Impact of Cash Settlement on Feeder Cattle Basis

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The feeder cattle futures contract specifications were changed in 1986 from physical delivery to cash settlement. The Chicago Mercantile Exchange expected this change to reduce basis variability and improve the ability of hedgers to predict basis. This study analyzes the basis for individual lots of feeder cattle before and after cash settlement. Basis equations were estimated by breed, sex, weight, grade, and season. These equations were used to predict basis. The results indicate basis variability was not reduced and hedger ability to forecast basis, in general, was not improved significantly under cash settlement compared to physical delivery.

Key words: feeder cattle basis, cash settlement, futures markets.

Cash settlement for feeder cattle futures began with the September 1986 contract. The Chicago Mercantile Exchange (CME) instituted cash settlement basically for three reasons. First, physical deliveries under the old system averaged approximately 25% of average month-end open positions during 1978 to 1985 (Paul). These deliveries caused the CME grader-scheduling problems at delivery points, dissatisfied traders over grades assigned to delivered cattle, and increased costs for traders and the CME. Second, because of multiple delivery points, long traders never knew where delivery would occur, hence both long speculation and long hedging were discouraged (Cohen and Gorham). Third, local market basis relationships were volatile, reducing hedging effectiveness and interest (Ernst). Hence, the CME introduced cash settlement as a means of eliminating physical deliveries, encouraging long participation by speculators and hedgers, and increasing hedge participation by reducing basis variation.

The purpose of this article is to analyze the impact of cash settlement on the variability and predictability of feeder cattle basis. Before the introduction of cash settlement, Cohen and Gorham of the CME hypothesized that the introduction of cash settlement would lower basis variability and strengthen the relationship between expected and actual hedge outcomes, thus improving the effectiveness of hedging as a forward pricing tool. Enough time has passed to begin testing this hypothesis. The impact of cash settlement on feeder cattle basis is important to the CME because it wants to improve the hedging effectiveness of the feeder cattle contract. In addition, the CME has considered cash settlement for live cattle futures in the recent past, and the issue may be raised again in the future. The change in basis variability under cash settlement for feeder cattle could be of major importance in deciding whether or not to implement cash settlement on other futures contracts with a high percentage of physical deliveries and high physical delivery costs.

Previous Research

Before cash settlement began, Cohen and Gorham estimated that cash settlement might reduce basis variability at contract expiration by about one-third. Their basis estimates were based on weekly 600–700-pound USDA steer prices for 14 individual markets and weekly state 600–800-pound steer prices calculated and reported by *Cattle-Fax* for the week in

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which futures expire. The physical delivery futures price was the average of the CME feeder cattle settlement prices for the same week. The cash-settled futures price was assumed to equal the weekly average U.S. Feeder Steer Price (USFSP) reported by *Cattle-Fax* for the same week. Basis was calculated for expiring contracts for 1980–83, and the standard deviation of basis was computed under the two systems. The standard deviation of basis declined under cash settlement for each market. Cohen and Gorham indicated that 67% of the time the range in mean maturity basis might fall from \$3.38 under physical delivery to \$1.84 under cash settlement at Oklahoma City.

Cohen and Gorham indicated that maturity basis risk will never be zero since the cash settlement price is an average over space, time, and grade, whereas the hedger will sell at a local price which is only one component of this average. The hedger will confront basis risk equal to the range of differences between the average price and the local cash price. They also indicated that basis variability will increase as the time to contract expiration increases because of increased variability in futures market expectations. For example, the basis range at Oklahoma City under cash settlement was estimated to be \$1.71 cwt. greater four weeks prior to expiration compared to expiration week basis during 1979–83.

After cash settlement was implemented, the Commodity Futures Trading Commission (CFTC) analyzed the impact of cash settlement on basis variability for 600–800-pound Oklahoma City feeder steers for the September 1986 through May 1987 contracts. Oklahoma City was a par delivery point under physical delivery but is only one market from 27 states used to calculate the USFSP for 600–800-pound steers under cash settlement. The monthly average basis for the first seven months under cash settlement varied from \$2.85 to \$4.14 per cwt. Across the same period the previous year under the physical delivery system, the monthly average basis varied from −\$2.46 to \$3.02 per cwt. The CFTC concluded that basis variability had been reduced in Oklahoma City and ". . . that it is likely that basis volatility for feeder cattle declined in most other cash markets at the same time." However, given the great diversity among feeder cattle markets, the CFTC suggested that further research on local basis changes as a result of cash settlement should be studied.

Elam, and Schroeder and Mintert evaluated the impact of cash settlement on feeder cattle hedging risk. In both studies the authors estimated optimal hedge ratios before and after cash settlement and measured hedging risk as the standard deviation between expected and actual hedge returns. Since both studies include some cattle not meeting feeder cattle futures contract specifications in terms of weight and sex, their estimates of hedging risk for nonpar cattle include both basis and cross-hedging risks.[1] Using weekly Arkansas auction data from 1977–86, Elam found that hedging risk was consistently lower in September, October, and November under cash settlement but that hedging risk increased during March, April, and May for feeder cattle weighing less than 600 pounds. Elam concluded that since the majority of hedges are placed on animals weighing more than 600 pounds, hedging risk is estimated to be lower with the new cash settlement contract compared to the physical delivery contract for 600–700-pound steers and heifers.

Schroeder and Mintert used similar methods to analyze hedging risk for the Amarillo, Texas; Dodge City, Kansas; Kansas City, Missouri; and Illinois Direct Markets covering the January 1977 through December 1987 period. They found that hedge ratios for 600–800-pound feeder steers were in general not significantly different from one and that almost all the cash-settled feeder cattle futures contracts had hedging risk lower than that of the physical delivery futures contracts. Hedge ratios for 600–800-pound feeder heifers were generally less than one and, with the exception of Dodge City, hedging risks were less with cash-settled futures contracts. There was no difference in risk reduction between the three markets included in the USFSP calculation and the Illinois Direct Market, which is not included in the USFSP series.

Because cash settlement for feeder cattle began with the September 1986 contract, both Elam, and Schroeder and Mintert were forced to assume that futures prices under cash settlement were equal to the historical USFSP price series. Hence, their results are based on simulated futures prices under cash settlement,

[1] When the optimal hedge ratio for feeder cattle meeting the futures contract specifications is one, hedging risk and basis risk are equal.

and their results are valid only to the extent that the relationship between the USFSP and futures prices remains the same after cash settlement. Since cash settlement has been in effect for several years, it is possible to evaluate the impact of cash settlement on basis variability using actual futures prices.

Conceptual Issues

The net revenue from a hedge depends upon the relationship among cash prices, futures prices, and the percentage of expected production hedged. For livestock, the difference between expected quantity and actual quantity produced is usually small; hence quantity is assumed constant. Elam, and Schroeder and Mintert have found that the optimal hedge ratio to minimize feeder cattle hedging revenue risk is not statistically different from one when quantity is constant and the cash and futures prices are for the same type of animal. With a hedge ratio of one, the cash position is hedged with an equal and opposite futures position, and minimizing the variance of expected net price and minimizing the variance of expected revenue from hedging are equivalent. Both variances are minimized by minimizing the basis forecast error. If cash and futures prices are not for the same type of animal, then hedging risk includes basis risk and cross-hedging risks, and the optimal hedge ratio may be different from one. This article considers only the impact of cash settlement on basis risk for feeder cattle weighing 600–800 pounds when the hedge ratio is one.

Hedging effectiveness depends upon the ability at the time the hedge is initiated to estimate the relationship between cash and futures (basis) when the hedge is terminated. If the termination basis cannot be accurately predicted, there will be a substantial difference between the expected and actual net price from hedging. Assuming the hedger's objective is to minimize the difference between the expected and actual net price from hedging, the hedger attempts to minimize the variance about the expected net price (*ENP*).

$$ENP = F_1 + E(B_2), \tag{1}$$

where F_1 is the futures price at the time the hedge is initiated and $E(B_2)$ is the expected termination basis. Termination basis (B_2) is

$$B_2 = C_2 - F_2, \tag{2}$$

where C_2 and F_2 are the cash and futures prices at hedge termination. The actual net price (*NP*) from hedging is

$$NP = F_1 + B_2. \tag{3}$$

The variance about *ENP* is

$$\text{Var}\,(ENP) = \sum^{n} (NP - ENP)^2/n. \tag{4}$$

Substituting equations (1) and (3) into equation (4) gives

$$\text{Var}\,(ENP) = \sum^{n} (B_2 - E(B_2))^2/n. \tag{5}$$

Equation (5) indicates that the difference between expected and actual net price can be minimized by reducing the difference between actual and predicted termination basis. Hence, reducing termination basis forecast error improves hedging effectiveness.

Basis forecast error and basis variance are not equivalent. Basis forecast error is defined by equation (5), while termination basis variance is

$$\text{Var}\,(B_2) = (B_2 - \bar{B}_2)^2/(n - 1). \tag{6}$$

Substituting equation (2) into equation (6) yields

$$\text{Var}\,(B_2) = \sigma^2_{f2} + \sigma^2_{c2} - 2\sigma_{c2f2} \tag{7}$$

where σ^2_{f2}, σ^2_{c2}, and σ_{c2f2} are the variances and covariances of futures and cash prices when the hedge is terminated. The difference between basis forecast error and basis variance is that the latter depends upon the average of historical basis. A reduction in basis variance over years does not necessarily result in a reduction in basis forecast error. The CME hypothesized that basis variance would decline under cash settlement and hedging effectiveness would increase. But improved hedging effectiveness requires a decline in basis forecast error. The empirical question addressed in this article is whether basis variance and basis forecast error have been reduced by the introduction of cash settlement in feeder cattle futures contracts.

It is not intuitively obvious that moving from physical delivery to cash settlement will reduce local basis variance. Whether or not basis variance declines depends upon the variance and covariance of cash and futures prices. Cash settlement of futures contracts should not affect the local cash price variance since the local price variance is largely determined by changes in national and local supply and demand conditions. The frequency and magnitude of change in these economic events would not be expected to change in response to switching from physical delivery to cash settlement of feeder cattle futures contracts.

The method of calculating the USFSP under cash settlement may, however, reduce the variance of futures prices relative to cash prices. Under the physical delivery system, the nearby feeder cattle futures contract was tied to cash prices of feeder cattle meeting futures contract specifications in designated delivery markets. The largest and most active delivery market was Oklahoma City. As the nearby futures contract approached maturity, the futures contract price and the Oklahoma City cash price converged to within the range of delivery cost since the futures contract and the cash price represented the same economic conditions. Under cash settlement, the futures market price is tied to the USFSP during the delivery month. There are several reasons to expect the USFSP to be less volatile than the cash price in one market like Oklahoma City. First, the USFSP is a weighted average price across 27 states. Second, the USFSP is a moving average of the last seven calendar days. Third, the USFSP includes a wider weight and grade range than the old physical delivery contract. If the daily USFSP is less volatile than local market cash prices, then the variance of futures price with cash settlement may decline relative to the variance of cash price in a local cash market. This decline in futures variance relative to cash variance could lead to a more volatile rather than a more stable local market basis, depending on what happens to the covariance of local market cash and futures prices.

The impact of cash settlement on the covariance of cash and futures prices is hard to determine a priori. One could argue that the daily publication and wide dissemination of the USFSP could improve overall cash price correlations across the United States and between cash and futures market prices as more buyers and sellers become better informed on general market price levels. The research of Oellermann, Brorsen, and Farris indicates that during 1979–86, futures prices generally led cash prices for feeder cattle. Their results suggest that the futures market serves as a center for price discovery for feeder cattle because it is the focal point of information assimilation for large numbers of buyers and sellers. If this suggestion is correct, then tying the nearby futures prices to the USFSP could improve the correlation among futures and cash prices across the United States. The other side of this argument is that a large percentage of feeder cattle are produced on farms and ranches where less than one contract of feeder cattle are produced per year; hence these individuals may pay little or no attention to futures prices. In 1977, only 40% of producers with sales greater than $10,000 kept track of futures prices (General Accounting Office). If many cattlemen ignore futures, a relative decline in futures price variance under cash settlement could lead to a reduction in the correlation and covariance between local cash and futures prices, leading to an increase in basis variance. Reduced correlation between cash and futures would be most likely to occur in markets not included in the USFSP series.

If termination basis variance is reduced under cash settlement, it is usually assumed that hedgers' ability to forecast termination basis when the hedge is initiated will improve, decreasing the deviation between expected basis at hedge initiation and actual basis at hedge termination. However, reduction in termination basis variance over time does not assure that basis forecast error will be reduced. The empirical analysis here is directed toward determining if cash settlement has reduced termination basis variance in two markets and basis forecast error for individual lots of cattle in one market.

Data Sources

Two different data sets are used. The first data set consists of weekly average cash and futures prices for an equal number of weeks before and after cash settlement and is used to determine basis variance before and after cash settlement. Weekly data are used to facilitate comparison to the earlier Cohen and Gorham and CFTC studies. Two markets are analyzed to determine the impact in a market included versus excluded from calculation of the USFSP. The weekly data set includes only steers meeting USFSP weight specifications. There is consensus in the industry that Oklahoma City was the largest and most influential market under the physical delivery system. Southwest Virginia markets were chosen because they are not included in the USFSP, but feeder cattle are important in Virginia's agricultural economy. Cattle and calves are the single most important agricultural commodity in Virginia (Virginia Department of Agriculture and Consumer Affairs, *Virginia Agricultural Statistics 1988*) accounting for about 25% of gross farm income.

In the first data set, the cash settlement period is September 1986 through April 1989, or 138 weeks. An equal period before cash settlement under the physical delivery system includes January 1984 to August 1986. For Oklahoma City, the cash data are simple weekly average prices for 600–700- and 700–800-pound medium frame, number one muscle score steers for weeks ending on Saturday as reported in *Livestock, Meat, and Wool Market News* (U.S. Department of Agriculture). Futures prices are the simple average settlement price of the nearby contract during that week. Virginia prices are the average of four Southwest Virginia auction markets for 600–700- and 700–800-pound medium frame, number one muscle score steers. These prices are reported from Thursday of one week until Wednesday of the following week in *Virginia Agricultural Commodity Newsletter* (Virginia Department of Agriculture and Consumer Affairs). The settlement price of the nearby futures contract was averaged across the Thursday-to-Wednesday week to determine the simple average futures price. For both markets, when a futures contract expired in the middle of a week, the next contract was used to determine the average price for the week.

The second data set consists of individual lot prices for feeder cattle in 16 Virginia markets from 1983 through 1988. Feeder cattle consigned to these auction sales are comingled into uniform lots and sold at one price for each lot. The average price, weight, breed, sex, frame, and muscle score are recorded for each lot by market and date. The sale dates are concentrated in the months of March, April, September, and October. Hence, many of the observations in this data set occurred on the same day. Basis was calculated as the difference between the cash price and the nearby futures contract price until the fourteenth of the delivery month. On the fifteenth of the delivery month, the futures price switches to the next delivery month futures contract. Using these data, basis forecast models were estimated and the ability of these models to estimate termination basis before and after cash settlement was evaluated.

Weekly Basis Variance Analysis

The standard deviations of cash, futures, and basis before and after cash settlement are in table 1. Both weekly average cash and futures market prices were more volatile during August 1986 to April 1989 than during January 1984 to August 1986. The standard deviation of futures prices increased 71% to 79% while the cash market standard deviations increased 57% to 191%, depending upon the market location and weight. In general, the variance of cash price increased more than the variance of futures prices, supporting the hypothesis that tying nearby futures to the USFSP might reduce the variance of futures price relative to the variance of local cash market prices. However, table 1 indicates that the correlation, and the covariance, between cash and nearby futures prices increased after the feeder contract became cash settled. The increase in Oklahoma City was relatively small, but the correlation between cash and futures prices in Virginia increased 70% and 36% for 600–700- and 700–800-pound medium 1 steers, respectively. Even though the cash price variance increased more than the futures price variance in three of the four markets, the increased covariance between cash and futures offset these increases, resulting in a decrease of 3% to 14% in the standard deviation of basis across the four markets.

The correlation between Virginia cash prices and nearby futures prices after cash settlement improved substantially. The daily publication and wide dissemination of the USFSP may have helped bring Virginia prices into better alignment with U.S. feeder cattle market prices. Another possible explanation is that the USFSP includes several southern markets with price and basis relationships similar to those of Virginia. Hence, the USFSP is more correlated with Virginia market prices than were futures under physical delivery when prices were tied to a limited number of western markets and only one southern market. The CME and Cohen and Gorham in particular hypothesized that feeder cattle basis would be less volatile under cash settlement compared to physical delivery. The CFTC study after nine months of cash-settled trading indicated the

Table 1. Means, Standard Deviations, and Correlations of Weekly Average Cash, Futures, and Basis before and after Cash Settlement, 1984-89

Time	Mean			Standard Deviation			Cash and Futures Correlation	Basis Variance F-test[f]
	Cash	Futures	Basis	Cash	Futures	Basis		
			Oklahoma City 600–700 lb. M1[c] Steers[d]					
			$/cwt.					
Before[a]	64.18	65.41	−1.23	3.71	4.01	1.73	.905	
After[b]	79.45	74.92	4.53	7.75	7.18	1.63	.979	1.12
			% Change					
	24	15	468	109	79	−6	8	
			Oklahoma City 700–800 lb. M1 Steers					
			$/cwt.					
Before	62.40	65.41	−3.01	4.39	4.01	1.51	.943	
After	76.21	74.92	1.29	6.89	7.18	1.42	.981	1.13
			% Change					
	22	15	143	57	79	−6	4	
			Virginia 600–700 lb. M1 Steers[e]					
			$/cwt.					
Before	58.97	65.51	−6.54	2.82	4.16	3.51	.535	
After	73.33	74.76	−1.43	8.20	7.11	3.42	.910	1.05
			% Change					
	24	14	78	191	71	−3	70	
			Virginia 700–800 lb. M1 Steers					
			$/cwt.					
Before	56.71	65.51	−8.80	2.83	4.16	3.02	.688	
After	69.77	74.76	−4.99	6.94	7.11	2.60	.933	1.35
			% Change					
	23	14	43	145	71	−14	36	

[a] Before is January 1984 through August 1986.
[b] After is September 1986 through April 1989.
[c] M1 is medium frame, number 1 muscle score.
[d] Weekly average prices for Sunday through Saturday.
[e] Weekly average prices for Thursday through Wednesday.
[f] Null hypothesis is $\sigma^2_{before} = \sigma^2_{after}$. Critical $F_{120,120,.05} = 1.35$.

range in Oklahoma City basis had declined. An F-test of the hypothesis that the basis variance is the same under cash settlement compared to physical delivery was not rejected at the 5% level for three of the four markets in table 1. These data indicate a small drop in feeder cattle basis variation under cash settlement, but a decline in the standard deviation of basis of approximately 10¢ a cwt. is not economically significant for a hedger. When hedging a typical 600–800-pound steer, this decline in basis variation would amount to less than $1 per head in most circumstances. This reduction is small relative to a typical desired hedge margin of $40–60 per head for return to risk and management and a gross market value of $500 or more per head.

Individual Lot Basis Analysis

Hedgers and speculators usually price individual lots of cattle on specific days, and these cattle may or may not meet futures contract specifications. Hence, even though weekly average historical basis variation for par cattle appears to have declined somewhat, the basis variance for individual lots of cattle may not have declined. The impact of cash settlement on the basis for individual lots of cattle is determined using the second data set described earlier. The change in basis forecast error before and after cash settlement for individual lots of cattle is determined using estimated basis models by season, sex, frame, grade, and breed.

Basis Models

Feeder cattle prices at a specific location and time reflect the derived demand for various animal characteristics, available supply, market-specific economic factors, and expectations about future economic conditions. Nearby feeder cattle futures prices reflect the same general economic variables at the designated delivery points under physical delivery and for the U.S. feeder cattle market under cash settlement. The difference between the local cash price and nearby futures is the termination basis. In the individual lot data set there is never more than 30 days' difference between the local cash price date and the nearby futures contract maturity date. Many of the observations are within the delivery month under the physical delivery system. Under these circumstances, current and expected economic factors should affect the cash and futures markets similarly at the industry level. The local market basis then should largely be a function of the physical attributes of the cattle, local supply and demand for cattle, and any unique factors associated with the operation of the local market.

On any given sale day, the total supply of local cattle is essentially fixed. Buyers evaluate each lot of cattle in terms of their physical characteristics as they relate to feedlot performance, or in the case of heifers, their desirability as possible breeding stock. Since supply is fixed, prices reflect the demand for various bundles of characteristics. Since nearby futures prices reflect the same characteristics for cattle meeting contract specifications, the local basis is largely a function of the local demand for various kinds of cattle. Given these considerations, local termination basis for a specific lot of cattle at a specific market can be estimated as a function of the physical characteristics of the cattle and the characteristics of the particular market.

Buccola; Faminow and Gum; and Schroeder et al. have all estimated the relationship between feeder cattle prices and animal and market characteristics. Buccola found that weight, breed, grade, sale size, lot size, and sale order can affect sales price. Faminow and Gum concentrated on the relationships among price, weight, and lot size. They found curvilinear relationships between price and weight that varied by year and sex. They also found price to be responsive to lot size, with both small and large lots selling at a discount to tractor-trailer size lots. Schroeder et al. investigated the impact of fill, condition, and health on feeder cattle prices. Of these characteristics, health had the most impact on price. Cattle that were not in good health, had physical impairments, or were muddy received large discounts (Schroeder et al.). Unfortunately, the data used by Schroeder et al. are unavailable in secondary data sources.

Based on this previous research, basis was specified as a function of the following variables

$$(8) \quad B = f(W, W^2, F, M, BR, LS, LS^2, SS, S, FUT),$$

where B is the basis relative to nearby futures in dollars per cwt., W is weight in pounds per head, F is frame size with medium as par, M is muscle score with number 1 as par, BR is breed with Angus and Angus/Hereford crossbreed as par, LS is lot size in head, SS is sale size in head, S is sex, and FUT is futures contract month. The variables basis, weight, lot size, and sale size are continuous. The other variables are (0, 1) dummy variables. The par animal is a medium frame, number 1 muscle score (m1) Angus or Angus/Hereford cross. These animals are the largest in number and highest priced in Virginia Special Graded Sales.

The model was initially estimated as one equation across both sexes and the spring and fall seasons. The sex and season dummy variables were highly significant, and the weight coefficients were very different by sex and season. In Virginia the spring market is for light cattle to be placed on grass. In the fall the primary market is for heavier cattle for feedlot placement outside Virginia and for calves to be wintered in Virginia. The difference in these markets by season and sex lead to the individual estimation of four equations by sex and season. This disaggregation permitted all the estimated coefficients to reflect the different economic circumstances in these periods. The variables lot size and total sale size were consistently statistically insignificant at the 5% level and were removed from the equations. Lot size ranged from 5–168 head, but average lot size was 20 head, with few lots over 40 head. The narrow range in lot size probably explains why it was not a significant variable. The coefficients on W^2 were not statistically significant at the 5% level. F tests comparing equations with and without W^2 indicated that the relationship between basis and weight was

Table 2. Basis Model Coefficient Estimates for Virginia Feeder Steers before and after Cash Settlement

	Spring[a]		Fall[b]	
	Before	After	Before	After
Intercept	23.76	41.47	9.51	26.66
	(10.62)	(14.82)	(8.10)	(19.04)
Weight	−.037	−.054	−.017	−.035
	(−11.99)	(−14.23)	(−10.80)	(−17.29)
Large[c]	−.88	−.92	−.86	−.65
	(−1.48)	(−1.46)	(−2.61)	(−1.75)
L&M[d]	.65	.63	−1.42	−1.44
	(1.53)	(1.26)	(−6.00)	(−6.53)
Small	−5.00	−6.34	−4.09	−5.34
	(−9.16)	(−10.81)	(−16.73)	(−15.89)
Muscle 2	−3.53	−3.60	−3.21	−4.14
	(−7.64)	(−5.57)	(−14.32)	(−16.83)
Hereford	−2.63	−4.28	−3.05	−3.76
	(−6.00)	(−7.91)	(−15.31)	(−14.26)
Charolais	−.48	−1.21	−.80	−1.53
	(−1.20)	(−2.61)	(−3.67)	(−6.91)
September[e]	NA[f]	NA[f]	1.25	.69
			(7.30)	(3.17)
Lots	450.0	376.0	1,480.0	994.0
F	39.7	49.6	103.4	116.8
R^2	.386	.485	.360	.487
D.W.	.842	1.013	.838	1.116
RMSE	3.40	3.71	3.07	3.06
Basis				
Mean	−3.67	1.75	−5.10	−.55
St. dev.	4.31	5.12	3.83	4.26

Note: Numbers in parentheses are t-ratios. Par animal is 600–800-pound medium frame, number 1 muscle score Angus or Angus/Hereford crossbred.
[a] Spring is 15 March to 14 April.
[b] Fall is 15 August to 14 October.
[c] Frame size.
[d] L&M is large and medium frame combined.
[e] September = 1 for 15 August to 14 September, 0 otherwise.
[f] NA is "not applicable."

linear over the 600–800-pound weight range. Schroeder et al. indicate that price is more responsive to weights under 600 pounds, but previous studies finding a curvilinear price-weight relationship used larger (300–800 pound-) weight ranges.

The basis equations were estimated for the purpose of predicting termination basis and determining the impact of cash settlement on the ability to forecast basis. The weekly data set analysis indicated the correlation between cash and futures prices in Virginia changed substantially after the initiation of cash settlement. For this reason separate equations were estimated for the periods before and after cash settlement, to permit maximum flexibility in estimating the basis relationship coefficients. The after-cash-settlement fall equations contain data from 1986, 1987, and 1988 and the before equations are estimated using data from 1983, 1984, and 1985. The spring-after-cash-settlement equations are based on data from 1987 and 1988 and the spring-before equations contain data from 1985 and 1986. The final estimated models using ordinary least squares are in tables 2 and 3.

The R^2s for the equations range from .35 to .49, and all the F-tests are highly significant. The t-ratios in parentheses below each coefficient indicate that almost all of the coefficients are statistically significant at the 5% level. The Durbin-Watson statistics indicate that the error terms are serially correlated. The data contain unequal numbers of cross section ob-

Table 3. Basis Model Coefficient Estimates for Virginia Feeder Heifers before and after Cash Settlement

	Spring[a]		Fall[b]	
	Before	After	Before	After
Intercept	−4.27	15.15	−2.23	9.57
	(−2.18)	(6.18)	(−1.40)	(3.45)
Weight	−.009	−.032	−.014	−.024
	(−3.04)	(−8.95)	(−6.21)	(−5.86)
Large[c]	.61	1.55	1.35	.50
	(1.63)	(2.62)	(3.11)	(.98)
L&M[d]	.17	.94	.29	−.46
	(.50)	(2.14)	(1.01)	(−1.08)
Small	−4.58	−4.29	−4.65	−9.87
	(−7.99)	(−5.90)	(−7.42)	(−7.00)
Muscle 2	−3.58	−2.37	−4.03	−4.22
	(−6.32)	(−3.04)	(−10.13)	(−6.63)
Hereford	−1.86	−1.76	−1.84	−1.59
	(−4.52)	(−1.99)	(−4.95)	(−2.61)
Charolais	1.36	.39	.15	.69
	(3.92)	(1.05)	(.47)	(1.75)
September[e]	NA[f]	NA[f]	.99	.54
			(3.56)	(1.43)
Lots	266.0	156.0	495.0	325.0
F	27.6	17.58	33.0	28.3
R^2	.428	.454	.352	.418
D.W.	1.160	1.247	1.13	1.18
RMSE	2.33	2.21	2.89	3.42
Basis				
Mean	−10.85	−6.38	−12.44	−7.76
St. dev.	3.04	2.93	3.56	4.43

Note: Numbers in parentheses are *t*-ratios. Par animal is 600–800-pound medium frame, number 1 muscle score Angus or Angus/Hereford crossbred.
[a] Spring is 15 March to 14 April.
[b] Fall is 15 August to 14 October.
[c] Frame size.
[d] L&M is large and medium frame combined.
[e] September = 1 for 15 August to 14 September, 0 otherwise.
[f] NA is "not applicable."

servations per period and the time-series dates are not equally spaced apart. Appropriate corrective procedures are not available for data of this nature. The estimated coefficients are unbiased but inefficient, and the t, F, and R^2 are biased upward.

The standard errors for the coefficient estimates have been corrected for heteroskedasticity using the procedure developed by White. This method corrects the parameter standard error estimates without assuming knowledge of the true nature of heteroskedasticity. Other procedures require exact knowledge of the functional form (linear, log linear, exponential) between the variance and the Xs. Since no a priori knowledge of the exact functional form is available, the OLS parameter standard error estimates were corrected.

The estimated coefficients in the steer models in table 2 are consistent with economic theory, and the magnitude of the coefficients are consistent with the price premiums and discounts observed in Virginia feeder cattle markets. The coefficients of the models across the two periods are similar, indicating the movement to cash settlement did not substantially alter the premiums and discounts across frame size, muscle score, and breeds.

The weight coefficients were negative and highly significant in all four steer models (table 2). Basis is more sensitive to weight in the spring than in the fall. Virginia producers prefer lighter cattle in the spring to maximize gains on grass. The large and large and medium combined frame size (L&M) coefficients are not statistically significant in the spring models. In the fall, large and L&M combined steers are discounted relative to medium frame steers. Small frame, number 2 muscle score, and Herefords are all heavily discounted in the spring and fall.

The heifer basis model results are similar, with a few exceptions (table 3). Weight has less impact on heifer basis. Each additional 10 pounds reduces heifer basis by 10–32¢ per cwt., while a similar 10-pound increase decreases steer basis 17–54¢ per cwt., depending upon the season and model. The impact of weight on heifer basis is approximately the same in the spring and fall. The difference in weight coefficients between heifers and steers is probably related to the fact that heifer demand is for both feeding and breeding stock.

All the coefficients for large and mixed large and medium frame heifers are positive, except one which is statistically insignificant. Since heifers tend to be smaller than steers and are discounted relative to steers by packers because of their lower weight and resultant higher processing costs, feeder cattle buyers are willing to pay premiums for larger frame heifers. In addition, since both small frame heifers and steers are heavily discounted, breeding stock buyers prefer larger frame heifers to reduce the number of small frame calves produced and to minimize calving difficulties.

The models in tables 2 and 3 explain 35% to 48% of the variation in termination basis, leaving a large percentage of the basis variation unexplained. Part of the residuals could be explained by fill, condition, and health data (Schroeder et al.). Market-specific data about number and size of buyers present would help better identify demand. But these data are unavailable. Since such data are not available, the root mean-square errors (RMSE) of these estimated models are still large. They range from $2.21 to $3.71 per cwt. across the eight models estimated. Given that a typical feeder cattle operator might attempt to hedge in a $40–60 margin per head on 700-pound cattle, this magnitude of basis error could frequently reduce the expected margin by one half. The large remaining unexplained basis risk helps explain why the CME introduced cash settlement in an attempt to reduce basis risk and improve hedging effectiveness.

Basis Forecast Error Analysis

One feature of the estimated basis models is that they can be used to estimate the termination basis when the hedge is initiated. All the hedger needs to do is estimate the final weight, frame, and muscle score. Experienced cattlemen should be good at estimating these three variables. Hence, the above equations can be used to evaluate whether or not termination basis can be estimated more accurately after implementation of cash settlement.

The basis equations in tables 2 and 3 were used to calculate the expected basis for each lot of 600–800-pound M1 cattle from 1983 to 1988, assuming cattlemen could accurately forecast the actual weight, frame size, and muscle score. The expected basis was compared to the actual basis for each lot of cattle to determine the basis forecast error. The errors were then analyzed before and after cash settlement to determine if cash settlement has reduced the standard deviation of basis forecast error. The results of this analysis are in table 4. The number of lots analyzed in table 4 is less than in tables 2 and 3 because nonpar cattle (small and number 2 muscle score) have been excluded.

The results are mixed across seasons and sex in terms of the impact of cash settlement on the ability to forecast termination basis. For spring steers, the actual basis mean increased from −$2.24 to $3.13 cwt., and the standard deviation of basis increased by 25% across the two periods, even though the correlation between Virginia cash prices and nearby futures prices increased 27%. The standard deviation of basis forecast error before cash settlement was $3.29 cwt. for spring steers. After cash settlement, the basis forecast error standard deviation was $3.67 cwt., an increase of 12%. The termination basis for spring steers was more difficult to predict after cash settlement.

The results for fall heifers were similar to those for spring steers in that the standard deviation of actual basis increased 25% across the two periods, the correlation between cash and futures prices increased 37%, and the standard deviation of basis forecast error increased 30%. For these two groups of feeder cattle where the actual basis variability increased substantially across the two periods, the movement to cash settlement increased basis forecast error. An F-test of the basis forecast errors before and after cash settlement indicates the fall-

Table 4. Basis Statistics and Errors before and after Cash Settlement on Individual Lots of Virginia 600-800-pound, Medium 1 Steers and Heifers, 1983-88

Model	Years	Lots (No.)	Basis Mean ($/cwt.)	Basis SD[a] ($/cwt.)	Correlation Futures and Cash	Basis Forecast Error[f] SD ($/cwt.)	F-test[g]
			Spring[d] Steers				
Before[b]	85–86	230	−2.24	4.03	0.649	3.29	
After[c]	87–88	204	3.13	5.02	0.827	3.67	1.24
Change		−26	$5.37	25%	27%	12%	
			Fall[e] Steers				
Before	83–85	690	−3.58	3.62	0.548	3.16	
After	86–88	560	1.03	3.78	0.912	3.05	1.07
Change		−130	$4.61	4%	66%	−3%	
			Spring Heifers				
Before	85–86	168	−10.15	2.49	0.879	2.25	
After	87–88	110	−6.00	2.70	0.889	2.09	1.15
Change		−58	$4.15	8%	1%	−7%	
			Fall Heifers				
Before	83–85	295	−11.50	2.73	0.673	2.40	
After	86–88	230	−6.79	3.42	0.922	3.13	1.70
Change		−65	$4.71	25%	37%	30%	

[a] Standard deviation.
[b] Before cash settlement.
[c] After cash settlement.
[d] Spring is 15 March to 14 April.
[e] Fall is 15 August to 14 October.
[f] Basis forecast error (BFE) is $\sum^{n} (B_2 - E(B_2))^2$ where B_2 is termination basis.
[g] Null hypothesis: $BFE_{before} = BFE_{after}$. Critical $F_{120,120,.05} = 1.35$.

heifers basis forecast error increased while the spring-steers basis forecast error was statistically unchanged.

For fall steers and spring heifers, the standard deviation of basis forecast error declined 3–7% after cash settlement. For these two groups of cattle the actual basis standard deviation increased only 4–8% across the two periods. The correlation between cash and futures prices increased substantially across the two periods for fall steers. The reduction in basis forecast error variance computed using the before and after equations is not statistically significant at the 5% level for fall steers and spring heifers.

Using the number of lots to weight the standard deviation of basis forecast error in each of the four categories, the standard deviation before cash settlement was $2.91 per cwt. compared to $3.09 per cwt. after cash settlement. Based on the F-test, these two variances are not statistically significantly different at the 5% level. For these individual Virginia lots of cattle and the basis equations estimated over 1983–88, the changing of the feeder cattle contract from physical delivery to cash settlement did not reduce basis forecast error in aggregate. In fact, for this sample, the basis forecast error variance increased slightly after the introduction of cash settlement of feeder cattle futures contracts.

These results are different from those presented in table 1 for two reasons. First, the weekly data cover the period 1984 to 1989 while the individual lot data cover the period 1983 to 1988. More important, the weekly data are averages over five business days, and the averaging process tends to reduce basis variation. Second, the basis variance is measured differently in the two data sets. The weekly data are used to compute an historical variance, to permit comparison to CME earlier studies and hypotheses. The second data set is used to calculate the individual lot basis forecast error, to test the assertion that reducing historical basis variance does not necessarily reduce basis forecast error for individual lots of feeder steers. The results indicate that reducing weekly historical variance did not reduce basis forecast error for 600–800-pound M1 steers in Virginia markets in 1986–88.

Conclusions

One of the reasons the CME changed the feeder cattle futures contract to cash settlement was to reduce basis risk. Using weekly average cash and futures prices, the standard deviations of feeder steer basis in Oklahoma City and Southwest Virginia auction markets were found to be 3–14% smaller after the introduction of cash settlement compared to physical delivery, but these differences were not statistically significant.

A second data set consisting of individual lot data from March 1983 to October 1988 was used to estimate basis equations and basis forecasts before and after cash settlement. The basis forecast error in general did not decline under cash settlement compared to physical delivery. Hence, basis risk in general has not been reduced for feeder cattle hedgers in Virginia as a result of cash settlement. These results indicate that reducing historical basis variance does not necessarily reduce basis forecast error on individual lots of cattle.

Our analysis differs from those of Elam, and Schroeder et al. in that actual futures prices after cash settlement were used. Elam, and Schroeder et al. were forced to use the USFSP as a proxy for cash-settled futures prices. Our analysis indicates that cash settlement changed the relationship between cash and futures prices; hence the assumption that futures prices equal cash settlement prices may not be appropriate except in the last few days of trading on each contract. Our analysis is also different from those of Elam; Schroeder et al.; Schroeder and Mintert in that only feeder cattle in the 600–800-pound weight range are examined.

Overall, the results suggest that cash settlement has not significantly changed the basis risk in hedging feeder cattle in Virginia. These results need to be tested and evaluated in other markets using actual cash and futures prices under cash settlement as more data are generated over time. Even though basis risk may not be reduced for hedgers, neither is it substantially increased. Both hedgers and the CME no longer have to deal with the costs and uncertainty associated with physical delivery. With basis risk for hedgers unchanged, and with local cash market and futures prices more highly correlated, the movement to cash settlement is an improvement for both hedgers and the CME.

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