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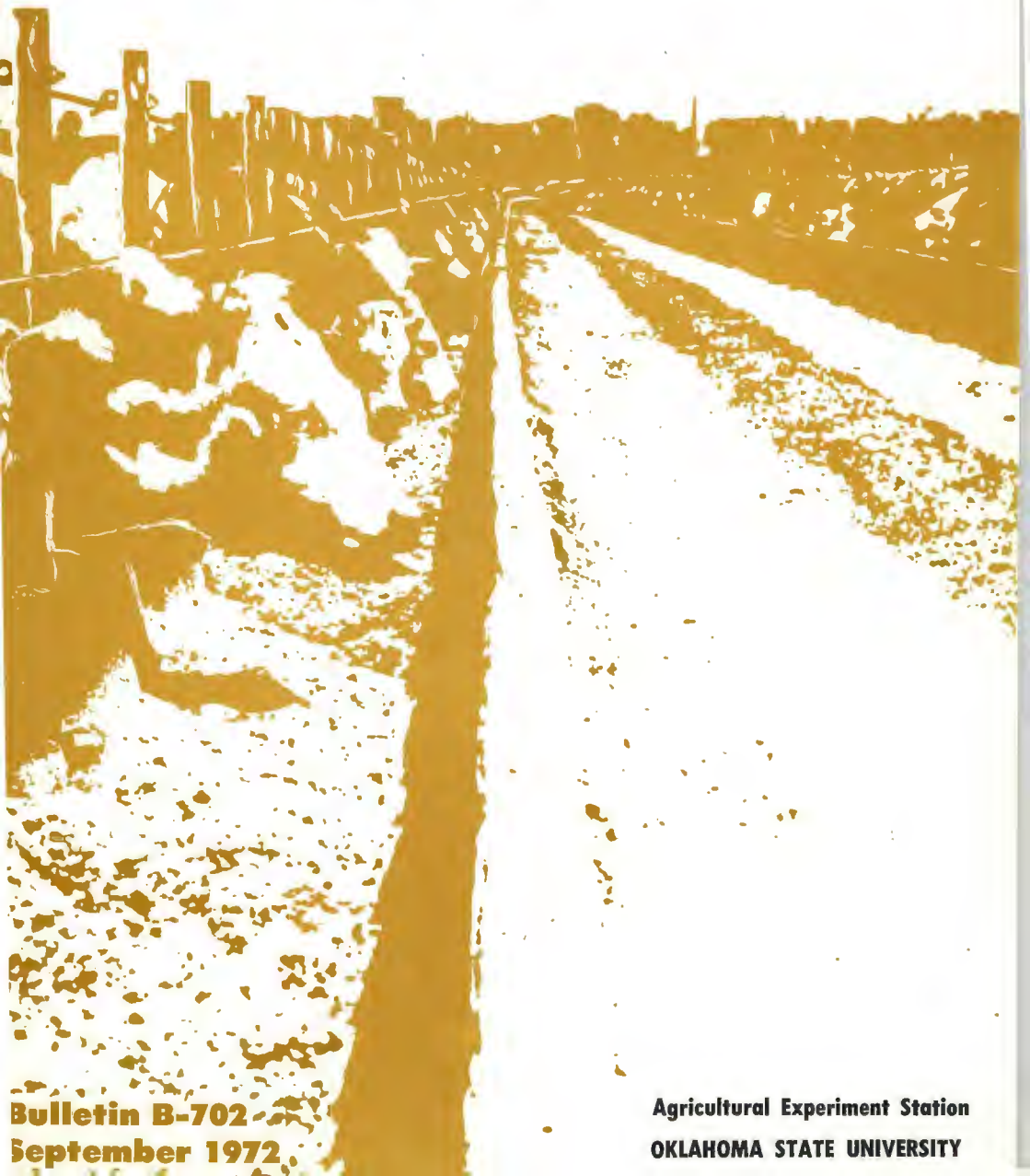

Bulletin B-702
September 1972

Agricultural Experiment Station
OKLAHOMA STATE UNIVERSITY

Economic Evaluation of Alternative Hedging Strategies for the Cattle Feeder

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Trade in live cattle futures contracts is relatively new. Launched by the Chicago Merchantile Exchange in late 1964, trade in a futures contract for live (slaughter) cattle began on a rather shaky basis. Theoretically, trade in futures contracts for any commodity provides the opportunity to reduce the risk associated with a cash operation in that commodity. Not all analysts were convinced such would be the case. One of the earliest analyses predicted the live cattle futures would not succeed, citing (1) the non-storable nature of the commodity, and (2) the lack of any stable seasonal price pattern as reasons for the probable failure of the contract [6]. But the contract survived, trade volume increased, and speculator interest increased rapidly. In terms of volume of trade and interest by traders, the contract must now be labeled a success.

To this date, however, very little hedging is done in the Southern Plains feeding area[1] in general or in the feeding areas of Oklahoma which comprise part of the Plains area. The element of price risk is present. During the 1965-1970 period, trade in slaughter steers in the Plains area was reported from market news offices located in Clovis, New Mexico (prior to 1970) and Amarillo, Texas (for 1970). By dividing the 1965-70 period into sequential 140-day feeding periods, a new period starting each week, one can observe the following measures of cash price fluctuation:

1. During 123 of the 140-day feeding periods, cash price for slaughter steers dropped while the cattle were on feed;

Research reported herein was conducted under Oklahoma Station Project 1423.

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[1]Reference is to the 5-state area consisting primarily of the panhandle areas of Texas and Oklahoma, eastern New Mexico, southeastern Colorado and southwestern Kansas. For more detailed description of this area, refer to Purcell [5].

2. There were 63 feeding periods during which cash price went down by more than $1.00 per cwt.; and
3. In 1969, for example, cash price dropped from $34.62 per cwt. the second week in June to $27.25 per cwt. the third week in October, a drop of $7.37 per cwt. within one of the hypothetical 140-day feeding periods.

Such price developments follow no pattern which can be predicted with a high degree of accuracy. Consequently, cattle feeders are subjected to often large losses during periods when cash prices move down unexpectedly or by unexpectedly large amounts. It is this type of largely unpredictable cash price movements that hedging[2] is expected to protect against.

The Problem

The relative absence of hedging activity can be attributed to a number of factors. Of primary importance, however, is the lack of complete understanding of the basics of hedging and how to effectively integrate hedging activities into the feeder's decision model. Often, poorly informed feeders have tried hedging with disastrous results in the form of losses or decreased net returns. Informed decision processes are essential to effective hedging in any market and especially in the 1965-71 market which has trended upward.

Objective of the Study

The primary objective of this study was to develop and test the usefulness of several strategies involving hedging of cattle feeding operations. An underlying and related objective was to demonstrate the origination and application of hedging strategies which are not overly complex, strategies with potential for direct application by the cattle feeder.

Method of Analysis

The period 1965-1970 was divided into consecutive feeding periods of 140 days each. Using computerized techniques, the feeding of cattle was simulated employing the following steps:

1. Choice feeder steers weighing 650 lbs. were placed on feed at a cost represented by the weekly average price for 550-750 lb. Choice feeder steers at Oklahoma City for the week in which

[2]Hedging is defined as the taking of opposite positions in the cash and futures markets respectively. For example, the cattle feeder is hedging when he (1) places light cattle on feed, and (2) sells live cattle futures for the period in which the cattle will be sold on the cash market.

the cattle were placed;

2. The cattle were fed for 140 days at a cost of feeding estimated from published research results [2]. Feed costs were automatically adjusted by the computer for each 5-cent increment in the cost of milo per cwt; and
3. The slaughter cattle were sold at a price represented by the weekly average price from the Clovis-Amarillo price series for 900-1100 lb. Choice steers for the week in which the cattle were sold.

More detail on the data sources and procedures can be found in the M.S. thesis by Hague [3] and in the journal article by Holland, Purcell, and Hague [4]. More detail will be provided, as needed, in this bulletin during presentation of the results of the analysis.

To insure the analysis would be applicable to the majority of cattle feeders, feeding operations under several alternative sets of conditions were analyzed. Table 1 shows the breakdowns for size, percent of operating capacity (or utilization rate) and daily gain.

Employing research results as reported by Dietrich [2] the total cost per pound of gain for the various combinations shown in Table 1 was calculated. A price of $1.85 per cwt. for milo was used as a base price.[3] Feed costs were then allowed to vary, for the appropriate rate of gain, in accordance with the following equation:

$$\sum_{t=t-19}^{t} \frac{(M_t - 1.85)\ \text{Gain}^{K}}{.05}$$

where: Gain^{K} = the cost of gain as a function of the rate of gain; and
M_t = milo price for the t^{th} week in dollars per cwt.

[3]The mean price of the weekly price series for the "triangle area" of the Texas Panhandle was $1.85 per cwt. over the 1965-70 period. This series was judged to be the most representative for the High Plains feeding area.

Table 1. Important Attributes of the Feeding Operations Simulated

Size of Operation in No. Head, One-Time Capacity	Rate of Daily Gain (lbs.)	Utilization Rate As % of Capacity
1,000	2.3	50%
2,500	2.8	75%
5,000	3.3	100%
7,500		
10,000		
20,000		

Since the feed cost is the primary variable component of total costs of feeding and since Dietrich's results were based on surveys taken in the middle of the 1965-70 period, the estimated total costs should be quite representative of the costs incurred by feeders during the period. Table 2 records the costs by size of feedlot, rate of gain, and utilization rate.

The appropriate costs from Table 2, as adjusted for changes in the price of milo, will be incurred whenever the strategy being tested calls for cattle to be fed. The net revenue per head for cattle to be sold in week t with no hedging involved can then be defined as follows:

$$NR_t = (EWT)^K CLO_t - 6.5\ (OKP_{t-19}) - 20\ (CAPUT^{ij}) - \sum_{t=t-19}^{t} \frac{(M_t - 1.85)\ GAIN^K}{.05}$$

where:

NR_t = net revenue per head for cattle sold in week t;
EWT^K = weight of finished animal for rate of gain K;
CLO_t = Clovis price for 900-1100 lb. Choice steer in week t;
OKP_{t-19} = Oklahoma City price for 550-750 lb. Choice feeder steer in week t − 19; and
$CAPUT^{ij}$ = cost of gain by weeks for lot size i and utilization rate j.

The variables M_t and $GAIN^K$ were defined earlier.

For those strategies involving hedging, the net revenue from the hedging part of the operation must be defined. In equation form, this is defined as follows for hedged cattle sold in week t:

$$HNET_t = (FP_{t-19} - FP_t)\ EWT^K - 1.04$$

where:

$HNET_t$ = net returns per head attributable to the hedge or sell-buy activities in the futures for cattle sold in week t;
FP_t = price of a futures contract at close of trade on Monday, Chicago, for week t; and
FP_{t-19} = price of a futures contract at close of trade on Monday, Chicago, for week t-19.

Of course, the futures prices for the contract being used to hedge any particular feeding period are the prices which are used. The $1.04 is the estimated commission on a per head basis. Interest charges on margin money were *not* included since the margin requirements can and do vary.

Using the previously defined variables, the net returns per head for cattle sold in week t where hedging is involved is then as follows:

$$NRH_t = NR_t + HNET_t$$

Table 2. Feedlot Operators Total Cost Per Pound of Gain at a Milo Cost of $1.85/cwt.

Feedlot Size	Rate of Gain Per Head (lbs./day)								
	2.3			2.8			3.3		
	100%	75%	50%	100%	75%	50%	100%	75%	50%
(hd)		($ Per lb.)			($ Per lb.)			($ Per lb.)	
1,000	.2731	.2771	.2829	.2650	.2690	.2748	.2600	.2640	.2698
2,500	.2637	.2677	.2720	.2556	.2596	.2639	.2506	.2546	.2589
5,000	.2594	.2628	.2673	.2513	.2547	.2592	.2463	.2497	.2542
7,500	.2550	.2587	.2627	.2469	.2506	.2546	.2419	.2456	.2496
10,000	.2491	.2523	.2567	.2410	.2442	.2486	.2360	.2392	.2436
20,000	.2431	.2462	.2503	.2350	.2381	.2422	.2300	.2331	.2372

A Basis for Comparison

For whatever strategies are analyzed, a basis of comparison is needed. Two possible criteria immediately come to mind:

1. The mean (or average) net returns per head for the alternative strategies; and
2. The variance (a measure of variability) of net returns per head for the alternative strategies.

The typical feeder would be interested in a large or high mean return with the lowest possible variance since reducing the variance reduces the risk associated with his operation. Consequently, the "good" strategy would be a strategy which does one of the following:

1. Increases mean net returns and decreases the variance of net returns; or
2. Decreases the variance significantly without a concurrent significant decrease in the mean.

The mean and variance of any hedging strategy, relative to the mean and variance of a feeding operation with no hedging activity, is used as the primary basis of comparison.

Figure 1 depicts what is involved in a slightly different manner. The possible results from any hedging strategies are labeled as "superior", "inferior" or "can't tell" depending upon which of the quadrants they

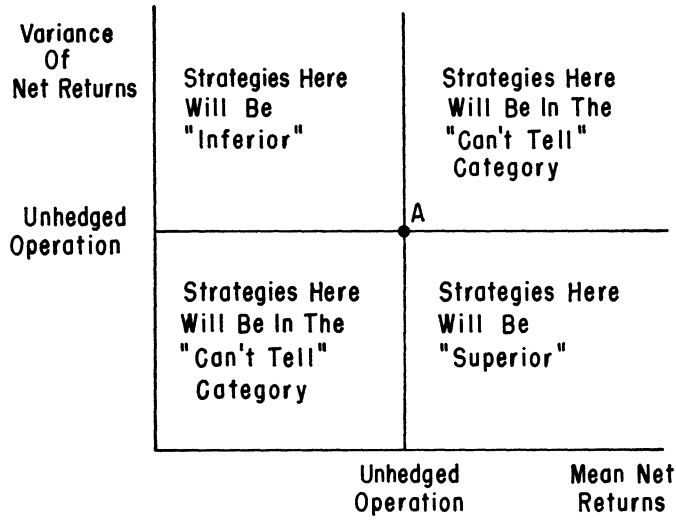

Figure 1. A Basis for Comparison of Hedging Strategies to an Unhedged Feeding Operation

fall in. Note the base point, point A, is the intersection of the mean and variance measures for an operation involving no hedging.

In Figure 1, strategies which fall in the quadrant below and to the right of point A will be "superior" to an unhedged operation, offering both (1) a higher mean, and (2) a lower variance. In the quadrant above and to the left of A, the mean is lower and the variance is higher — results clearly "inferior" to those at point A. In the other two quadrants, the evidence is mixed. Whether such strategies would be preferred to a strategy with no hedging activity will depend upon the entrepreneur's attitude toward, and financial ability to carry, price risk.

The Strategies Analyzed

A total of seven strategies, where the feeding operation with no hedging involved is included as a strategy, were analyzed. The results for each were simulated over the entire 1965-70 period and, thereby, over 295 of the 140-day feeding periods. Each strategy will be explained, the results of all compared for a given feeding operation and the results for the various combinations or types of feeding operations (as illustrated in Tables 1 and 2) presented.

Strategy I: Unhedged Feeding Operation

The unhedged feeding operation consists of the feeding operation described earlier in which 650-lb. Choice feeder steers are placed on feed, fed for 140 days (or 20 weeks) and sold at a weight varying with the rate of gain used. The results of this strategy provide a standard against which the other strategies, which involve hedging activities, will be compared. To begin the basis for comparison, the results for a 20,000 head lot, operating at essentially 100 per cent capacity and with an average daily gain of 2.8 pounds is presented as follows:

Mean = $10.16 per head
Variance = 454.71

Strategy II: Completely Hedged Operation

Under this strategy, every animal placed was fully hedged for the entire feeding period. During the week the cattle were placed, a sufficient number of the appropriate futures contract[4] was sold to fully hedge the feeding operation. Given the procedure developed, these actions were taken during week t-19. Then, in week t or after 20 weeks on feed, the

[4]The "appropriate futures contract" selected was either the contract which matured during the week the cattle were to be sold (week t) or the futures contract for the closest possible month *after* week t. In either case, the "buy back" order on the futures was completed at the price denoted by Monday's close during the week the cattle were sold.

cattle were sold at the Clovis cash price for week t and the futures contracts were bought back. On a per head basis, the net returns from the hedged feeding operation for the 1965-70 period were as follows, again for the 20,000 head lot as described under Strategy I:

Mean = $3.73
Variance = 135.64

Strategy III: Seasonal Hedging Operation

Seasonal hedging refers to hedging in accordance with seasonal price movements in fed cattle prices. Data in recent years have shown a downward trend in fed cattle prices in the fall months of the year. Therefore, the strategy was to hedge all cattle being sold in the fall (September - December) to protect against the expected low prices. None of the cattle to be sold during the months January through August were hedged. Thus, this becomes a "selective" hedging strategy, following the rule of selecting the periods—based on expected developments in the cash market —in which to hedge. The mean and variance for this strategy were as follows:

Mean = $10.96
Variance = 407.97

Strategy IV: Hedging when ELI < Mean Net Returns

Here, the relationship between "expected lock-in" (ELI) and the mean net returns from the "feeding only" operation becomes the criterion. ELI was calculated by subtracting from the appropriate Chicago futures price the estimated cost of producing the slaughter animals *plus* allowances for geographical and time differences between the Southern Plains market area and Chicago. In algebraic terms, the ELI during week t-19 was calculated as follows:

$$ELI_{t-19} = FP_{t-19} - BASIS - COSTS$$

where:

BASIS = geographical location basis (GLOC) plus time basis (TIME), and
COSTS = simply the costs of feeding over a 20-week or 140-day period as defined earlier.

The GLOC portion of the total adjustment needed was the mean difference between Chicago and Clovis weekly cash prices for the months for which futures contracts were traded during the period 1965-70. In other words, an adjustment factor for each of the futures trading months was estimated based on the differences in weekly cash prices, Chicago minus Clovis.

The TIME portion of the total adjustment is simply the mean difference in Chicago futures and Chicago weekly cash prices for each trading month over the 1965-70 period. When combined, the GLOC + TIME adjustment provides an "adjusted futures price" which most analysts agree should be used when considering hedging in a nonpar market area for which no delivery point was established.[5]

Given these developments, the strategy calls for a hedge when

$$ELI_{t-19} < U_R$$

where U_R = mean return (per head) from the "just feeding" operation.

Such a strategy allows the feeder to use his knowledge of returns from feeding and to hedge when the expected lock-in is relatively small, viewed as meaning a "down turn" in the market is probable. When the reverse situation holds ($ELI_{t-19} > U_R$) this is viewed as meaning the market will be strong and the feeder does not hedge. The mean and variance for the 20,000 head lot being used as a common denominator were as follows for this strategy:

Mean = $4.45
Variance = 324.68

Strategy V: Hedge if ELI $\geq$ U_R

The "mirror image" of strategy IV, this strategy uses a criterion which is perhaps more representative of conventional thinking—hedge to guarantee the larger margin if more than the normal (or mean) return can be "locked in". In other words, the criterion is to hedge when

$$ELI \geq U_R$$

where ELI and U_R are as defined under Strategy IV.

Like strategies III and IV, Strategy V is a "selective hedging strategy". The selection of the time to hedge is based upon the relationship expected to prevail between the futures and cash markets during the feeding period and past results from "just feeding". The comparable mean and variance for this strategy were as follows:

Mean = $10.33
Variance = 301.95

Strategy VI: Hedge if ENR < U_R and ELI > 0

A strategy which protects against the "down" market, the new element is the decision to hedge when expected net returns (ENR) is less than U_R

[5]Prior to August, 1971, the par market for the slaughter cattle futures was Chicago. During the 1965-70 period, there was no delivery point in the Southern Plains cattle feeding area and the "adjusted futures price" is therefore needed. For further discussion of the situation since Guymon, Oklahoma was established as a nonpar delivery point effective in August of 1971, see the article by Crow, Riley and Purcell [1].

where

$$ENR = (PJCLO_t)\ (EWT^{K}) - COSTS$$

and

$PJCLO_t$ = projected Clovis price for 900-1100 lb. Choice steers estimated by adjusting CLO_{t-19} consistent with the change in a seasonal index for Choice slaughter steers from t-19 to t.

The other variables have already been defined. The ELI > 0 is added to insure the hedge would not be locking in a loss, a situation in which most cattle feeders would probably prefer not to hedge.

Like several of the other strategies already presented, Strategy VI "selects" the time to hedge. In this case, the cash market is projected (the $PJCLO_t$ component) and used in the decision criterion. When the outlook is more favorable—i.e., ENR > U_R—no hedge is placed. The expected result would then be protection against the down market and freedom to take advantage of the rising cash market. The mean and variance for the 20,000 head lot comparable to those used in presenting results for strategies I through V were as follows:

Mean = $9.17
Variance = 332.23

Strategy VII: Seasonal Hedge With Corrections

The "seasonal hedge strategy", identified as Strategy III, called for a hedge on all cattle to be sold during September-December—the part of the year in which the cash price often moves downward. None of the cattle sold during January-August were hedged.

Strategy VII "corrects" the no-hedge decision during January-August using a decision rule as follows:

Place hedge if cash price falls more than $1.00 per cwt.
during any consecutive four-week period.

The intent was to protect against the serious decline in price. The $1.00 per cwt. was chosen after examination of historical cash price movements indicated that decreases of such magnitude (>$1.00 per cwt.) were indicative of significant downturns in price and were not just short run fluctuations. Use of this decision rule meant a "partial hedge" was placed when the $1.00 decline was encountered—meaning the cattle were hedged for only part of the feeding period. The results for this strategy were as follows:

Mean = $11.63
Variance = 438.85

Interpretation of Results[6]

Table 3 records the results of the seven strategies for the 20,000 head lot, operating at 100 per cent capacity with an average daily gain of 2.8 pounds.

In Figure 2, the results of the seven strategies are plotted on the type of diagram presented earlier. The results of the "feeding only strategy", Strategy I, are plotted to provide a basis for comparison. The coordinates (10.16, 454.71) give a point comparable to the point A used in the earlier exposition.

A number of important messages are apparent when the results are examined and compared. One of the more striking is the marked decrease in mean returns associated with complete hedging of the feeding operation, Strategy II. There is a significant reduction in the risk component as measured by the variance of net returns but at the cost of a $6.43 decrease in mean net returns per head. This is the almost inevitable results of following a naive "hedge everything" strategy when cash price is trending upward. Such results are also one of the reasons feeders who have "tried" hedging are skeptical and prone to dismiss hedging as being not useful or worthwhile.

Three strategies (III, V, VII) fall in the "superior" quadrant, qualifying by providing both a reduction in variance *and* an increase in mean net returns.[7] There is little basis to choose a single best strategy from

[6]Discussion will be based on results generated by applying the different strategies to a 20,000-head lot, operated at full capacity, for a 2.8 average daily gain. Results for all combinations of size, utilization rate, rate of gain and strategies will be presented in the appendix to this bulletin.

[7]Not all departures from the mean and variance of Strategy I are statistically significant. In general, however, any strategy which reduces the variability without a concurrent significant decrease in the mean would be judged to be a highly successful strategy. Strategy V, for example, gives a highly significant decrease (statistically and otherwise) in variance with an increase (not statistically significant) in mean net returns. Conversely, Strategy VII gives a statistically significant increase in mean net returns but no statistically significant decrease in variance.

Table 3. Mean and Variance of Net Returns per Head for Selected Hedging Strategies: 20,000 Capacity Lot, 100% of Capacity, 2.8 lb. Average Daily Gain

Strategy	Mean μ_R	Variance σ_R^2
	($ per head)	($ per head)
I	10.16	454.71
II	3.73	135.64
III	10.96	407.97
IV	4.45	324.68
V	10.32	301.95
VI	9.17	322.23
VII	11.63	438.85

Number of observations = 295

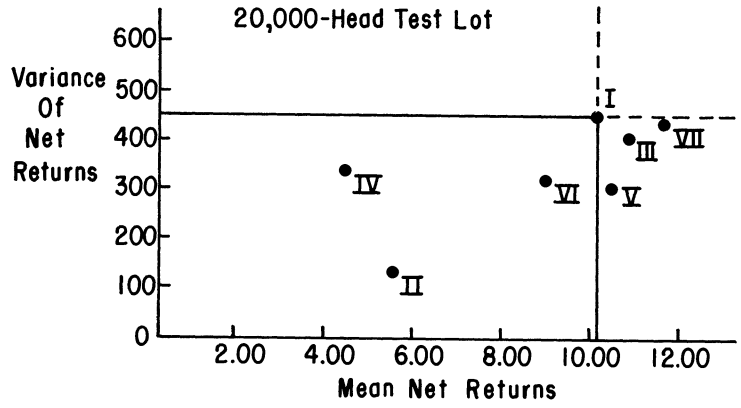

Figure 2. Graphical Presentation of Results for the 20,000-Head Test Lot

among the three. Strategy V does the best job of doing what hedging is theoretically expected to do—reduce the variance (or risk) confronting the entrepreneur.

Checking the output of the model in more detail provides additional support for the soundness of Strategy V. For cattle being sold during 1967, every head placed was hedged. Ex post, it can be observed the quotes for the 1967 futures contracts were, in t-19 relative to the week t during the contract months, seriously over-predicting the cash price for week t. Such a situation translates into a relatively high lock-in margin which would dictate a hedge under Strategy V. Conversely, the futures market under-predicted cash prices during 1968 and only 11 of the 52 lots of cattle sold during 1968 were hedged. Strategy V, it would appear, was capable of picking up the atypical futures-cash relationships and taking advantage of what might be called imperfections in the markets.

Of the three "superior" strategies, Strategy VII—with its significantly higher mean—would be appealing to many cattle feeders. The decision rule which corrected the no-hedge decision during January-August when cash price fell proved to be a fairly effective "stop-loss" hedge. Examination of the results of this strategy reveals periods during which substantial losses were avoided. Examples were the June-August period in 1966 and the January-May period in 1967. During these periods what would have been large losses without a hedge were converted to smaller losses or, in a majority of the cases, positive profits.

The primary shortcoming of Strategy VII is the lack of flexibility of the decision rule employed. When a four-week period in which cash

price of slaughter steers (Clovis series) fell by more than $1.00 per cwt. occurred, this same period would dictate a partial hedge for *all* feeding periods of which the four-week interval was a part. In some instances, this meant placing a hedge only 5-6 weeks before the cattle were sold—not always an economically rational move. In other instances, the rule would dictate a hedge be placed even though the 140-day feeding period carried on past the trough in cash price and into a period with substantially higher cash prices. As a result, what could have been lucrative profits in the cash market were curtailed by losses in the futures market —i.e., the futures moved back up with the cash market and were sometimes bought back at prices above the level for which they had been sold when the hedge was placed. Strategy VII would likely be improved by incorporating measures such as the following:

1. Buy back the futures whenever the futures price, reacting concurrently with a rising cash market, moves above the price at which the futures were sold when the hedge was placed; and
2. Incorporate an outlook indicator for the cash market which would preclude the placing of a hedge, even when the $1.00 per cwt. rule is violated, just before the cash market is expected to move back up.

Results of other strategies are, on an ex post basis, largely the expected results when compared to Strategies V and VII. Strategy III performs well but lacks the "corrective mechanism" for the January-August period which VII offers. Strategy IV is a conservative strategy calling for a hedge only when the lock-in is less than the normal mean return. The decrease in mean returns emerges because the strategy does the same thing Strategy II does—call for a hedge during many periods of rising cash prices. Similarly, Strategy VI is a conservative strategy and results in some decrease in mean returns. Both IV and VI, it should be noticed, effect a significant decrease in variance. For the feeder who can ill afford to carry risk, such strategies may have some appeal.

The Importance of Selective Hedging

The three strategies which performed well (III, V, VII) share a common trait: they are *selective* hedging strategies. The decision to hedge or not hedge is made on the basis of market conditions—made selectively. In the case of Strategies III and VII, expected or actual developments in the cash market constitute the criteria used in making the decision. Strategy V employs the relationship between spot futures prices and estimated costs of production (this relationship is of course the lock-in margin) as compared to past experience in feeding. The results are especially appealing—a large reduction in the risk component or variance and a concurrent increase, albeit small, in mean net returns.

Selective hedging strategies can become important parts of the cattle feeder's overall kit of managerial tools. It would appear the notion of full and continuous hedging should be dismissed as overly naive and potentially damaging to the financial position and profit potential of cattle feeding operations.

Summary, Implications

Seven hedging strategies were developed and applied to simulated cattle feeding operations in the Southern Plains feeding area over the period 1965-70. The results were generated in terms of mean net returns per head and variance of net returns per head, the variance measure being used as a proxy for the risk confronting cattle feeders.

When compared to a "feeding only" operation, the strategy which hedged all cattle decreased the variance of net returns markedly but at a largely prohibitive cost in terms of reduced mean net returns. Such results indicate why so little hedging has been done and verified the need for efforts to generate and test the applicability of more sophisticated hedging strategies.

Several selective hedging strategies gave results far superior to the "hedge everything" strategy—superiority being evidenced by a *decrease in the variance* of net returns with a *concurrent increase in mean* net returns. Two of the selective hedging strategies used past and/or expected behavior of the cash market as a decision criterion concerning when to hedge. The third strategy employed the relationship between the futures quote and estimated production costs (lock-in margin) as compared to previous mean returns from feeding as a decision criterion.

One of the two strategies using cash price movements called for a hedge on all cattle to be sold during the months September-December. The rule was based on the observable tendency for cash price to move downward in the fall months. The results were a 10 percent decrease in variance and an eight percent increase in the mean as compared to the "feeding only" standard. A second strategy was but a modified version of this "seasonal hedging strategy". The "no-hedge" decision during January-August was changed and a hedge placed if cash price fell by more than $1.00 per cwt. during any four-week interval encompassed by the 140-day feeding period. Compared to the "feeding only" standard, the results were a 14 percent (statistically significant at .01 level) increase in mean net returns with a concurrent three percent decrease in variance.

A third strategy called for a hedge whenever the expected or estimated lock-in margin exceeded the mean returns from "just feeding". The results were a 33 percent reduction in variance (statistically significant at .01 level) and a two percent increase in the mean.

The remaining strategies involving hedging effected decreases in the variance of net returns but at some (varying by strategies) cost in the form of decreased mean net returns. Overall, the results clearly verify the working hypothesis that hedging strategies can be developed which, if applied selectively based on the market situation, can decrease the risk confronting the cattle feeder without costly decreases in the mean level of net returns. More refined models need to be developed and checked to more nearly exhaust the potential contribution hedging can make to the entrepreneur's decision model.

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Appendix

In the Appendix tables, the results of the seven strategies are presented for all sizes, rates of gain, and utilization rates. The relative performance of the strategies is, of course, independent of the variables which affect the absolute level of cost. The tables are presented to facilitate the efforts of any particular feeder to estimate how his particular operation would have fared using any particular strategy.

Appendix Table 1. Mean and Variance of Net Returns for all Strategies at a Feedlot Size of 1,000 Head

Strategy	Utilization Rate	Rate of Gain Per Head Lbs./Day					
		2.3		2.8		3.3	
		Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)
		($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)
I		—3.6585	416.7087	—0.8869	448.0955	1.5840	484.1462
II		—9.7247	135.2825	—7.3196	138.2062	—5.2153	145.4935
III		—2.9311	370.2351	—0.0822	400.2014	2.4659	435.3262
IV	100%	—9.7680	291.0332	—7.4933	320.1731	—6.0582	337.3606
V		—4.4802	296.0750	—1.2435	304.1921	2.1922	323.0837
VI		—2.5917	348.5166	—0.9206	359.1301	1.4087	390.0862
VII		—3.1285	404.6787	—0.0860	438.3926	2.6374	476.6553
I		—4.8684	417.3767	—2.3597	448.4058	—0.1518	483.9856
II		—10.9346	136.8974	—8.7924	139.7403	—6.9510	146.8595
III		—4.1410	370.7893	—1.5550	400.3572	0.7301	434.9670
IV	75%	—11.0750	291.2493	—9.0613	320.1738	—7.9062	337.3586
V		—5.7492	295.6555	—2.8115	304.1938	0.3442	323.0840
VI		—3.8850	350.9053	—1.8901	365.4702	0.2848	396.4736
VII		—4.4121	404.7122	—1.6487	438.4021	0.7956	476.6343
I		—6.6226	418.6777	—4.4952	449.3508	—2.6687	484.4438
II		—12.6888	139.5721	—10.9280	142.4609	—9.4680	149.5298
III		—5.8952	371.9260	—3.6906	401.0811	—1.7868	435.1387
IV	50%	—13.0255	291.7136	—11.6124	311.9119	—10.7077	332.4185
V		—7.5339	294.2886	—4.8076	308.8276	—2.2134	325.9775
VI		—5.7881	363.2446	—3.1622	390.0505	—1.8340	398.4036
VII		—6.2733	404.7803	—3.9146	438.4438	—1.8748	476.6436

Appendix Table 2. Mean and Variance of Net Returns for all Strategies at a Feedlot Size of 2,500 Head

Strategy	Utilization Rate	Rate of Gain Per Head Lbs./Day					
		2.3		2.8		3.3	
		Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)
		($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)
I		—0.8115	415.8889	2.5742	448.4734	5.6632	486.0574
II		—6.8817	132.2310	—3.8586	135.7041	—1.1362	143.8178
III		—0.0882	369.6809	3.3788	400.9382	6.5451	437.7021
IV	100%	—6.6186	293.5427	—3.7353	322.1389	—1.5876	341.6277
V		—1.5761	294.8318	2.3678	303.1316	6.4071	320.8945
VI		—0.4888	336.8569	2.7017	364.8293	4.9100	349.3787
VII		—0.1120	404.6443	3.5863	438.4365	6.9654	476.7969
I		—2.0253	416.1096	1.1014	448.1245	3.9274	484.9805
II		—8.0915	133.4015	—5.3314	136.5793	—2.8720	144.2676
III		—1.2979	369.7886	1.9060	400.4370	4.8093	436.4277
IV	75%	—7.9066	293.5427	—5.2685	320.0159	—3.4710	338.4060
V		—2.8640	294.8311	0.7651	304.6802	4.5946	323.5461
VI		—1.6596	335.1997	1.0256	357.2842	3.9133	389.5432
VII		—1.3956	404.6521	2.0236	438.4055	5.1237	476.7200
I		—3.3258	416.5588	0.4818	448.0605	2.0614	484.2593
II		—9.3921	134.8710	—6.9146	134.8337	—4.7379	145.1862
III		—2.5984	370.1157	0.3228	400.2080	2.9433	435.4927
IV	50%	—9.4138	291.0313	—7.0621	320.1736	—5.5500	337.3599
V		—4.1260	296.0750	—0.8124	304.1984	2.7004	323.0840
VI		—2.2375	348.5178	—0.4487	361.5051	1.9169	390.0872
VII		—2.7755	404.6721	0.3437	438.3933	3.1438	476.6667

Appendix Table 3. Mean and Variance of Net Returns for all Strategies at a Feedlot Size of 5,000 Head

Strategy	Utilization Rate	Rate of Gain Per Head Lbs./Day					
		2.3		2.8		3.3	
		Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)
		($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)
I		0.4850	415.8604	4.1575	449.1636	7.5292	487.6467
II		—5.5812	131.1824	—2.2754	135.0767	0.7298	143.7684
III		1.2124	369.7747	4.9621	401.7937	8.4111	439.5042
IV	100%	—5.2340	293.5435	—1.9115	324.0876	0.5489	343.9434
V		—0.1915	294.8311	3.9152	302.8328	8.2438	320.9294
VI		0.6639	334.9395	4.1885	367.2632	6.4295	351.7041
VII		1.2678	404.6501	5.2660	438.4851	8.9453	476.9038
I		—0.5433	415.8635	2.9056	448.5913	6.0538	486.3525
II		—6.6095	131.9932	—3.5273	135.5458	—0.7457	143.7697
III		0.1840	369.6824	3.7102	401.0906	6.9356	438.0413
IV	75%	—6.3288	293.5427	—3.3453	322.4900	—1.1718	341.6255
V		—1.2863	294.8313	2.6834	303.2322	6.8229	320.8943
VI		—0.1529	335.1733	2.8582	367.1348	5.2579	350.0115
VII		0.1768	404.6450	3.9378	438.4434	7.3798	476.8176
I		—1.9043	416.0776	1.2487	448.1467	4.1010	485.0706
II		—7.9705	133.2760	—5.1841	136.4792	—2.6984	144.2053
III		—1.1769	369.7688	2.0533	400.4744	4.9828	436.5381
IV	50%	—7.7778	293.5430	—5.1116	321.0154	—3.2862	338.4058
V		—2.7352	294.8308	0.9219	304.6797	4.7794	323.5457
VI		—1.5270	355.1697	1.1825	357,2834	4.0189	390.4709
VII		—1.2673	404.6509	2.1799	438.4092	5.3078	476.7285

Appendix Table 4. Mean and Variance of Net Returns for all Strategies at a Feedlot Size of 7,500 Head

Strategy	Utilization Rate	Rate of Gain Per Head Lbs./Day: 2.3 Mean (U_R)	2.3 Variance (σ^2_R)	2.8 Mean (U_R)	2.8 Variance (σ^2_R)	3.3 Mean (U_R)	3.3 Variance (σ^2_R)
		($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)
I		1.8158	416.0574	5.7775	450.2024	9.4386	489.7397
II		—4.2505	130.3364	—0.6554	134.7691	2.6392	144.1843
III		2.5431	370.0981	6.5821	403.0010	10.3205	441.8147
IV	100%	—3.8173	293.5437	—0.1868	324.0886	2.8226	348.8098
V		1.2253	294.8291	5.6399	302.8308	10.0357	319.6541
VI		1.8705	333.7935	5.2495	329.0364	8.0999	352.1394
VII		2.6798	404.6702	6.9850	438.5591	10.9711	477.0410
I		0.6967	415.8755	4.4153	449.3052	7.8330	487.9482
II		—5.3695	131.0325	—2.0176	135.0052	1.0335	143.8033
III		1.4241	369.8105	5.2199	401.9624	8.7149	439.8406
IV	75%	—5.0087	293.5437	—1.6370	324.0876	0.8723	343.9431
V		0.0339	294.8306	4.1897	302.8320	8.5672	320.9290
VI		0.8914	334.9158	4.4630	367.2610	6.6948	351.9458
VII		1.4925	404.6528	5.5396	438.4971	9.2676	476.9236
I		—0.5131	415.8608	2.9424	448.6052	6.0972	486.3860
II		—6.5793	131.9677	—3.4904	135.5298	—0.7023	143.7659
III		0.2143	369.6826	3.7471	401.1084	6.9790	438.0803
IV	50%	—6.2966	293.5425	—3.3060	322.4895	—1.1256	341.6260
V		—1.2541	294.8313	2.7226	303.2329	6.8691	320.8940
VI		—0.1781	335.9006	2.9099	366.8494	5.3041	350.0110
VII		0.2089	404.6453	3.9769	438.4465	7.4259	476.8201

Appendix Table 5. Mean and Variance of Net Returns for all Strategies at a Feedlot Size of 10,000 Head

Strategy	Utilization Rate	Rate of Gain Per Head Lbs./Day					
		2.3		2.8		3.3	
		Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)	Mean (U_R)	Variance (σ^2_R)
		($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)
I		3.6003	416.6816	7.9500	452.1282	11.9990	493.2859
II		—2.4660	129.5615	1.5171	134.8902	5.1995	145.4817
III		4.3276	370.8911	8.7546	405.1528	12.8807	445.6543
IV	100%	—1.9175	293.5432	2.1013	324.6797	5.5485	348.8093
V		3.1251	294.8281	7.9776	301.9480	12.7615	319.6538
VI		3.7105	335.8398	7.1315	330.8364	10.8092	366.4680
VII		4.5731	404.7163	9.2900	438.6855	13.6876	477.2710
I		2.6324	416.2917	6.7717	451.0098	10.6103	491.2561
II		—3.4339	129.9306	0.3388	134.7495	3.8108	144.6730
III		3.3598	370.4092	7.5763	403.9114	11.4922	443.4644
IV	75%	—2.9479	293.5430	0.8717	324.0881	4.0700	348.8091
V		2.0947	294.8281	6.6984	302.8328	11.2831	319.6538
VI		2.7357	333.8413	6.0096	329.2273	9.1991	352.9146
VII		3.5463	404.6887	8.0398	438.6113	12.2144	477.1389
I		1.3016	415.9531	5.1517	449.7615	8.7009	488.8745
II		—4.7646	130.6361	—1.2812	134.8477	1.9015	143.9680
III		2.0290	369.9448	5.9563	402.4937	9.5828	440.8665
IV	50%	—4.3647	293.5417	—0.8530	324.0879	2.0159	349.0984
V		0.6779	294.8289	4.9737	302.8323	9.2716	319.0571
VI		1.4048	333.0408	4.8604	347.0049	7.5334	352.3579
VII		2.1343	404.6599	6.3209	438.5276	10.1885	476.9851

Appendix Table 6. Mean and Variance of Net Returns for all Strategies at a Feedlot Size of 20,000 Head

Strategy	Utilization Rate	Rate of Gain Per Head Lbs./Day: 2.3 Mean (U_R)	2.3 Variance (σ^2_R)	2.8 Mean (U_R)	2.8 Variance (σ^2_R)	3.3 Mean (U_R)	3.3 Variance (σ^2_R)
		($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)	($ Per Head)
I		5.4150	417.7393	10.1592	454.7131	14.6022	497.7705
II		—0.6514	129.1957	3.7263	135.6389	7.8032	147.6701
III		6.1423	372.1174	10.9638	407.9663	15.4841	450.4370
IV	100%	0.0144	293.5410	4.4533	324.6785	8.4715	355.5869
V		5.0570	294.8269	10.3296	301.9480	15.3819	315.0200
VI		4.8341	301.9485	9.1684	332.2280	13.5310	366.4727
VII		6.4986	404.7898	11.6341	438.8506	16.4498	477.5649
I		4.4774	417.1396	9.0178	453.2993	13.2572	495.3447
II		—1.5890	129.3313	2.5849	135.1734	6.4580	146.4296
III		5.2047	371.4304	9.8224	406.4360	14.1390	447.8550
IV	75%	—0.9838	293.5425	3.2381	324.6807	6.8882	348.8074
V		4.0588	294.8269	9.1144	301.9487	14.1008	319.6655
VI		4.5274	335.9304	7.9532	331.3647	12.1489	366.4670
VII		5.5038	404.7493	10.4230	438.7627	15.0226	477.4072
I		3.2373	416.5215	7.5081	451.6895	11.4782	492.4951
II		—2.8290	129.6858	1.0752	134.8170	4.6788	145.1496
III		3.9647	370.6965	8,3128	404.6680	12.3601	444.8015
IV	50%	—2.3039	293.5432	1.6309	324.6794	4.9940	348.8033
V		2.7386	294.8286	7.5072	301.9509	12.2071	319.6541
VI		3.3980	335.0603	6.7291	329.8757	10.2548	366.4688
VII		4.1881	404.7053	8.8211	438.6567	13.1352	477.2163