Cross Hedging Cattle Rations Using Corn Futures

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ABSTRACT

The feasibility of cross hedging cattle ration costs using corn futures was investigated. Simulation results for 1985-89 showed that unpredictable variations in ration costs could be reduced up to 54% with cross hedging. The greatest reduction in hedging risk was achieved for longer hedging horizons.

KEY WORDS: Cross hedge, cattle ration, corn futures, fed cattle.

Cattle feeding is an extremely competitive and risky business. Substantial investments in a feeder animal and feed and uncertain returns from feeding increase the possibility of losses (i.e., risk). The average return above all costs from cattle feeding is estimated to be less than $11 per head, while the standard deviation of return is $37 per head (Trapp and Ward, 1990; Trapp and Webb, 1986). Potentially small and highly variable returns make risk management especially important to the economic viability of a cattle feeder.

Cattle feeders can use futures markets to remove some of the price uncertainty in feeding cattle. When a 600-800 pound feeder animal is placed on feed, a live cattle futures contract (which reflects the price of a 1,100 pound finished steer) can be sold to "fix" the price of the finished animal. Corn (or milo), the principal ingredient in a cattle ration, can be cross hedged using corn futures to protect the cattle feeder from variable ration costs. The effectiveness of a cross hedge depends on the degree of correlation between ration costs and corn futures prices (Anderson and Danthine, 1981).

This research investigates the feasibility of using corn futures to fix cattle ration costs. A feedlot manager can attract feeding customers by offering them a set ration cost for the feeding period. The cash forward sale of rations to feeding customers can be cross hedged by purchasing corn futures. It is important to an individual cattle feeder to fix the ration cost, as well as the finished price of cattle, to reduce or minimize return variance. Reducing risk should lower the return required to maintain resources in the cattle feeding industry.

The objective of this research was to determine how effectively corn futures could be used as a cross hedge for cattle rations. The second section of the paper describes a commonly used method to evaluate hedging effectiveness. The third section reports the results from a simulated experiment of cross hedging ration costs in corn futures. The final section provides a summary and the conclusions.

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CROSS HEDGING MECHANICS

A cross hedge is a futures position opposite an existing or anticipated cash position, but in a different commodity (Anderson and Danthine, 1981). For example, corn futures can be used to cross hedge a cattle ration. Because the cost of corn (or milo) is approximately 80% of the value of a cattle ration, changes in corn prices account for a large portion of changes in ration costs.

How effectively corn futures can be used as a cross hedge for ration costs depends on the correlation between ration costs and corn futures prices. The average correlation coefficient between ration costs and corn futures prices is $r=0.88$.[1] Researchers have concluded that corn futures are an effective cross hedge for hay (Blake and Catlett, 1984), wheat millfeeds (Miller, 1985), and rice bran (Elam et al., 1986). Correlation coefficients are reported for hay and corn futures prices ($r=0.93$), and for rice bran and corn futures prices ($r=0.73$). Based on the results for hay and rice bran, a correlation as high as $r=0.88$ for ration costs and corn futures prices indicates that corn futures should be an effective cross hedge for cattle rations.

To use corn futures as a cross hedge, one must first estimate the number of bushels of corn futures required to cross hedge a ton of ration. This can be accomplished by regressing the ration cost on the corn futures price:

$$R_t = b_0 + b_1 CF_t^T \quad (1)$$

where R_t equals the predicted ration cost in time t in dollars per ton; CF_t^T equals the corn futures price in dollars per bushel at time t for the corn futures contract that matures at time T, where T is the contract maturity date nearest to, but not before, time t ($T \geq t$); and b_0 and b_1 are estimated intercept and slope coefficients, respectively. The slope coefficient in Eq. (1)--called the hedge ratio--provides an estimate of the number of bushels of corn futures required to hedge one ton of ration. (Note that b_1 also indicates the change in R in dollars per ton associated with a \$0.01 per bushel change in CF.) For example, if $b_1=24.2$, then 24.2 bushels of corn futures are required to cross hedge a ton of ration. Corn futures are traded in contracts of 1,000 bushels at the Mid-America Exchange and 5,000 bushels at the Chicago Board of Trade. If the hedge ratio is 24.2, then the 1,000 bushel Mid-America contract can be used to cross hedge 41 tons (1,000/24.2) of ration.

A cattle feeder who desires to fix ration costs can accomplish this by buying 24.2 bushels of corn futures for each ton of ration needed. The long position in corn futures should be held until the actual ration is purchased, and at that time the corn futures position would be sold. The purpose in buying corn futures is to offset an unpredictable increase in the cost of ration. If ration cost increases, the corn futures position most likely will increase in value also, and the return from the corn futures position will offset the increase in the ration cost. Usually in cross hedging, the corn futures position will not change dollar-for-dollar with ration costs. This can result in the cross hedge only partially protecting the cattle feeder from an increase in ration costs.

The uncertainty in cross hedging is due to the difference in the net cost of cross hedging and the target cost. The net cost is the actual cost incurred by cross hedging, and the target cost is the expected cost determined at the time a cross hedge is placed. The net and target costs are defined mathematically in Eqs. (2) and (3).

The target cost is used by a cattle feeder in deciding whether to cross hedge a ration. The target cost is derived at the time a hedge is placed, and represents the cost a hedger expects to incur from hedging. The target cost for a cross hedge to be lifted at time t is calculated at time t-j by substituting the corn futures price for the contract maturing nearest to, but not before, time t into Eq. (1) and solving for the predicted ration cost. The result is then adjusted for hedging costs. The target cost equation for a long cross hedge is represented as follows:

$$T_{t-j}^{t} = b_0 + b_1 CF_{t-j}^{T} + b_1 HC_t \tag{2}$$

where T_{t-j}^{t} is the per ton target cost as calculated at time t-j for a cross hedge to be lifted at time t; CF_{t-j}^{T} is the per bushel corn futures price observed at time t-j for the contract which matures at time T, where T is the contract maturity date nearest to, but not before, time t ($T \geq t$); and HC_t is the per bushel futures hedging costs.

The net cost is the actual cost achieved by hedging, and is calculated at the time a hedge is lifted. The net cost is equal to the ration cost at the time the hedge is lifted, minus the return on the b_1 bushel corn futures position, plus hedging costs:

$$N_t = R_t - b_1(CF_t^T - CF_{t-j}^T) + b_1 HC_t, \tag{3}$$

where N_t is the per ton net cost for a j-period cross hedge that is lifted at time t.

An example is provided in Table 1 to illustrate the mechanics of a ration cross hedge. In the example, it is assumed that a cattle feeder decides to buy May corn futures in January to fix the cost on 200 tons of May ration. The cross hedge ratio is $b_1=24.2$ bushels. To cross hedge 200 tons of ration requires 4,840 bushels of corn futures (i.e., 200 tons times 24.2 bushels). One corn futures contract on the Chicago Board of Trade is 5,000 bushels, which is close to 4,840 bushels.

Target and net costs for the ration cross hedge are calculated in Table 1. When the May corn futures contract is purchased in January, the cattle feeder expects to pay \$105.57/ton for 200 tons of cross hedged May ration. The net cost calculated at the time the hedge is lifted in May is \$108.30 per ton. The difference between the net and target costs (\$2.73/ton) represents the uncertainty in the cross hedge.

A perfect cross hedge results when the net cost is exactly equal to the target cost. This occurs when the change in the ration cost is equal to the change in the value of 24.2 bushels of May corn futures. Usually in cross hedging (or even direct hedging), the net cost is not exactly equal to the target cost. In the example in Table 1, the ration cost increased by \$17.43 per ton from the target cost, while the 24.2 bushel corn futures position increased by only \$14.23 (i.e., \$0.588/bu. [\$0.60 - \$0.012/bu. hedging costs--explained below] multiplied by 24.2 bushels). The gain in the value of the corn futures position offset all but \$3.20 (17.43-14.23) of the increase in the per ton ration cost. The cross hedge partially protected the cattle feeder from the rising ration cost.

The example in Table 1 illustrates that there is risk (uncertainty) in a cross hedge. In the following section, the root mean square difference between net and target costs is used to quantify the risk in a ration cross hedge in corn futures. This concept of hedging risk has been used in practical applications (Hieronymus, 1977; Chicago Board of Trade, 1978), and in academic studies (Miller, 1985; Elam et al., 1986; Elam, 1988; Schroeder and Mintert, 1988).

Table 1. Example of a cross hedge for cattle rations using corn futures.

Date	Ration Cost	May Corn Futures
Jan. 1st	Target=49.62+24.2($2.312)* =$105.57	Buy 5,000 bu. at $2.30/bu.
May 1st	Buy 200 tons at $123./ton	Sell 5,000 bu. at $2.90/bu.
		Profit------------$0.60/bu.

Summary:
$24,600 Ration cost ($123./ton x 200 tons)
- 3,000 Futures profit ($0.60/bu. x 5,000 bu.)
+ 60 Futures hedging costs ($0.012/bu. x 5,000 bu.)
$21,660 Net cost for 200 tons ($108.30 per ton)

*The value 49.62 is the estimated intercept coefficient (b_0) from eq. (1) in the text, and 24.2 is the estimated slope coefficient (b_1). The figure in parentheses is the futures price ($2.30/bu.) plus hedging costs ($0.012/bu.)

CROSS HEDGING SIMULATION FOR CATTLE RATION COSTS

In this section, the results are reported for simulated cross hedges of cattle ration costs. The ration costs used are average monthly ration costs for cattle feedlots in the Plains region. Average monthly corn futures prices were obtained for the nearby futures contracts. Five corn futures contracts are traded each year (i.e., March, May, July, September, and December). The ration costs and corn futures prices were collected for the years 1979-89.

Hedge ratios (b_1 values) were estimated using Eq. (1). Separate regressions were estimated for each month to account for differences in the regression coefficients due to seasonal factors. The first regressions included the years 1979-84. For example, the first January regression included the six Januarys for the years 1979-84. The estimates of b_0 and b_1 from this regression were used in Eq. (2) to calculate the target cost for a cross hedge to be lifted in January 1985. Ration cross hedges were simulated for the five years, 1985-89. Each year an additional year was added to the data set, and the regression was rerun. For example, for a January 1986 cross hedge, the hedge ratio was determined from a regression including the seven Januarys for the years 1979-85. All available data (starting with the year 1979) were used in estimation to maximize the number of observations in the sample.

Target and net costs were calculated using eqs. (2) and (3). The target cost was calculated using information available at the time a cross hedge was initiated. For example, for a cross hedge to be lifted in January 1985, Eq. (1) was estimated for the years 1979-84, and the b_0 and b_1 values were used in the target cost equation (Eq. (2)). The March 1985 corn futures (nearby contract) was used as the cross hedge for the January 1985 ration. The futures hedging costs were assumed to be $0.012 per bushel (i.e., $35 per contract [5,000 bushels] for the round-turn futures commission plus $25 execution costs [1/2 cent for the bid-ask spread]). A 3-month hedge to be lifted in January 1985 was placed in October 1984. The March 1985 corn futures price observed in mid-October 1984 was substituted for CF^T_{t-3} in Eq. (2), where t-3 is mid-October 1984 and T is March 1985. The net cost for the January 1985 cross hedge was calculated at the time the cross hedge was lifted in January 1985, using Eq. (3). The procedure described above was used to calculate net and target costs for 3-month cross hedges lifted in each month for the years 1985-89. Also, net and target costs were calculated for 5- and 9-month horizons. The 5- and 9-month hedges are used by feeders to fix ration cost before the cattle are actually placed on feed (for the usual 4- to 5-month feeding period). A total of 60 cross hedges were simulated for each hedging horizon (i.e., 12 months per year times 5 years).

Mean differences (MD_1's) between net and target costs were calculated (Table 2, column 3). The MD_1's are positive, which indicates that a cross hedger will typically pay more for a ration than the expected (target) cost.

The root mean square difference between net and target costs ($RMSD_1$) can be used to measure the risks associated with the divergence between net and target costs with cross hedging (Table 2, column 4). Peck (1975) used the variance of actual returns about expected returns as a measure of hedging risk for egg producers. Holt and Brandt (1985) used a definition of hedging risk similar to $RMSD_1$ to evaluate hog hedging strategies. Assuming a normal distribution for the difference between net and target costs, $RMSD_1$ is the maximum dollar amount (per ton) that the net cost will differ from the target cost two-thirds of the time. With a value for $RMSD_1$=\$6.46, a cross hedger should expect to pay the target cost $\pm$\$6.46 per ton two-thirds of the time.[2]

The uncertainty in subsequent ration costs faced by cattle feeders without cross hedging was estimated using the RMSD between actual and projected ration costs (Peck, 1975; Holt and Brandt, 1985). Two different projections of ration costs were used--(1) target cost, and (2) current cost at the time a hedge is placed. In this study, it was assumed that the current ration cost was the most recent published ration cost. Feedstuffs (Miller Publishing Co., Minnetonka, MN.) reports ration costs monthly. For example, if a decision was being made in March, the current ration cost was the February cost. $RMSD_2$ in Table 2 is the root mean square difference for target projections; and $RMSD_3$ is the root mean square difference for current cost projections. $RMSD_2$ is lower than $RMSD_3$ for all hedging horizons. This indicates that the target cost (based on corn futures prices) provides a more accurate projection of subsequent ration costs than the current ration cost.

The usefulness of a cross hedge as a risk management tool is provided by comparing the RMSD with cross hedging to the RMSDs without cross hedging. $RMSD_1$ with cross hedging is lower than $RMSD_2$ and $RMSD_3$ without cross hedging (Table 2). This indicates that corn futures provide an effective cross hedge for cattle rations. The longer the hedging horizon, the lower is the RMSD with cross hedging compared to the RMSD's without cross hedging. For a five-month horizon, the typical feeding period for steer cattle (Dietrich et al., 1985), $RMSD_1$ with cross hedging is 10.5% lower than $RMSD_2$ (based on the target projection) and 38.4% lower than $RMSD_3$ (based on the current cost projection). A 9-month ration cross hedge would involve fixing ration costs before the cattle are put on feed. For a 9-month cross hedge, the RMSD with cross hedging is 28.5 and 53.6% lower, respectively, than $RMSD_2$ and $RMSD_3$ without cross hedging.

The results in Table 2 show the mean ration cost with cross hedging is higher than the mean cost without cross hedging (Table 2, columns 2 and 5). This indicates that

Table 2. Summary of simulated cattle ration cross hedges, 1985-89.[a]

Hedging Horizon	Mean Net Ration Cost	With Cross Hedging: Target Cost as Projection of Net Cost[b,c] MD_1	$RMSD_1$	Without Cross Hedging: Mean Ration Cost	Target Cost as Projection of Ration Cost[d] MD_2	$RMSD_2$	Current Cost as Projection of Ration Cost[e] MD_3	$RMSD_3$
	(dollars per ton)							
3 Months	111.36	2.24[f]	6.46	111.15	1.81	6.54	-0.47	8.18
5 Months	112.65	2.24[f]	6.46[g]	111.15	0.52	7.22	-0.88	10.49
9 Months	113.18	2.24[f]	6.46[h]	111.15	-0.01	9.03	-1.50	13.92

[a]Number of simulated cross hedges = 60 for each hedging horizon.
[b]Target and net costs are reduced by the assumed hedging cost of $0.012 per bushel of corn futures.
[c]MD_1=average difference between net and target costs; $RMSD_1=[MSD_1]^{1/2}$ where MSD_1=mean of the squared differences between net and target costs.
[d]MD_2=average difference between actual and target costs; $RMSD_2=[MSD_2]^{1/2}$ where MSD_2=mean of the squared differences between actual and target costs.
[e]MD_3=average difference between actual and current costs; $RMSD_3=[MSD_3]^{1/2}$ where MSD_3=mean of the squared differences between actual and current costs.
[f]Significantly different from zero at the 0.05 level based on a two-tail t-test (d.f.=59).
[g]MSD_1 is significantly less than MSD_3 at the 0.05 level based on a two-tailed F-test (d.f.=(59,59)).
[h]MSD_1 is significantly less than MSD_2 and MSD_3 at the 0.05 level based on a two-tailed F-test (d.f.=(59,59)).

a cattle feeder who continuously cross hedges pays more for ration than a feeder who buys ration on a day-to-day basis. The higher net cost from cross hedging is due to an overall loss in the corn futures position.[3] Research on futures price bias (Keynesian normal backwardation) suggests that if futures prices change, on average, they are more likely to rise than fall (Chang, 1985); thus a gain should be expected on the futures position, rather than a loss (as occurred for the ration cross hedges from 1985-89). This would cause the net cost from cross hedging to be lower on average than the actual cost, assuming the hedging cost is small.

SUMMARY AND CONCLUSIONS

The feasibility of cross hedging cattle ration costs using corn futures was investigated. Simulation results for 1985-89 showed that risk associated with cross hedging was lower than without cross hedging. For a 3-month cross hedging horizon, the risk with cross hedging was 1-21% lower than without cross hedging. And, as the hedging horizon lengthened, risk associated with cross hedging decreased relative to that without cross hedging. For a 9-month horizon, the risk with cross hedging was 28-54% lower than without cross hedging.

Research on cross hedging cattle rations is important because of the number of cattle and the amount of ration fed in the U.S. In 1989, 26.2 million cattle were fed in U.S. feedlots (USDA, 1990). Each animal was fed approximately 1.65 tons of ration during the feeding period. This amounts to 43.2 million tons of ration fed in 1989. This research has shown that up to 54% of the uncertainty in ration costs can be removed with a cross hedge in corn futures. With less uncertainty, the return required to hold resources in the cattle industry will be lower, which in a competitive beef industry should mean lower beef prices for consumers.[4]

Further research is needed to determine why cattle rations cannot be more effectively cross hedged for short time horizons (3 months or less). Perhaps, ration costs adjust slowly to changes in cash corn prices over time. This would call for a dynamic hedge ratio that adjusts to the length of time a hedge is held. Another possible cause of the ineffectiveness of ration cross hedges for short time horizons is an unpredictable corn basis for the Plains. That is, the ration cost may in fact be highly correlated with the Plains cash corn price, but the Plains corn price may exhibit low correlation with the corn futures price. If the Plains corn basis is highly variable, it will be difficult (if not impossible) to improve the ration cross hedge.[5]

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ENDNOTES

[1]Separate correlation coefficients (r's) were calculated for each month of the year using data for 1979-88. The r-values range from 0.81 for June to 0.96 for December. All 12 monthly r-values are significantly different from zero at the 0.05 level.

[2]The RMSD is the same for all hedging horizons because hedging risk depends on the relationship between ration costs and corn futures prices at the time a hedge is lifted. Hedging risk does not depend on cash and futures prices at the time a hedge is placed, or the hedging horizon (Elam and Davis, 1990).

[3]The difference between the mean net (N) and actual (R) ration costs is equal to the mean of $(-b_1(F_t^T-F_{t-j}^T)+b_1HC_t)$--from Eq. (3). When the futures price decreases on average over the time period a hedge is held, then the term $-b_1(F_t^T-F_{t-j}^T)$ is positive, and $(N-R)>0$, which says that $N>R$.

[4]This assumes that the risk from variable corn and cattle prices is being shifted to speculators who are more willing to assume the risk, and for less return (i.e., lower cost), than cattle feeders.

[5]Fryar et al. (1988) developed a procedure which divides hedging risk into two components. The first component measures the portion of hedging risk due to corn basis variance (basis = Plains cash corn price - corn futures price), and the second component measures the portion due to premium/discount variance (ration cost - Plains cash corn price). This decomposition will allow one to determine whether the poor performance of 3-month ration cross hedges is due to extreme variance in the Plains corn basis.