Rational Price Formation in Live Cattle and Live Hog Futures Markets

by

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In recent years, the efficiency of livestock futures markets has received increasing attention. Responding to producer concerns and charges that the markets are detrimental to the industry, researchers have examined the roles of livestock futures markets in discovering and forecasting prices, allocating resources to production, and in registering market information (Purcell and Hudson). The results of these studies are mixed and often dependent upon the time period and method of analysis chosen by the researcher(s) (Garcia, Hudson, and Waller). Indeed, "the available research results suggest it is very difficult to draw definitive conclusions about the efficiency of livestock futures markets" (Hudson, p. 197).

Analyses of the performance of futures markets have stressed two roles of these markets -- inventory guidance and the establishment of forward prices (Tomek and Gray). The allocative role of inventory guidance was developed initially by Working in his study of basis relationships and storage costs. The role of futures as a forward pricing mechanism was developed when futures prices of semi-storable commodities such as onions and potatoes were being scrutinized and further with the introduction of the livestock contracts.

An inconsistency which surfaces in the literature is that futures markets for storable commodities appear to perform both the allocative and forward pricing roles well, while futures markets for nonstorable commodities are notoriously poor forecasters (Just and Rausser; Martin and Garcia; and Leuthold and Hartmann). The conclusion then drawn is that the futures markets for nonstorables (specifically livestock) are not efficient and that the speculative participants in these markets are poorly informed.

The purpose of this paper is to examine the forward pricing function of the live cattle and live hog futures markets within the rational pricing framework suggested by Gray. At the outset, it is argued that livestock futures markets trade reasonably close to the cost of production during the period when supply can be changed. Once the possibility of supply response is eliminated, the futures price should adjust to reflect the supply and demand conditions expected to prevail at contract maturity. It should be noted that this hypothesis implicitly assumes that there are two primary reasons for a range of prices around the cost of production: 1) there will be a range of costs reflecting the average cost of production in different geographic locations, and 2) there is some magnitude of price change above or below the cost of production needed to stimulate the allocation of resources to expand supplies. It will be argued that livestock futures

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markets are rational if they trade near the cost of production during the supply response period and then adjust to reflect market conditions when a supply response is no longer possible.

The paper is structured as follows. Previous literature related to the forecasting performance of livestock futures markets is briefly reviewed in the next section. Section three considers the issue of rational price formation in futures markets. The models and data employed in the study are discussed in the fourth section of the paper. Section five documents that empirical results of the inquiry. The paper concludes with a brief section of concluding remarks.

Relevant Literature

The standard approach to assessing futures market efficiency is based on the concept that a market is efficient if prices reflect all relevant and available information (Fama). Thus, if futures markets for nonstorable commodities are performing the forward pricing function efficiently, futures prices should be accurate forecasts of subsequent cash prices. The forecasting performance of livestock futures markets has been widely examined within this framework.

The common approach to examining the forecasting performance of livestock futures markets involves the development of price forecasting models and comparison of the performance of the models and the futures market (e.g., Just and Rausser; Martin and Garcia; Leuthold, Garcia, Adam, and Park; and Leuthold and Hartmann). Results of such analyses typically find that futures markets do not satisfy the efficiency criteria in a forecasting context and that the forecasting ability of the markets declines as the forecast horizon increases.

The interpretation of futures prices as forecasts has also been addressed in the research literature. Working contended that futures prices were not forecasts and that any futures market cannot be both a forecasting agency and a mechanism for rational price formation. However, these arguments were made in a paper emphasizing the allocative role of futures prices for grains. Futures prices continue to be interpreted as reflecting a consensus of what traders expect the cash price of the underlying commodity to be at contract expiration (Leuthold).

Tomek and Gray suggested that the allocative and forward pricing roles were not mutually exclusive. In fact, futures markets for all commodities play both roles to some degree, with the storage characteristics of the commodity determining the extent of each role. For storable commodities, the role is primarily allocative, but by influencing storage decisions the prices given by the futures market become self-fulfilling forecasts. For semi-storables, the futures market should play an allocative role across the time period the crop is in storage (within crop year) but a forward pricing role across periods when the crop is not stored (across crop years). For nonstorable commodities such as livestock, the futures market should play a forward pricing role. The empirical results of Tomek and Gray suggest that the allocative role is satisfied but the forward pricing role is not as a simple cobweb model provides a better forecast than the futures market.

Gray later clarified the view that futures markets for nonstorables cannot be good forecasters, noting that "production responds to current and recent prices, but if futures were to reflect the anticipation of this response they would necessarily abort it in that reflection" (p. 348). Following this same logic, Gray addressed the concern over a cobweb model being a better predictor than futures, arguing that "a futures market cannot reflect the backward oriented cobweb mechanism without evoking the responses and hence the prices which will prove that reflection wrong" (p. 349).

The literature on rational price formation is relatively limited. Working coined the phase but did not elaborate on a specific definition. The fact that the first mention was contained in work on storable commodities may be a source of the delay in applying the concept to nonstorables, where the idea may be the most useful. Gray, in a study of potato futures, presented the first serious development of the topic (in the context of a semi-storable commodity) along with an empirical test.

The work of Miller and Kenyon for live cattle is the only serious attempt (to the author's knowledge) to apply the rational price formation concept to livestock markets. The purpose of this paper is to expand on their effort and extend the analysis into a more recent time period for both live cattle and live hogs. The rational price formation concept as applied herein is presented in the next section.

Rational Price Formation

Futures prices are the result of a more complex process than most simple forecasts. The difference is that there is arbitrage between the forecasting agency and the agents using the forecast. This can be direct arbitrage through hedging (Working) or indirect arbitrage through using the futures price as an expected output price from which production decisions are based. The result is that the forecast itself can influence whether or not it is realized, as noted above.

The research literature on forecasting performance has tended to ignore this arbitrage and the fact that decision makers trade futures contracts. A buy and a sell decision takes place at each price and the trade is voluntary. If the post-trade price changes, one of the two agents must lose money. The price of a futures contract must always be at a level that will not elicit direct or indirect arbitrage which will guarantee one of the agents a loss, since such a result would be irrational. This we believe is the motivation for Working's original statement about rational price formation. Rational from the perspective of a given trader in the market versus rational from the perspective of aggregate market actions or the aggregation of market information.

Tomek and Gray is one of the few works which generalizes concepts behind futures markets in the argument that all futures markets play an allocation role and a forward pricing role. Examining these roles under rational price formation reveals the generality of the concept. As a futures contract nears maturity the forward pricing role is consistent with rational price formation. During the supply response period, however, where production decisions are made which will determine future supplies, rational price formation suggests the futures price should initially be between average total costs and average variable costs of production on a cwt. scale. As time progresses and producers begin to make production decisions, the futures price should begin to reflect these decisions (forward pricing role) and shut down the supply response if it is adequate or continue to encourage a response if a relative shortage looks eminent (allocative role). Prior to the supply response period, the market should not perform either role and prices would be expected to trade at or near the cost of production.

Models and Data

Three procedures were used to test the hypothesis of rational price formation in the live cattle and live hog futures markets: (1) a comparison of differences between futures prices and average variable costs; (2) a regression analysis of relationships between futures prices and average variable costs; and (3) a forward pricing model suggested by Leuthold. The logic and expected results from each procedure are briefly discussed below.

Comparing the prices of futures contracts across the life of contracts to representative average variable costs of production ($/cwt.) provides insight into the degree of rational price formation in the markets. The comparison was made between the following simple differences:

$$\text{Difference}(i) = FP(t)_{t-i} - AVC_{t-j} \quad \text{for } i = 0,\ldots,11$$

where: $FP(t)_{t-i}$ = average price in month t-i of futures contract maturing in month t,
AVC_{t-j} = average variable costs in month t-j.

Two cases of the difference were examined: (1) setting i = j and comparing the prices of futures contracts across their life to the contemporaneous variable costs, and (2) setting i = j for i greater than the production lag and setting j equal to the production lag length for i less than that lag length. These alignments allowed comparison of the futures price with contemporaneous costs during the supply response months and to the costs incurred when the production decision was made during the months with irreversible supplies.

The difference between the futures contract price ($/cwt.) and the average variable costs ($/cwt.) should be small in months where a supply response is possible and is not restricted to any relationship once production becomes irreversible. Rational price formation implies that the mean and the variance of the difference between futures prices and costs should be such that the difference is not significantly different from zero for contracts which are further from maturity than the length of the production process. Once the time to maturity becomes shorter than the length of the production process the absence of a relationship between futures and costs implies the variance of the difference should increase.

The second procedure used to test for rational price formation involved a regression of costs of production on the contemporaneous price of the futures contract maturing at time t, $FP(t)_{t-j}$:

$$FP(t)_{t-i} = a + b\ AVC_{t-j} \quad \text{for } i = 0,\ldots,11.$$

As with the differences between futures and costs, two cases of this model are examined. The first sets i = j, and the second sets i = j for i longer than the production lag and j equal to the production lag for i less than the production lag.

Rational price formation implies that b = 1 for i greater that the production lag, that is, where a supply response could still influence the futures contract price. It should be noted that if b = 1 for regressions where i is less than the production lag, the rational price formation hypothesis is not refuted. If rational price formation ties the futures price to costs early in the contract life and the futures price adjusts to reflect supply and demand conditions as the contract approaches maturity, the result may well be that b = 1. What is of interest is that variance of b which should be greater as the contract approaches maturity if the market is rational in the context defined above.

The third procedure involves replication of Leuthold's forward pricing model with the current futures price data. The model is estimated as:

$$FP(t)_t = a + b\ FP(t)_{t-j} \quad \text{for } j = 1,\ldots,11.$$

In a market which successfully establishes forward prices b = 1. The results of these regressions will be compared across time horizons (j) with the results of the second procedure. The livestock futures markets should provide better forward prices inside the horizon where supply response is not possible. These should be the same periods when rational price formation begins to fail.

To facilitate the analysis, monthly averages of closing prices for each contract live cattle and live hog futures contract maturing between April 1978 to February 1987 were obtained from published sources. Twelve futures price variables were constructed for each commodity: a maturing contract price and lagged prices for each of the previous eleven months prior to contract maturity. Average variable costs representative of cornbelt hog feeding and Panhandle cattle feeding operations were obtained from the USDA's Livestock and Meat Situation and Outlook and are constructed from a formula which includes the feeder animal and feed. Cash prices used in the analysis were averaged from the Daily USDA Market News reports (LS-214). For hogs, the seven market average price was used and for cattle Nebraska direct sales prices were used.

Empirical Results

For ease of exposition, the results are presented first for the live hog futures market and then for the live cattle futures market. When the results of the three procedures are considered for each of the markets individually, they provide mixed support for the rational price formation hypothesis. In the aggregate, the results support the rational price formation hypothesis as a possible explanation for price behavior in live cattle and live hog futures markets.

Live Hog Futures: Table 1 presents the comparison of means and standard errors for the differences between live hog futures prices and average variable costs for both contemporaneous and incurred costs at various maturity horizons. The comparison of futures prices to contemporaneous costs and costs incurred when animals were placed on feed suggest the variance of this difference is smallest when futures contracts are 4 to 5 months from maturity -- the horizon when hogs are placed on feed. The variance of the difference increases as maturity approaches. Although the increase in variance of the difference from 6 months prior to maturity to 11 months prior does not lend support to the rational price formation hypothesis, it may simply reflect an increase in uncertainty or the expected costs of production rather than actual current costs.

Table 2 presents the results of the regressions of costs on futures prices at different horizons. These results support rational price formation. Models of futures prices 5 to 11 months prior to delivery have coefficients on average variable costs which are not significantly different from 1 in all cases. The coefficient is different from 1 for futures prices 4, 3 and 2 months from maturity in the contemporaneous costs models and for futures prices 1 month from and in the delivery month for the incurred cost models. In both versions of the model the R^2s are small for the model of futures prices in the delivery month, increase for models of prices up to 4 or 5 months before delivery, and then decline out to 11 months. The standard error of the estimate on the cost coefficient is smallest at the horizon when hogs are placed on feed and increases as maturity approaches for all models.

Table 3 reports results of Leuthold's forward pricing model. The findings suggest the live hog futures market is not a good forward pricing contract even in the months when supplies are essentially fixed. Only at the one month horizon is the coefficient on the lagged futures price not significantly different from 1. The magnitudes of the coefficients on the lagged futures prices decline and their standard errors increase as the forward pricing horizon increases until the six month horizon, beyond which they show little change.

Live Cattle Futures: Table 4 presents the means and standard errors of the differences between live cattle futures prices and average variable costs. The comparison of futures price to contemporaneous costs and costs incurred when cattle are placed on feed reveal the smallest variance in the difference for contracts 5 months from maturity -- the approximate length of the feeding period. The variance increases for contracts closer to maturity and remains fairly constant for contracts further from maturity.

Table 5 presents the regression results for costs and live cattle futures prices at different horizons. The findings are supportive of the rational price formation hypothesis in the distant months with the coefficients on the cost variables approaching 1 as the maturity horizon increases in the contemporaneous cost model. The variance of the coefficient declines as the horizon increases to 5 months and remains fairly constant thereafter. The results are similar for the incurred costs model.

Table 6 reports the results of Leuthold's forward pricing model for live cattle. The results suggest the live cattle futures market does not perform its forward pricing role well in the context of this simple model. The coefficient on the futures price at various horizons from maturity is significantly different from 1 at all horizons and rapidly declines in magnitude as the horizon increases.

Aggregate Results: When considered in the aggregate, the results presented above support several conclusions regarding the rational price formation hypothesis for live cattle and live hogs. First, it appears that the two markets behave in a manner consistent with rational price formation prior to the feeding period. For live cattle, the variance of the difference between costs and the futures price shows the smallest variance at the start of the feeding period, increases as maturity approaches, and remains fairly constant during the supply response period. For live hogs, the difference is again smallest at the start of the feeding period, although it increases both as maturity approaches and during the supply response period.

The estimated coefficients in regressions of costs on futures prices for live cattle are close to one during the supply response period and decline during the feeding period. Similar behavior is observed in live hogs with the estimated coefficients not significantly different from one during the 5 to 11 month horizon.

Estimation of Leuthold's forward pricing model indicates that neither the live cattle or live hog market performs the forward pricing function well during the supply response period. Further, when combined with the results of the futures and cost models, an apparent gap in market performance is revealed. The rational price formation hypothesis is supported during the supply response period for both markets, but the forward pricing function is not fulfilled until late in the feeding period (near contract maturity).

Concluding Remarks

Based on the results presented herein, it appears that the rational price formation hypothesis is generally supported by the behavior of live cattle and live hog futures prices. Price levels of distant futures contracts trade in a narrow range around the variable costs of production during the time period where a supply response is possible. Beyond that period the market appears to adjust to reflect current supply and demand conditions. As a result of this behavior, the markets forecast poorly at longer time horizons and improve as the contract nears maturity. This result suggests the analytical framework which attempts to draw conclusions related to the market efficiency based solely on forecast performance is perhaps too stringent.

In the context of the Tomek and Gray framework, it appears that the live hog futures market is superior to the live cattle futures market in terms of forward pricing. The live cattle market, on the other hand, conforms more to the rational price formation hypothesis more so than the live hog futures market. A number of plausible explanations for this behavior exist, centering around the level of uncertainty in the respective production processes. Specifically, for hogs there is additional uncertainty with regard to supplies available for finishing and there are fewer government reports related to supply levels. These issues would seem to merit further investigation and will be the subject of future work.

From the viewpoint of the decision maker interested in using the live cattle and live hog futures markets to manage price risk, the results have implications for the selection of hedging strategies. In particular, the results seem to suggest that covering the costs of production during the period where a supply response is possible would be the best strategy, as opportunities to lock in significant profits are limited due to rational price formation. Beyond the period when a supply response can occur, more profitable hedging opportunities may arise and a more selective approach to hedging is likely to yield higher returns in exchange for accepting the higher level of risk associated with unhedged production.

Table 1. Mean and Standard Error of the Difference Between Hog Futures Prices and Average Variable Costs of Hog Feeding, April 1978 to February 1987.

Variables	Mean	Standard Deviation	F-Test1[a]	F-Test2[b]
		Contemporaneous Costs		
$FP(t)_t - AVC_t$	9.52	4.90	-----	2.528*
$FP(t)_{t-1} - AVC_{t-1}$	9.14	4.16	1.385**	1.825*
$FP(t)_{t-2} - AVC_{t-2}$	8.95	3.65	1.799*	1.405**
$FP(t)_{t-3} - AVC_{t-3}$	8.85	2.99	2.667*	1.055
$FP(t)_{t-4} - AVC_{t-4}$	8.76	3.02	2.618*	1.035
$FP(t)_{t-5} - AVC_{t-5}$	8.95	3.07	2.528*	-----
$FP(t)_{t-6} - AVC_{t-6}$	8.90	3.74	1.712*	1.477**
$FP(t)_{t-7} - AVC_{t-7}$	8.99	4.29	1.303	1.939*
$FP(t)_{t-8} - AVC_{t-8}$	8.76	4.48	1.193	2.117*
$FP(t)_{t-9} - AVC_{t-9}$	8.69	4.36	1.260	2.006*
$FP(t)_{t-10} - AVC_{t-10}$	8.27	4.49	1.191	2.123*
$FP(t)_{t-11} - AVC_{t-11}$	8.03	4.79	1.045	2.419*
		Incurred Costs		
$FP(t)_t - AVC_{t-5}$	9.44	6.87	-----	4.976*
$FP(t)_{t-1} - AVC_{t-5}$	9.02	6.15	1.249	3.982*
$FP(t)_{t-2} - AVC_{t-5}$	9.18	5.71	1.446**	3.441*
$FP(t)_{t-3} - AVC_{t-5}$	9.17	4.73	2.111*	2.358*
$FP(t)_{t-4} - AVC_{t-5}$	9.13	3.02	3.055*	1.628*
$FP(t)_{t-5} - AVC_{t-5}$	8.95	3.07	4.976*	-----
$FP(t)_{t-6} - AVC_{t-6}$	8.90	3.74	3.369*	1.477**
$FP(t)_{t-7} - AVC_{t-7}$	8.99	4.29	2.565*	1.939*
$FP(t)_{t-8} - AVC_{t-8}$	8.76	4.48	2.350*	2.117*
$FP(t)_{t-9} - AVC_{t-9}$	8.69	4.36	2.481*	2.006*
$FP(t)_{t-10} - AVC_{t-10}$	8.27	4.49	2.344*	2.123*
$FP(t)_{t-11} - AVC_{t-11}$	8.03	4.79	2.057*	2.419*

a F-Test1 is the test statistic for the difference of the variance of $[FP(t)_t - AVC_t]$ and the remaining variables.

b F-Test2 is the test statistic for the difference of the variance of $[FP(t)_{t-5} - AVC_{t-5}]$ and the remaining variables.

NOTE: The critical value for F(63,63) at the 5% and 10% levels are 1.518 and 1.384, respectively. A single asterisk indicates that the F-test is significant at the 5% level and a double asterisk indicates significance at the 10% level.

Table 2. Regression Results Modeling Hog Futures Prices as a Function of Average Variable Costs of Hog Feeding, April 1978 to February 1987.

Dependent Variable	Independent Variable	Estimates a	Estimates b	R^2
		Contemporaneous Costs		
$FP(t)_t$	AVC_t	6.811 (5.523)*	1.069 (0.140)	49
$FP(t)_{t-1}$	AVC_{t-1}	4.695 (4.617)	1.114 (0.117)	60
$FP(t)_{t-2}$	AVC_{t-2}	-.175 (3.832)	1.232 (0.097)	73
$FP(t)_{t-3}$	AVC_{t-3}	1.489 (3.045)	1.187 (0.077)	80
$FP(t)_{t-4}$	AVC_{t-4}	-.646 (3.053)	1.238 (0.077)	81
$FP(t)_{t-5}$	AVC_{t-5}	5.187 (3.395)	1.096 (0.086)	73
$FP(t)_{t-6}$	AVC_{t-6}	3.189 (3.947)	1.147 (0.101)	68
$FP(t)_{t-7}$	AVC_{t-7}	11.252 (4.546)	0.941 (0.117)	51
$FP(t)_{t-8}$	AVC_{t-8}	7.436 (4.676)	1.035 (0.121)	55
$FP(t)_{t-9}$	AVC_{t-9}	12.689 (4.520)	0.896 (0.117)	49
$FP(t)_{t-10}$	AVC_{t-10}	8.523 (4.672)	0.994 (0.120)	53
$FP(t)_{t-11}$	AVC_{t-11}	15.868 (4.954)	0.797 (0.127)	39
		Incurred Costs[a]		
$FP(t)_t$	AVC_{t-5}	29.602 (7.196)	0.485 (0.182)	10
$FP(t)_{t-1}$	AVC_{t-5}	24.412 (6.550)	0.607 (0.166)	18
$FP(t)_{t-2}$	AVC_{t-5}	17.340 (6.274)	0.792 (0.159)	29
$FP(t)_{t-3}$	AVC_{t-5}	11.521 (5.257)	0.940 (0.133)	44
$FP(t)_{t-4}$	AVC_{t-5}	3.688 (4.320)	1.139 (0.110)	63

* Standard errors are in parentheses.

a The estimates for the incurred costs model are identical to those for the contemporaneous model for the periods beyond which a supply response is possible.

Table 3. Regression Results for Leuthold's Forward Pricing Model of the Live Hog Futures Market, April 1978 to February 1987.

Dependent Variable	Independent Variable	Estimates a	Estimates b	R^2
$FP(t)_t$	$FP(t)_{t-1}$	7.217 (3.772)*	0.859 (0.078)	.67
$FP(t)_t$	$FP(t)_{t-2}$	15.069 (4.688)	0.694 (0.096)	.46
$FP(t)_t$	$FP(t)_{t-3}$	21.981 (5.749)	0.551 (0.118)	.26
$FP(t)_t$	$FP(t)_{t-4}$	29.523 (6.116)	0.395 (0.126)	.14
$FP(t)_t$	$FP(t)_{t-5}$	29.641 (6.842)	0.394 (0.141)	.11
$FP(t)_t$	$FP(t)_{t-6}$	36.696 (6.295)	0.250 (0.131)	.06
$FP(t)_t$	$FP(t)_{t-7}$	37.391 (6.661)	0.236 (0.139)	.05
$FP(t)_t$	$FP(t)_{t-8}$	39.154 (6.148)	0.200 (0.129)	.04
$FP(t)_t$	$FP(t)_{t-9}$	39.140 (6.720)	0.201 (0.142)	.03
$FP(t)_t$	$FP(t)_{t-10}$	39.799 (6.228)	0.188 (0.131)	.03
$FP(t)_t$	$FP(t)_{t-11}$	40.264 (6.750)	0.179 (0.143)	.02

* Standard errors in parentheses.

Table 4. Mean and Standard Error of the Difference Between Cattle Futures Prices and Average Variable Costs of Cattle Feeding, April 1978 to February 1987.

Variables	Mean	Standard Deviation	F-Test1[a]	F-Test2[b]
		Contemporaneous Costs		
$FP(t)_t - AVC_t$	1.79	4.07	-----	2.079*
$FP(t)_{t-1} - AVC_{t-1}$	1.89	3.21	1.609*	1.296
$FP(t)_{t-2} - AVC_{t-2}$	1.70	2.89	1.988*	1.046
$FP(t)_{t-3} - AVC_{t-3}$	1.89	2.62	2.421*	1.164
$FP(t)_{t-4} - AVC_{t-4}$	1.56	2.48	2.692*	1.295
$FP(t)_{t-5} - AVC_{t-5}$	1.53	2.37	2.951*	1.419**
$FP(t)_{t-6} - AVC_{t-6}$	1.53	2.83	2.079*	-----
$FP(t)_{t-7} - AVC_{t-7}$	1.69	2.57	2.519*	1.212
$FP(t)_{t-8} - AVC_{t-8}$	1.75	2.78	2.148*	1.033
$FP(t)_{t-9} - AVC_{t-9}$	1.74	2.88	1.995*	1.042
$FP(t)_{t-10} - AVC_{t-10}$	1.90	2.71	2.261*	1.087
$FP(t)_{t-11} - AVC_{t-11}$	2.00	2.60	2.464*	1.185
		Incurred Costs		
$FP(t)_t - AVC_{t-6}$	2.68	6.47	-----	5.240*
$FP(t)_{t-1} - AVC_{t-6}$	2.77	5.55	1.359	3.857*
$FP(t)_{t-2} - AVC_{t-6}$	2.28	5.41	1.433**	3.658*
$FP(t)_{t-3} - AVC_{t-6}$	2.47	4.30	2.267*	2.311*
$FP(t)_{t-4} - AVC_{t-6}$	1.87	3.66	3.123*	1.678*
$FP(t)_{t-5} - AVC_{t-6}$	1.82	2.82	5.278*	1.007
$FP(t)_{t-6} - AVC_{t-6}$	1.53	2.83	5.240*	-----
$FP(t)_{t-7} - AVC_{t-7}$	1.69	4.57	6.349*	1.212
$FP(t)_{t-8} - AVC_{t-8}$	1.76	2.78	5.414*	1.033
$FP(t)_{t-9} - AVC_{t-9}$	1.74	2.88	5.027*	1.042
$FP(t)_{t-10} - AVC_{t-10}$	1.90	2.71	5.698*	1.087
$FP(t)_{t-11} - AVC_{t-11}$	2.00	2.60	6.210*	1.185

a F-Test1 is the test statistic for the difference of the variance of $[FP(t)_t - AVC_t]$ and the remaining variables.

b F-Test2 is the test statistic for the difference of the variance of $[FP(t)_{t-5} - AVC_{t-5}]$ and the remaining variables.

<u>NOTE:</u> The critical value for F(57,57) at the 5% and 10% levels are 1.552 and 1.408, respectively. A single asterisk indicates that the F-test is significant at the 5% level and a double asterisk indicates significance at the 10% level.

Table 5. Regression Results Modeling Cattle Futures Prices as a Function of Average Variable Costs of Cattle Feeding, April 1978 to February 1987.

Dependent Variable	Independent Variable	Estimates a	Estimates b	R^2
		Contemporaneous Costs		
$FP(t)_t$	AVC_t	20.545 (5.709)*	0.697 (0.093)	.51
$FP(t)_{t-1}$	AVC_{t-1}	10.030 (4.837)	0.868 (0.079)	.69
$FP(t)_{t-2}$	AVC_{t-2}	5.774 (4.144)	0.934 (0.068)	.78
$FP(t)_{t-3}$	AVC_{t-3}	0.981 (3.760)	1.015 (0.061)	.84
$FP(t)_{t-4}$	AVC_{t-4}	1.170 (3.313)	1.006 (0.054)	.86
$FP(t)_{t-5}$	AVC_{t-5}	-1.752 (3.076)	1.054 (0.050)	.89
$FP(t)_{t-6}$	AVC_{t-6}	2.791 (3.412)	0.978 (0.056)	.85
$FP(t)_{t-7}$	AVC_{t-7}	-1.512 (3.048)	1.053 (0.050)	.89
$FP(t)_{t-8}$	AVC_{t-8}	1.500 (3.117)	1.004 (0.051)	.88
$FP(t)_{t-9}$	AVC_{t-9}	0.384 (3.151)	1.022 (0.052)	.88
$FP(t)_{t-10}$	AVC_{t-10}	2.376 (2.803)	0.991 (0.046)	.89
$FP(t)_{t-11}$	AVC_{t-11}	0.012 (2.674)	1.033 (0.044)	.91
		Incurred Costs[a]		
$FP(t)_t$	AVC_{t-6}	42.835 (5.643)	0.338 (0.093)	.20
$FP(t)_{t-1}$	AVC_{t-6}	32.623 (5.394)	0.507 (0.088)	.38
$FP(t)_{t-2}$	AVC_{t-6}	27.243 (5.610)	0.587 (0.092)	.43
$FP(t)_{t-3}$	AVC_{t-6}	17.279 (4.779)	0.754 (0.078)	.63
$FP(t)_{t-4}$	AVC_{t-6}	10.942 (4.229)	0.849 (0.069)	.73
$FP(t)_{t-5}$	AVC_{t-6}	4.240 (3.352)	0.959 (0.055)	.85

* Standard errors are in parentheses.

a The estimates for the incurred costs model are identical to those for the contemporaneous model for the periods beyond which a supply response is possible.

Table 6. Regression Results of Leuthold's Forward Pricing Model for the Live Cattle Futures Market, April 1978 to February 1987

Dependent Variable	Independent Variable	Estimates a	b	R^2
$FP(t)_t$	$FP(t)_{t-1}$	17.528 (4.940)*	0.723 (0.078)	.62
$FP(t)_t$	$FP(t)_{t-2}$	34.203 (6.099)	0.464 (0.097)	.30
$FP(t)_t$	$FP(t)_{t-3}$	41.041 (6.184)	0.354 (0.098)	.20
$FP(t)_t$	$FP(t)_{t-4}$	45.300 (6.066)	0.289 (0.097)	.14
$FP(t)_t$	$FP(t)_{t-5}$	42.741 (5.558)	0.330 (0.089)	.20
$FP(t)_t$	$FP(t)_{t-6}$	43.864 (5.471)	0.313 (0.088)	.19
$FP(t)_t$	$FP(t)_{t-7}$	41.725 (4.892)	0.347 (0.078)	.27
$FP(t)_t$	$FP(t)_{t-8}$	42.681 (4.808)	0.332 (0.077)	.26
$FP(t)_t$	$FP(t)_{t-9}$	42.026 (4.475)	0.343 (0.071)	.30
$FP(t)_t$	$FP(t)_{t-10}$	43.085 (4.559)	0.327 (0.073)	.27
$FP(t)_t$	$FP(t)_{t-11}$	45.466 (4.534)	0.288 (0.072)	.23

* Standard errors are in parentheses.

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