific geographic location. Non-nested hypothesis tests suggest a joint model which contains both variables has greater explanatory power than models without both variables. Thus, lagged spread and lagged basis each contain unique information. A set of supply/demand variables has little explanatory power, but the more powerful *J*-test indicates the supply/demand variables contain some unique information

Forecasts of all four models are similar out of sample. The results indicate some potential to forecast the nearby basis using readily available futures and cash price series. The rankings of the forecast methods differ between root mean squared error and percentage of correct directions. The joint model has the lowest root mean squared

TABLE III

Statistics from Out-of-Sample Forecasts of Live Cattle Percentage, 1987–1991 Basis

Model	Bias	RMSE	No. Correct[a] Upturns	No. Correct[a] Downturns	Ratio of Accurate Forecasts[b]	HM Confidence Level[c]
1. Futures variables	−0.025	0.047	14	6	0.667	0.882
2. Lagged basis	−0.012	0.028	17	6	0.767	0.991
3. Supply/demand	−0.017	0.036	17	5	0.733	0.974
4. All variables	−0.025	0.027	15	5	0.667	0.863

[a]The total number of upturns is 18. The total number of downturns is 12.
[b]The ratio of accurate forecasts is the number of correct directions forecast divided by the total number of forecasts.
[c]One minus the Henriksson–Merton confidence level yields the significance level.

error, but the lagged basis model has the highest ratio of accurate forecasts and the highest Henriksson–Merton confidence level. The ambiguity of the out-of-sample results could be due to structural change in the out-of-sample time period. In-sample tests, however, reveal no significant structural change. The relatively higher cost of generating forecasts with the complete joint model are a disadvantage. Thus, one of the two simpler models may be preferred since they would be less costly to use. The results certainly suggest that short-term dynamics are at least as important as supply and demand considerations for predicting nearby basis.

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