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PERFORMANCE OF THE LIVE CATTLE FUTURES CONTRACT:

BASIS AND FORWARD-PRICING BEHAVIOR

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I. INTRODUCTION

This report is concerned with the performance of the futures market for live cattle contracts. There has been considerable discontent with trading in live and feeder cattle futures on the Chicago Mercantile Exchange (CME). Manipulation, concentration of market power and cash-futures prices schemes have been alleged (U.S. Congress 1980, page 1), and futures prices are thought to be biased and inefficient (Effertz and McDonald 1984).

Futures trading in any commodity is prone to attack when there is a protracted upward or downward trend in prices. Such trends inevitably benefit some market participants while wreaking havoc on others. The cattle market has been characterized by wide price swings, and the allegations about the poor performance of this market may merely reflect discontent with these fundamental changes. But neither cash nor futures markets are perfect, and they can perform poorly. Thus, it is worthwhile to investigate market performance.

We first provide background information and then review the allegations and existing evidence about the performance of this market. The body of the report addresses two issues related to price behavior--the efficiency of prices over the life of the contract and basis behavior at contract maturity.

Market for Live Cattle Contracts

The market for futures contracts in live cattle opened on the CME in late 1964, with 1965 the first full year of trading. This contract calls for the delivery of choice (grain-fed) steers at various locations. The specific details of the contract have changed with the passage of time as the CME has attempted to improve it. The writing of a contract to make it a useful commercial vehicle is partly an art, and in 1964 exchanges had had little experience in writing contracts for perishable commodities.

Success of a futures market is commonly associated with volume of trading, and Working (1953) has argued that hedging use is essential to

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the success of a futures market. In his view, volume cannot be built on speculative use alone, and hence volume has been taken as an indirect indicator of economic benefits of futures trading. In this sense, the cattle futures market has been successful. Annual volume has increased dramatically since 1965 (Table 1).

Table 1. Live cattle futures volume and open interest

Year	Annual volume	Open interest June 30
	---------1,000 contracts---------------	
1965	59	4.0
1970	579	14.3
1975	2,457	37.4
1977	2,640	46.9
1978	5,040	74.9
1979	7,215	60.3
1980	5,997	59.2
1981	4,282	50.2

Source: Various CME Yearbooks.

Market participants can benefit from an increase in market liquidity. Telser (1981) has shown that historically each one percent increase in volume of trading is accompanied by a one-half percent decrease in the variability of prices. In an illiquid market, a single transaction can have a large price effect. In a liquid market, a large trade has little perceptible impact on futures prices. Thus, this transaction cost is small for hedgers and speculators. An increase in the volume of trading also implies that more information is entering the market.1/ Hence, pricing efficiency may improve as traders specialize and bring their knowledge to the market place.

Volume of trading statistics capture both hedging and speculative activities, and in order to get a clearer picture of hedging usage, both past and present, open interest data are shown in Table 1. Working (1953) conceptualized that a futures contract's hedging use can be approximated

1/ However, it is quite possible that some traders bring little, and perhaps even erroneous, information to the market.

by observing open interest. Open interest includes positions held by hedgers and interday speculators, but excludes the volume generated by intraday traders, which is largely speculative.2/

The data in Table 1 imply that hedging usage increased between the years 1965 and 1978. Between the years 1978 and 1981, however, open interest declined by almost 33 percent; whereas annual volume of trading declined by only 15 percent. In order to further guage the hedging use of the live cattle contract, open interest can be compared to the number of cattle on feed, but this ratio overestimates hedging utilization because a significant proportion of open interest (the numerator) consists of interday speculative positions. In addition, there is the question of whether the cattle on feed number should include heifers, which cannot be delivered on the contract, but which could be cross hedged. During the decade of the 1970s, the ratio of steers on feed to open interest rose from a little over 8 to just over 36 percent.3/ Perhaps 18 percent or more of the total number of steers and heifers on feed in the U.S. were hedged in 1979.4/ By 1981 this figure declined to 11 percent. Presumably, as the market developed, hedging use trended upward, but the level of hedging use also can vary with the expected returns from hedging.

The numbers in Table 2 indicate that short hedging prevails in the live cattle futures market. (A hedger who is short has sold futures contracts anticipating a sale in the cash market.) This table is constructed to show the composition of large traders in live cattle futures. Over a twelve-year period, short hedging has been roughly four to seven times greater than long hedging.

The data in Table 2 indicate, however, that the market has not been overwhelmed by the trading activities of large traders. For instance, during the period 1977-1981 small traders, on average, held a larger percentage of long positions than did the large traders. Furthermore, if one looks at the proportion of open interest held by, say, the four largest traders short and long, the cattle market is not concentrated relative to the wheat and corn futures markets, at least in the mid-1970s (Paul et al. 1981, p. 43).

2/ Scalpers, who provided liquidity, are an important component of intraday volume.

3/ Each live cattle contract is (roughly) equivalent to 37 live steers, each weighing 1100 pounds. Hence, this ratio is constructed by first multiplying open interest (number of contracts) by 37 and then dividing by the number of steers on feed in the 23 major producing states.

4/ The 18 percent figure is consistent with the fact that 42 percent of the open interest during the period 1977-81 was short hedge positions held by large (reporting) traders (computed from CFTC commitments of traders data, see Table 2). However, large cattle feeders are not the only hedgers in the live cattle market; food retailers and small (non-reporting) traders, among others, also can hedge.

Table 2. Distribution of open interest in live cattle futures on June 30

	Reporting (large) traders[a/]					Nonreporting (small) traders	
	Speculative			Hedging			
Year	Only Long	Only Short	Spread	Long	Short	Long	Short
	-----------------Percent of open interest[b/]-----------------						
1970	13.9	7.5	4.7	27.8	31.8	53.6	56.0
1975	22.4	3.7	4.7	6.2	42.5	66.4	48.8
1977	16.4	8.0	4.1	8.6	56.7	70.9	31.2
1978	22.3	7.0	12.5	8.4	44.4	56.9	36.1
1979	14.7	9.2	8.7	10.7	33.3	66.0	48.9
1980	22.8	7.2	8.5	6.1	33.3	62.6	51.0
1981	15.5	10.2	3.6	10.4	40.7	70.5	45.7
1977-81 Ave.	18.3	8.3	7.5	8.8	41.7	65.4	42.6

a/ Large traders, by definition have held 25, 50, or 100 open positions, over the years, at any one time. By definition, small traders hold less.

b/ Sum of long positions plus spread equals 100, as does sum of short positions plus spread.

What explains the difference between the levels of short and long hedging? Presumably hedging in general is motivated by profitability and risk shifting. Paul and Wesson (1967) have shown that a positive relationship exists between the price of feedlot services (defined by futures prices) and feedlot placements. Feedlot operators can sometimes assure a positive return to feedlot services via short hedges.[5/] In contrast, little evidence exists about the lack of long hedging, but there is room to conjecture about why there is not more. The general issue is one of risk shifting and profitability and whether futures provides a relatively useful vehicle for commercial interests. Do profit opportunities exist for hedging or not? Perhaps no, but more likely they do. If so, then one is left with institutional disincentives and lack of knowledge as possible explanations for the lack of long hedging. We consider each of these possibilities in further detail.

5/ Leuthold (1975) and Helmuth (1977) surveyed small feedlot operations and found that only four to seven percent of them had previously used the live cattle contract. However, Helmuth did find this percentage to be much higher for the large feedlot operations.

Under certain conditions it would seem logical for meat packers to have long hedges in the live cattle futures market. A meat packer might enter into a forward cash contract with a food retailer in a carlot carcass sale. Normally the time horizon for deferred delivery is within a year. Unless the packer owns cattle in feedlots, he will have to buy finished steers at some later date. Between the time a contract is made and when the fed animals are purchased, the price of such animals may rise. In anticipation of future merchandising needs, the meat slaughterer may hedge in futures (Miller and Luke 1982).

Such anticipatory long hedging is common in the flour milling industry (Working 1970), but packers seldom use this type of hedge (McCoy 1979). Leuthold (1983) has conjectured that packers, "...can pass output price risks on to consumers through the wholesale price structure." This would obviate the risk-shifting benefits associated with futures hedging. Helmuth (1981), on the other hand, believes that, "...it cannot be expected that long hedging in live cattle futures will increase substantially until such times as significant amounts of beef are sold by packers on fixed-price forward contracts."

Institutional disincentives to long hedging may be caused by market inertia. Long before the live cattle futures market came into existence, the practice of short-term, directly-negotiated sales was (and is) widely used in the beef industry. Thus, institutional factors in the trade (direct marketing, formula pricing, etc.) stress short-term rather than long-term contractual commitments. Most food retailers purchase carcasses or boxed beef from packers on a formula or negotiated basis. And, delivery is usually made shortly after the sale. This procurement method is appealing to retailers because of its operational efficiency; great quantities of a standardized product can be acquired by a small staff of buyers--a cost-effective mechanism.

Nevertheless, food retailers would be in the position to hedge (long) in futures during a retail meat sale campaign, or in conjunction with a forward cash purchase of wholesale meat during periods of rising prices (McCoy 1979). For example, Cornell University Dining Service frequently hedges in the live cattle market in anticipation of future needs. The high correlation between wholesale and live animal prices makes such hedging possible (Hayenga and DiPietre 1982). Though public information is scarce on the subject, it appears that few food retailers, restaurants, or fast-food chains hedge in futures.

Another hypothesis about the lack of long hedging is that there is generally a lack of experience in hedging in the retail industry. Grain merchants have had a far longer experience with hedging in futures--over 100 years. Perhaps long hedging will play a more important role as meat procurement practices become more sophisticated. In summary, institutional disincentives (i.e., relatively little output price level risks, direct marketing, etc.) and a lack of hedging experience appear to have held down the demand for long hedging in the live cattle futures market.

Criticisms of the Cattle Market

Criticisms of the performance of the beef market have not been limited to trading in futures contracts. Concern has been expressed about formula pricing in wholesale carcass markets that rely on price quotes published in a proprietary publication which, in turn, depend on a small base of negotiated spot prices (USDA 1978). Economists have also wondered about the consequences of the decline in central markets for establishing live cattle prices (Tomek 1980). But this report is limited to an analysis of the performance of futures markets.

The criticisms of the cattle futures markets are summarized in an article by Helmuth (1981) and in the related reports of the House Committee on Small Business, which Helmuth cites (see also Gray and Rutledge 1971; Leuthold and Tomek 1980). One concern is the "imbalance" between short and long hedging, alluded to above. In Helmuth's view, supply fundamentals are expressed through short hedging, but demand fundamentals are not adequately reflected in the market, given the small amount of long hedging. "Such a situation is likely to result in systematic downward bias in prices" (p. 349).

Second, short hedging reflects the cost of feeding cattle relative to the current price of contracts for future delivery (the price of feedlot services), and if large commercial feedlots have lower unit costs than smaller farmer-feeders, then these large feeders can lock in a profit through hedging at a lower futures price than can the small farmer. Thus, the short hedging of large feeders may prevent futures prices from rising to levels that would permit profitable hedging by smaller feeders. This observation about relative costs and prices, if true, is not a criticism of the market, but more a description of how competitive markets work.

Helmuth has suggested (p. 351), however, that hedging by large firms has been accompanied by large sales by officers of these firms--insider trading--that has depressed prices. In general, he argues that, when futures prices rise to profitable levels for commercial feedlots, this starts a chain of events which results in a predictable price decline.

Another concern, expressed when futures trading first started for live cattle, is that basis risk might exceed price level risk and, hence, that the cattle contract might have little value for hedging (Skadberg and Futrell 1967). The growth in hedging use implies that some commercial interests have found the market to be valuable, but basis risk can vary among traders and relatively little attention has been paid to this question. As indicated earlier, few farmer-feeders do, in fact, use the cattle futures market, and Heinhold has testified (U.S. Congress 1982) that the volatility of futures prices discourages farmer use of futures.

According to recent research results (Hayenga, et al. 1983), a "typical" farmer-feeder in Iowa could have hedged to assure a positive return to cattle feeding in many extended time intervals, although in many other intervals hedging would not have been profitable, i.e., would have assured a negative margin. Thus, Helmuth's concern about the level of futures prices relative to the typical farmer's costs appears exaggerated.

Nonetheless, the research results about possible bias in cattle futures prices are definitely mixed (Kolb and Gay 1983; Koppenhaver 1983; Leuthold 1974; Martin and Garcia 1981).

In this context, our report concentrates on two issues of price performance: basis behavior at contract maturity and possible bias in futures prices over the life of a contract. The analysis of bases provides new evidence on a little researched topic, and in this sense is exploratory. The results imply that the basis risk faced by cattle feeders is large and provides new insights into the nature of this risk. But the research raises as many questions as it answers, and clearly further analysis of basis behavior is warranted.

Far more research has been done on the question of bias in futures prices. Consequently, our research takes on a methodological flavor, suggesting why different methods and different sample periods can give different results. We conclude on a rather pessimistic note about the possibility of existing methods, used with existing data, to discriminate between markets with "avoidable errors" which might be corrected and "unavoidable errors" which are the typical outcome of an efficient market.

II. BASIS BEHAVIOR IN THE DELIVERY MONTH

The working hypothesis behind this section is that basis behavior, in the delivery month, is influenced by systematic and random economic forces, including market imperfections that are reflected as high delivery costs. The mere presence of these factors suggests that bases are not normally equal to zero in the delivery month.

Presumably hedgers have expectations about cash-futures price differences (their basis). Hedgers participate in futures trading if basis risk is not too great. Otherwise, many will choose not to hedge in futures; large imperfections (a delivery month squeeze) would weaken the institution of live cattle futures trading.

The major objective of this section is to evaluate, using empirical analyses, basis risk for the live cattle contract at maturity. An attempt is made to identify the presence of delivery month "squeezes." In practice, this study identifies symptoms of unusual basis behavior, but does not identify direct causes.

The first subsection provides a conceptual framework for describing both normal and anomalous delivery month basis behavior. From this framework, the next subsection develops an empirical criterion for identifying anomalously large bases. This criterion is then applied to a sample of 78 live cattle contracts. In the last subsection, hedging implications are discussed in light of empirical analyses.

Conceptual Framework

Basis consists of a difference between a futures and cash price. Thus, one basis may differ from another merely because the cash price differs. In addition, the cash price may not be pricing the identical product as in the contract delivery month. Thus, while most introductory textbooks make the simplifying assumption that basis is zero in the delivery month, one should expect cash-futures price differences throughout the delivery month, including the last trading day.

Bases vary through time, in part, because the economic forces determining prices change through time. Regional cash prices are affected by regional supplies and demands as well as any changes in transportation costs among regions. Since some latitude exists for changes in regional prices, relative to each other, the bases also can change. In addition, of course, these prices are influenced by random (nonsystematic) events, and part of the basis merely reflects differences in random events through time (see Leuthold, 1979, for a formal model of basis behavior).

Certain imperfections which prevent cash and futures prices from converging at maturity, even at par delivery points, are basically due to the costs of making or taking delivery. Sometimes it is cheaper for a seller of futures to offset the futures position at a futures premium over the apparent spot market than it is to make delivery (or vice versa for the buyer of futures).6/ To some degree these may be correctable errors but it is not possible to write the perfect contract that can anticipate all situations. It may, for example, be desirable to have a variety of delivery points specified in the contract (to limit squeeze potential), but the diversity of delivery points creates uncertainty among buyers about where delivery will occur and raises issues about the amount, if any, of price differentials among delivery points. In other words, contract writing is an art and involves compromises. Thus, even with the best of efforts, some relatively large bases are likely to occur.

The rest of this section describes imperfections that can influence the maturity month basis. This is in contrast to a perfect market, where transaction costs are zero and cash and live cattle futures price series will converge to an identical value by the 20th day of the maturing contract month.7/ Under this paradigm, delivery date is known by all parties;

6/ For instance, the number of deliveries made on the live cattle contract increased substantially from previous years' levels during the latter part of 1973 and first part of 1974. This can be attributed, in large part, to the (red meat) wage and price controls put into effect for two months beginning June 13, 1973 (Hall et al. 1981). A large number of feedlot operators, in anticipation of a quick end to these price controls, held overweight cattle off the market. Hedgers found that futures overpriced heavy steers relative to cash. This situation encouraged deliveries. If the live cattle contract had assessed a greater penalty for heavy cattle, then deliveries during this time period might have been smaller.

7/ For example, suppose that a cash commodity in the delivery month is selling at a price under its futures market quote. This price relationship encourages (futures market) speculators to buy the cash commodity and sell its future. Then, to fulfill their contractual obligation, the quality of animals is known prior to delivery; handling and transportation costs associated with delivery are zero; actual delivery location is known by all contracting parties; and transaction costs associated with arbitrage are zero.

These assumptions oversimplify actual practice. Delivery in the maturity month is made at the seller's pleasure, and the precise quality of animals delivered cannot be determined until actual delivery is made.

Animals shipped by the seller to a par delivery market may not satisfy par delivery unit requirements, i.e., grades, weight, hot yield requirements, health, lack of dairy characteristics, etc.8/ Even if an acceptable "par delivery unit" of choice steers were loaded onto a truck, live animals can deteriorate while in transit. The contract has provisions for assessing price penalties to sellers in these instances, and sellers may try to avoid delivery risks by liquidating their futures positions before the last day of active trading. Such action puts upward pressure on futures prices.

Like sellers, buyers of futures contemplating delivery face uncertainties. The animals delivered to merchandisers (buyers) may be unsuited for their particular needs. Buyers also face risk when animals are kept in a holding pen at a delivery point for too long a time period. Animal deterioration is a problem in such cases. In the end, buyers may wish to avoid taking delivery. Instead of accepting deliveries, they could purchase cattle in spot markets in order to satisfy their merchandising requirements.

The live cattle contract has seven par delivery points: Peoria, Illinois; Joliet, Illinois; Omaha, Nebraska; Sioux City, Iowa; Guymon, Oklahoma; and Greeley, Colorado. Buyers may be uncertain about where the cattle will be delivered. Presumably merchandisers prefer to obtain their supply of cattle at some convenient spot market; whereas the delivery of cattle may be at any one of seven locations.

The general principle behind delivery, including the location, is that sellers will deliver at the par delivery point that is least expensive for them while still satisfying the terms of the futures contract. Low cost choices may differ for various sellers, and the buyer will be uncertain about the particular delivery notice that will be received.

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these speculators deliver the purchased cash commodity to a location specified in the (future) contract. Assuming zero transaction costs, these speculators reap a profit by making such transactions; their reward is equal to the difference between the cash and future price multiplied by the (physical) volume of the commodity bought or sold. (If cash is above its future, speculators could make a profit if they sell the cash commodity and buy its future.) In the end, this uneven price relationship extinguishes itself; buying raises the cash price, and selling lowers the future price until there is no longer a discrepancy between the two.

8/ The text covers conditions as they were. Under a recent contract revision, a certificate delivery system became effective in December 1983. Opinion is divided about the effect of the new system on the basis at maturity (Abbott 1984).

In addition, there are out-of-pocket expenses associated with deliveries. Sellers must shoulder the bill for all yardage costs (i.e., bedding, feeding, insurance, grading, documental, etc.) up to and including weighing at the delivery point. They must also transport the animals to a par delivery point at their own expense. If such costs are substantial, sellers may prefer to avoid delivery by offsetting futures positions.

Buyers must pay all yardage costs after the animals are weighed at the delivery point. Buyers may face substantial handling costs if delivered animals remain in a holding pen at a delivery point for too long a time period. Also, transporting the delivered animals to a processing (e.g., packing) plant is an added expense. Thus, the cash commodity is worth more to buyers than the futures commodity.

Also, there are explicit costs associated with futures market usage, such as commissions. Therefore, on the last trading day the effective futures price is equal to the nominal price less any arbitrage costs. The effective futures price may be less than the cash price.

It is plausible to think of a "squeeze" as an extension of the nonzero bases concept (Paul 1976). That is, the delivery-month squeeze can be thought of as large nonzero bases caused by unusually high, and unanticipated, delivery costs. The futures price is "out of line" with spot prices. A squeeze usually affects the entire family of bases (pertaining to a particular contract) and not a subset of that group.

An undesirable basis likely can be avoided by hedgers, if it is the result of a particular cash price. In this case, hedgers have the option to sell their finished steers in an alternative, nearby cash market with a more favorable basis. However, hedgers would not have this option in event of a delivery month squeeze, since futures tend to be out of line with all cash prices.

The extent of a squeeze tends to be limited by the size of "unusual" delivery costs. Hence, it is an empirical question as to whether excessive delivery costs have occurred in the past. The next subsection sets about building the analysis that will, hopefully, identify past "squeezes."

Data and Methods

Price data were obtained for each business day for five spot markets: Interior Iowa; Sioux City, Iowa; Omaha, Nebraska; East St. Louis, Illinois; and Peoria, Illinois. All prices are in nominal terms and on a per hundredweight (cwt) scale. Hence, the computed bases are in dollars per cwt. The February, April, June, August, October, and December futures contracts are represented in the data set.9/ In total, 30 (5 cash markets x 6 contracts) maturity month bases are calculated for each year.

9/ The data set used in this report consists of cash and futures prices collected by the Department of Economics, Iowa State University (DiPietre 1982).

The midpoint of the daily high and low spot market prices is used for each location, and for the sake of consistency, the midpoint of the daily high and low futures price is also used. Bases were computed by subtracting cash prices from futures prices.

A simple average of the daily bases was computed for each maturity month for each market. Sometimes, when the volume of trading in a cash market was sparse, a cash price was not reported for that trading day. Thus, the monthly average is based on the number of days for which observations are available. In addition, global averages are computed over the sample years for each market and contract month.

A potential problem with the basis data is the uniformity of cash prices during the latter part of the business week. The volume of trading in the cash markets is largest on Monday, and tapers off by week's end. As a result, the cash market may merely reflect Tuesday's or Wednesday's price on Thursday and Friday. If futures prices continue to change during these days, while cash prices remain at nominal levels, end-of-the-week bases could be relatively more variable than beginning-of-the-week bases. Unfortunately, this problem, if indeed it is a problem, cannot be easily solved. Part of the analysis involves daily bases, as well as averages, and it is useful to have the daily observations available.

Prices in the data base start with the first trading day of 1969 and end on the last day in 1981.10/ During the time period, 78 live cattle contracts were traded. The choice of starting the sample period in 1969 was rather arbitrary. Futures markets do not always work well in their infancy (Tomek 1979-1980) and years with small volume are not included in the analysis.

For purposes of this appraisal, no attempt is made to develop a model to explain year-to-year variability of the basis. Rather, the variability of each monthly basis is examined relative to its global mean. For example, the five bases for February 1969 delivery are compared with their respective average bases derived from the full time period. In this study, "normal basis behavior" is defined as: any basis that is not more than one standard deviation (plus or minus) from its interyear average.11/ With this rule of thumb, developing a criterion for identifying a possible squeeze is made easier.

The following criterion is used for identifying possible squeezes: if at least four of the five bases in a particular delivery month deviate (in the same direction) from their interyear average by one interyear standard deviation, then this month is defined as experiencing a squeeze.

10/ Because of the availability of the data, a simple average of the daily bases was computed for the February 1982 and April 1982 contracts. While the bases associated with these two contracts were not part of the sample analyzed, they were used (to increase the sample size) to calculate interyear means (arithmetic and trend).

11/ Admittedly, one standard deviation is an arbitrary number. For purposes of identifying aberrations, however, this choice appears to be reasonable, as will be seen later.

This criterion assumes that, if the bases for four or more cash markets are simultaneously wide (or narrow) relative to their respective norms, then the problem likely lies with the futures quotation. On the other hand, when only one basis is out of line with the norm, this is more likely related to the local cash price quotation than to a problem in futures. In fact, isolated cases of an anomalous basis should be expected. Bases should and do vary, and if a basis, say for Omaha, is normally distributed, then 32 percent of the observations should be greater or smaller than plus or minus one standard deviation from its interyear average. But it is less likely that four or five bases would randomly wander more than one standard deviation in the same direction from their respective historical means in the same contract month. In this sense, the criterion just described is a rigorous one.

The nominal bases are not deflated because the criterion is a relative one. However, in order to adjust for possible systematic changes in bases, a trend equation is fitted separately for each basis, using Ordinary Least Squares regression (OLS), by contract month and market over the sample years. Also, the bases are graphed against time, by contract and by market, showing interyear basis behavior at maturity. Then, a judgment is made about whether "significant" trends exist by month. Given the OLS equations and visual examination of the graphs, does the basis appear to be trending upward? It would be preferable to use either five trend equations or five arithmetic means for each month: if a mixture is used, it will be based on logical grounds.

Those contracts identified as squeeze candidates are then subjected to supplementary analysis. During the life of a contract, open interest gradually builds to a peak and then declines to zero by the final day of the delivery month. Open interest is reduced as traders buy or sell contracts until their net position in a particular contract is zero, or as traders make or take delivery of the physical commodity. There are times, however, when open interest is relatively large at the beginning of a delivery month. Then, the market must liquidate these open positions rather quickly, and this may result in more (contract) deliveries being made than usual. It has been hypothesized that large deliveries, relative to open interest, are a by-product of a delivery month squeeze (Paul 1976). Large deliveries relative to open interest may be a sign of a problem.

For those contracts identified as having apparent squeeze problems, it would be useful to know whether the basis was unusually large at the beginning or end of the delivery month or both. If an unusually large basis occurred only in the last few days of the delivery month, then those hedgers who offset their futures positions prior to the terminal month avoided substantial basis risk. However, if an anomalous basis manifested itself prior to the delivery month, then such evasive action may have been ineffective.

In order to study intramonth basis variability, the ratio of average of futures prices observed during the first five days of the month to the average of futures prices during the last three days of the month is computed;

a similar ratio also is computed for the bases of selected markets.12/ In addition, the standard deviation of the daily bases is estimated for these months.

Empirical Results

Interyear basis behavior is described by interyear mean and standard deviation statistics shown in Table 3. 13/ Presumably all bases tend to be positioned around their historical mean. For example, one would expect that Omaha basis for the 1976 February contract to be somewhere near $0.84 per cwt (the February contract's mean for the sample period)--plus or minus another 74 cents per cwt (the contract's standard deviation).14/ The $0.74 per cwt measures random events specific to the Omaha basis for the February contract. The same principle is applied to means estimated from trend analysis.

12/ The five-day mean merely is the average futures price for the first full week of trading. The three-day mean also is arbitrary, but if the basis was to widen near the end of the contract's life, the last three days of (futures) trading should capture the change.

13/ Trend equations were fitted for each basis and the results are shown in Appendix A. Some of these equations appear in Table 3. An effort was made to use either five trend equations or five global means when applying the squeeze criterion. For instance, only one February basis (i.e., Interior Iowa) appears to have followed a significant trend over the sample years, i.e., over a 13-year period. But for consistency and given the fact that this basis experienced a negative trend, the decision was made to use its (arithmetic) global mean in Table 3 and, hence, in the analysis. On the other hand, the Interior Iowa basis was the only one associated with the April contract that did not follow an upward trend over the sample years. Thus, to be consistent, its trend equation is used. The results from the trend analysis for the June, August, October, and December bases were mixed. The East St. Louis and Peoria bases appear to have followed an upward trend over the sample years for each of these four contracts. Thus, it was decided to only use the East St. Louis and Peoria trend equations (for these four contracts).

14/ The interyear standard deviation statistic is used for measuring basis variability. The coefficient of variation statistic, an alternative measure of variability, is not very useful since many bases are close to zero in value, and therefore, the coefficient of variation can be huge.

Table 3. Interyear means and standard deviations for bases in five markets ($/cwt)

Market		Delivery Month	Interyear[a/] Mean	Interyear[b/] Std. Dev.
Interior Iowa	(1)	Feb.	$0.88	$0.72
Sioux City	(2)	Feb.	1.04	0.73
Omaha	(3)	Feb.	0.84	0.74
East St. Louis	(4)	Feb.	0.96	1.00
Peoria	(5)	Feb.	0.26	0.65
(1)		Apr.	1.07 + 0.03 (TRD)[c/]	0.68
(2)		Apr.	0.74 + 0.07 (TRD)	0.50
(3)		Apr.	0.36 + 0.15 (TRD)	1.08
(4)		Apr.	0.39 + 0.20 (TRD)	1.13
(5)		Apr.	-0.44 + 0.22 (TRD)	0.96
(1)		June	0.79	0.73
(2)		June	0.63	0.85
(3)		June	0.66	0.73
(4)		June	0.49 + 0.17 (TRD)	1.07
(5)		June	-0.24 + 0.16 (TRD)	0.91
(1)		Aug.	0.69	1.06
(2)		Aug.	0.64	2.07
(3)		Aug.	0.23	1.13
(4)		Aug.	0.20 + 0.14 (TRD)	0.80
(5)		Aug.	-0.24 + 0.11 (TRD)	1.23
(1)		Oct.	0.65	0.66
(2)		Oct.	0.64	0.68
(3)		Oct.	0.44	0.68
(4)		Oct.	-0.57 + 0.13 (TRD)	0.66
(5)		Oct.	-1.04 + 0.17 (TRD)	0.98
(1)		Dec.	1.41	0.70
(2)		Dec.	1.46	0.59
(3)		Dec.	1.24	0.61
(4)		Dec.	0.75 + 0.16 (TRD)	1.10
(5)		Dec.	0.24 + 0.14 (TRD)	0.69

a/ Arithmetic or trend mean.

b/ Standard deviation of variable or of error term of trend regression.

c/ Trend variable, 1969 = 0; 1970 = 1; ... 1981 = 12.

To summarize the results in Table 3, 13 out of 30 interyear bases grew "significantly" larger with the passage of time. Furthermore, except for February, the easternmost bases (Peoria and East St. Louis) trended upward between 1969 and 1981, while the other bases did not (with the exception of the April contract). These trends perhaps reflect regional shifts in supplies, but as indicated earlier, structural econometric analysis of basis behavior is beyond the scope of this research.

Table 4 was constructed to summarize the change in the monthly basis pattern observed in 1981 from the pattern observed in 1969. This table clearly shows that the East St. Louis and Peoria bases have risen, over time, relative to the other markets, i.e., Interior Iowa, Sioux City, and Omaha. Also, the December basis was, and remains, relatively large compared to the other maturities. Furthermore, the trend analysis implies that the April basis has tended to increase relative to the other contract months for all markets. Not much can be said about basis variability, although the East St. Louis market usually had the largest variability.

The information in Table 3 can be used for identifying potential delivery month squeezes, using the criterion defined above. To help illustrate how this rule is used, several examples are worked out in Table 5.

Table 4. Mean bases in 1969 and 1981 ($/cwt)

Market		Feb.	Apr.	June	Aug.	Oct.	Dec.
(a) 1969 Bases							
Interior Iowa	(1)	0.88	1.07	0.79	0.69	0.65	1.41
Sioux City	(2)	0.04	0.74	0.63	0.64	0.64	1.46
Omaha	(3)	0.84	0.36	0.66	0.23	0.44	1.24
East St. Louis	(4)	0.96	0.39	0.49	0.20	-0.57	0.75
Peoria	(5)	0.26	-0.44	-0.24	-0.24	-1.04	0.24
Mean basis for contract		0.60	0.42	0.47	0.30	0.02	1.02
(b) 1981 Bases							
Interior Iowa	(1)	0.88	1.43	0.79	0.69	0.65	1.41
Sioux City	(2)	0.04	1.58	0.63	0.64	0.64	1.46
Omaha	(3)	0.84	2.16	0.66	0.23	0.44	1.24
East St. Louis	(4)	0.96	2.79	2.53	1.88	0.99	2.67
Peoria	(5)	0.26	2.20	1.68	1.08	1.00	1.92
Mean basis for contract		0.60	2.03	1.26	0.90	0.74	1.74

Table 5. Normal versus wide bases for the June contract, selected years

Market		Year	Interyear Mean ($\overline{X}$)	Individual Mean, $\overline{X}_i$	Difference $\overline{X} - \overline{X}_i$
			---$/cwt---		
Interior Iowa	(1)	1973	0.79	0.65	0.14
Sioux City	(2)	1973	0.63	0.61	0.02
Omaha	(3)	1973	0.66	0.64	0.02
East St. Louis	(4)	1973	1.17[a/]	1.09	0.08
Peoria	(5)	1973	0.40[a/]	0.56	-0.16
	(1)	1974	0.79	-0.82	1.61
	(2)	1974	0.63	-0.79	1.42
	(3)	1974	0.66	-0.27	0.93
	(4)	1974	1.34[a/]	-0.98	2.32
	(5)	1974	0.56[a/]	-0.96	1.52
	(1)	1975	0.79	1.16	-0.37
	(2)	1975	0.63	0.22	0.41
	(3)	1975	0.66	0.72	-0.06
	(4)	1975	1.51[a/]	3.11	-1.60
	(5)	1975	0.72[a/]	0.64	0.08
	(1)	1976	0.79	2.07	-1.28
	(2)	1976	0.63	2.13	-1.50
	(3)	1976	0.66	1.84	-1.18
	(4)	1976	1.68[a/]	2.93	-1.25
	(5)	1976	0.88[a/]	2.61	-1.73

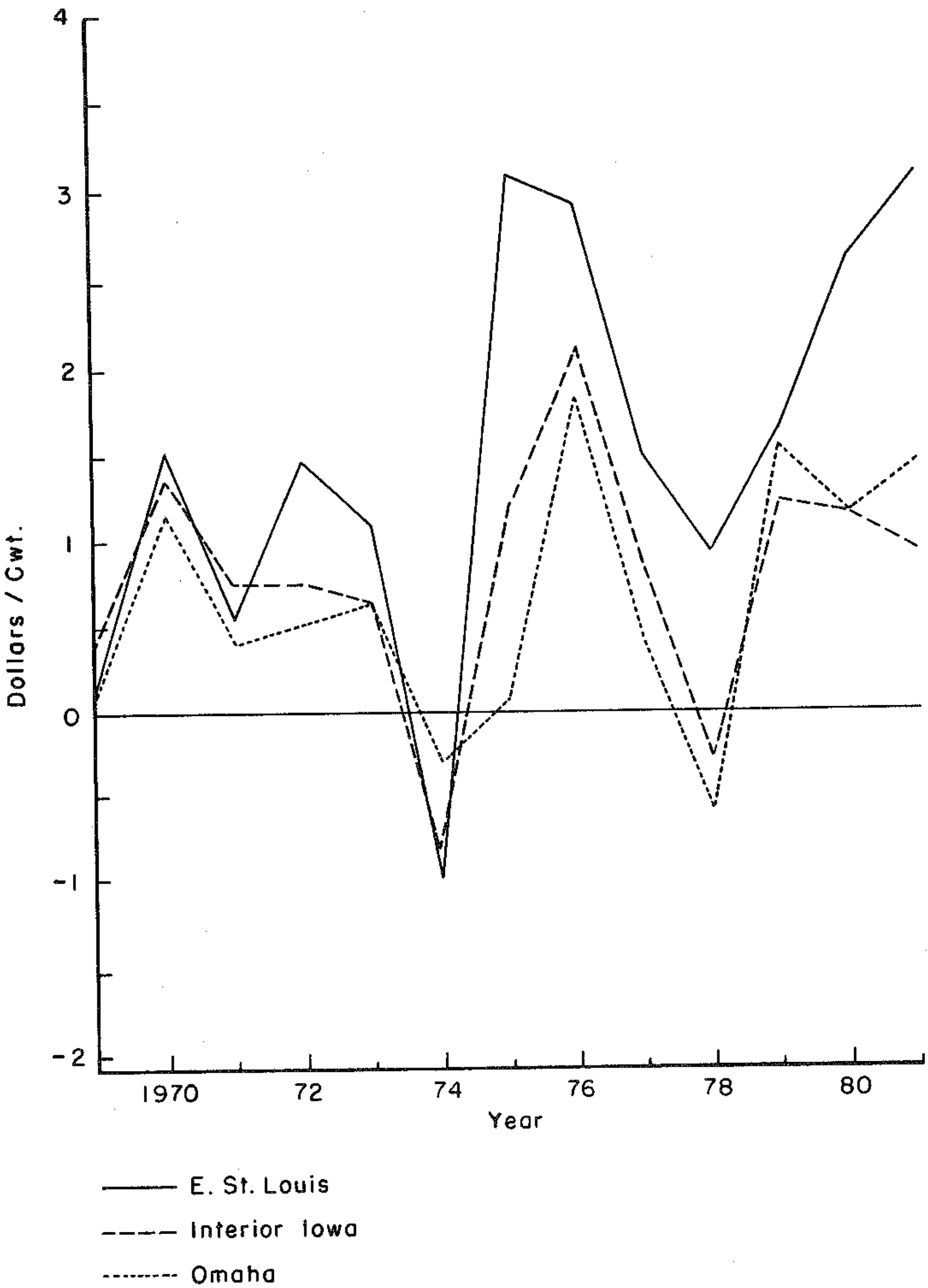
a/ Computed from trend (see Table 3).

This table reports data collected for each June basis for the years 1973 through 1976. The columns contain information about the basis in a particular market: interyear mean, individual mean, and the differences. The interyear mean is computed for the entire sample of months of June; individual means are merely average bases for the June contract in particular years for each market.

The criterion suggests that the 1974 and 1976 June contracts may have experienced abnormal bases or "squeezes." All five June bases in both years fell outside the range of plus or minus one standard deviation. In particular, the five bases associated with the 1974 contract fell below the range, while those associated with the 1976 contract all fell at the other end of the spectrum. Furthermore, most of the differences approached, or surpassed, an absolute value of one dollar per hundredweight for these two contracts.

To visualize these two situations, refer to Figure 1. Selected June bases, which represent the behavior in the five markets, are plotted over the 13-year sample period. In 1974, all bases systematically dropped from

FIGURE I. HISTORICAL JUNE BASES



1973 levels. In fact, futures prices were so depressed that choice steer prices in the cash market were higher than futures. Conversely, in 1976, sellers were apparently forced to liquidate (buy) positions at relatively inflated prices.

Examples of "normal" basis behavior can be found in the 1975 and 1973 June contracts (see again, Table 5). With one exception, all of the individual bases were positioned within the range of one standard deviation. Furthermore, most of the residuals associated with these bases were less than one dollar per hundredweight.

The East St. Louis basis, however, was large (and positive) in 1975. The fact that one basis out of five is unusually large suggests that the problem lies with the cash market, not the futures market. Presumably hedgers in this market could have sold their cattle in an alternative (nearby) cash market in order to lift the hedge at a relatively favorable basis.

The East St. Louis basis is generally larger than the rest (Figure 1). In addition, as observed previously, the East St. Louis basis is more variable than those for the other markets. This relatively variable basis perhaps reflects a cash market that is not working well. Cattle feeders selling in this market face greater basis risk and would find hedging, using these spot prices, relatively unattractive.

After applying the criterion to the entire data set, 14 of 78 contracts were identified as possible squeeze candidates, although short hedgers would have benefited from relatively small bases in 10 of these contracts. In other words, approximately 18 percent of all contracts traded in a thirteen-year period had bases that were unusually large in absolute value, but in many cases such bases were negative, favoring the short hedger.

Turning to the supplementary evidence, peak open interest and deliveries are shown in Table 6 for each contract identified by the squeeze criterion. A ratio was constructed by dividing the total number of deliveries on each contract by that contract's peak open interest. Of the 14 contracts listed in the table, only 5 have a ratio greater than 5 percent. That is, only 5 contracts with anomalous bases experienced large deliveries, as defined by a simple rule of thumb. There were, however, 7 other months of relatively large deliveries, but "normal" basis behavior.

Table 7 summarizes the nature of deliveries and bases for the 78 maturities under study. This table clearly shows that the interrelationship between "large" bases and "large" deliveries is rather weak, i.e., only 5/78 of the contracts fell in this category. This (weak) relationship is contrary to the one hypothesized above.

The intramonth character of those 14 contracts previously identified as squeeze candidates is described in Tables 8 and 9. Clearly, the ratios of futures prices lie near one. The level of futures prices changed relatively little from the beginning to the end of these months, and in this sense, the anomalous basis behavior does not appear to be related to dramatic changes in futures prices near the end of the life of the contract.

Table 6. Deliveries as a percentage of peak open interest for contracts with four or five anomalous bases

Contract	(1) No. of deliveries[a/]	(2) Max. open interest[a/]	Ratio (1)/(2)
	----------contracts----------		%
Five Large Bases[b/]			
April 1973	96	18,492	0.52
February 1974	504	8,877	5.68
June 1974	423	11,781	3.59
August 1975	81	19,022	0.43
October 1975	149	12,092	1.23
February 1976	81	17,160	0.47
June 1976	1,517	15,068	10.01
June 1978	307	27,407	1.12
October 1981	831	24,762	3.36
Four Large Bases			
August 1973	823	7,526	11.00
December 1973	1,238	10,998	11.26
August 1978	343	24,824	1.38
December 1978	1,657	29,976	5.53
April 1980	572	29,794	1.96

a/ Data from the Chicago Mercantile Exchange Yearbook, various issues.

b/ Bases large in absolute value relative to the mean--see text.

Table 7. Relationship between bases and deliveries (frequencies)

		Deliveries: Large	Deliveries: Small	Sum
Bases	Large	5	9	14
Bases	Small	7	57	64
		12	66	78

Table 8. Ratio of beginning of month to ending of month futures prices for contracts with large bases

	Contract	First five[a/] day mean	Last three[a/] day mean	5 day mean / 3 day mean
		---------$ per cwt----------		
All have five anomalous bases	April 1973	43.91	45.45	0.97
	June 1974	36.93	38.48	0.96
	August 1975	44.92	47.49	0.95
	October 1975	48.71	47.16	1.03
	February 1976	38.24	38.96	0.98
	June 1976	43.85	41.02	1.07
	June 1978	58.75	55.62	1.06
	October 1981	65.02	63.84	1.02
All have four anomalous bases	August 1973	56.03	55.34	1.01
	December 1973	38.09	40.70	0.94
	August 1978	52.25	51.39	1.02
	December 1978	56.97	57.83	0.99
	April 1980	60.93	65.27	0.94

a/ Means calculated using average of the daily high and low futures prices.

Table 9. Intramonth descriptive statistics for bases

Delivery month	market	monthly mean	ratio of daily means[a/]	st. dev. daily basis
April 1973	(1)	-0.27	-1.35	0.751
	(2)	0.20		
	(3)	-0.51	-4.88	0.538
	(4)	-0.76	-3.60	1.063
	(5)	-1.72		
August 1973	(1)	2.88	1.76	0.985
	(2)	2.08		
	(3)	2.49	1.83	0.641
	(4)	1.26	5.39	1.074
	(5)	1.70		
December 1973	(1)	0.47	0.58	0.773
	(2)	0.69		
	(3)	0.70	0.68	0.961
	(4)	-0.79	4.12	1.241
	(5)	-0.71		
February 1974	(1)	0.07	-0.72	0.487
	(2)	0.24		
	(3)	-0.46	-0.05	0.628
	(4)	-1.50	0.45	1.151
	(5)	-0.95		
June 1974	(1)	-0.89	1.45	0.904
	(2)	-0.79		
	(3)	-0.29	-0.88	1.212
	(4)	-0.98	1.13	0.839
	(5)	-0.96		
August 1975	(1)	-1.47	21.80	1.420
	(2)	-2.27		
	(3)	-1.80	25.36	1.533
	(4)	0.07	-- b/	1.660
	(5)	-2.12		
October 1975	(1)	-0.51	-0.26	0.752
	(2)	-0.95		
	(3)	-1.11	1.48	0.454
	(4)	-1.04	--	--
	(5)	-2.52		
February 1976	(1)	0.05	-0.75	0.642
	(2)	-0.10		
	(3)	-0.19	-2.61	0.481
	(4)	-0.74	--	0.816
	(5)	-0.66		
June 1976	(1)	2.07	3.97	1.056
	(2)	2.13		
	(3)	1.84	3.41	0.954
	(4)	2.93	2.51	1.220
	(5)	2.61		

(continued)

Table 9 (continued)

Delivery month	market	monthly mean	ratio of daily means[a/]	st. dev. daily basis
June 1978	(1)	-0.28	0.33	0.986
	(2)	-0.58		
	(3)	-0.52	-0.48	0.966
	(4)	0.93	0.78	0.989
	(5)	-0.48		
August 1978	(1)	-0.48	-1.54	0.893
	(2)	-0.68		
	(3)	-1.06	-4.26	1.077
	(4)	0.04	--	0.326
	(5)	-0.63		
December 1978	(1)	2.22	1.16	0.322
	(2)	2.07		
	(3)	1.84	1.24	0.332
	(4)	3.73	0.92	0.509
	(5)	2.00		
April 1980	(1)	0.70	-0.14	0.887
	(2)	1.27		
	(3)	0.84	-0.47	1.840
	(4)	0.86	--	1.458
	(5)	1.00		
October 1981	(1)	1.44	0.38	0.647
	(2)	2.03		
	(3)	1.63	0.62	0.507
	(4)	1.63	0.32	1.069
	(5)	2.04		

a/ Ratio of average basis in first five days to last three days. A negative sign shows a change of sign in basis during the month.

b/ -- indicates that an inadequate number of observations existed for computing the three and/or five day mean. The ratios were not computed for markets (2) and (5).

Nonetheless, the bases are highly variable; the standard deviations of the daily bases (last column Table 9) are large relative to their respective means. But this appears to be true in all maturity months, not just those with "squeezes," although these months seem to have somewhat larger daily variation than the normal months (compare results for the June contract in Table 10). Consistent with earlier results, the basis for East St. Louis (market (4)) is typically more variable than the basis in Omaha (market (3)).

It is difficult to generalize about "trends" in the daily basis during those maturity months that had abnormally large or small bases on average. The ratios of the average basis for the first five days of the month to the last three days of the month are diverse. The negative signs indicate those months when the basis moved from negative to positive or from positive to negative as maturity approached; this occurred in at least some markets in eight of the 14 months. Ratios different than one reflect differences in the beginning and ending means of the bases; the ratios ranged from about -5 to 25.

These statistics combined with a visual inspection of the daily data suggest two things. First, the daily basis typically is highly variable in those months with abnormal means and the basis in the last three days can be quite different than earlier in the month. Second, however, abnormal behavior is observable throughout the maturity month, and the unusual means typically are not just a function of the last three days of trading. These results certainly have implications for the successful completion of hedges.

Hedging Implications and Conclusion

The effectiveness of the live cattle contract, as a hedging tool, is limited by basis volatility. The standard deviations are often a large proportion of the average bases. For example, the standard deviation of the Interior Iowa basis in June was 94 percent of the average basis during the sample period (Table 3). An unpredictable delivery month basis may discourage some potential hedgers from using live cattle futures. This is because hedgers are unable to consistently "lock in" a known return for their feedlot services.

The nature of basis instability is highlighted in Table 10; this table shows descriptive statistics for the Interior Iowa basis in June, a contract that might be used by a farmer-feeder. The standard deviations associated with the individual means are a measure of the daily variability of the basis, which is often substantial. The overall standard deviation shows the variability of the monthly means about the 13-year average, and as indicated above, the coefficient of variation is .94, indicating relatively large variability. Three of the months--1974, 1976 and 1978--appear to be characterized by aberrant futures behavior relative to cash prices. If these three years are deleted, the average basis is $0.93 and the standard deviation a more modest $0.30 per cwt.

Table 10. Descriptive statistics for Interior Iowa basis for live cattle in June maturity month

Year	Mean	St. Dev.
	----------------$ per cwt--------------	
1969	0.415	0.403[a/]
1970	1.376	0.355
1971	0.744	0.236
1972	0.758	0.205
1973	0.651	0.164
1974	-0.891[c/]	0.904
1975	1.162	0.871
1976	2.073[c/]	1.056
1977	0.850	0.474
1978	-0.276[c/]	0.986
1979	1.239	0.795
1980	1.160	0.566
1981	0.952	0.927
Overall	0.79	0.74[b/]

a/ Based on variability of daily base about monthly mean.

b/ Based on variability of monthly means about 13 year average. (Result differs slightly from Table 3 due to rounding.) The annual standard deviation is used for squeeze criterion.

c/ Month identified as an aberration or "squeeze." If these months are excluded, then the standard deviation is 0.30 and the mean 0.93 for the 10 year sample.

A short hedger can benefit, as well as suffer, from a squeeze. When the basis is unexpectedly narrow, the net return from the combined futures and spot transactions is greater than the amount expected using the average basis. For example, the June contract's price on January 15, 1974 was \$54.65 per cwt. If the expected June basis were \$1.00 per cwt for Interior Iowa points,15/ then the expected return from the hedge for these farmers would have been \$53.65. In retrospect, this contract appears to have had a much smaller basis than expected. Thus, if an Iowa hedger had sold futures on January 15 and lifted his hedge on the first Monday in June with a basis that day of \$-1.20 per cwt, the price obtained by the hedge was actually \$55.85 per cwt, or \$2.20 more than expected.

Conversely, long hedgers, facing a similar basis relationship, would be harmed. In addition, the unexpected return from an individual favorable basis does not obviate the general erratic nature of the cattle basis. A risk-averse hedger would be concerned about the unexplainable variability of the basis and hence in the returns from hedging.

If a cattle feeder had routinely hedged in the June contract in January selling the cattle and lifting the hedge on the first Monday in June, the average return would have been \$44.76 with a standard deviation of \$15.42 per cwt for the entire 13 years. In contrast, the unhedged cash sale would have provided a return of \$46.59 with a standard deviation of \$13.66. Thus, routine hedging would have penalized the feeder both in terms of average returns and the variability of returns.16/

The effects of an anomalous basis on the farmer-feeder's income are potentially more dramatic than on the large feedlot-operator's income. The farmer-feeder only uses one or two contracts per year for hedging.17/ On

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15/ The average June basis was \$0.79 for the sample period and \$0.93 omitting three aberrant observations. The \$1.00 basis used in the calculations is a convenient, conservative estimate.

16/ The hedge is assumed to have been placed by a sale of June futures on January 15 and held 5 1/2 months. Prices rose in eight of the 13 years; thus, the loss in futures over this sample period reduced net returns. If appraised in terms of achieving a target price, however, the performance is somewhat better. A conservative view would have been to treat Interior Iowa cash prices as being about one dollar below futures during the maturity month, and since the June futures averaged \$45.46 on January 15, this implies that a hedge on that day would have "locked in" an expected return of \$44.46 per cwt. The actual net was \$44.76. As explained in the text, several of the aberrations involved futures that were unusually low relative to the cash prices.

17/ Farmer-feeders often follow a fixed feeding regime. They place feeder animals on a concentrated grain ration in the winter after the cattle have been grazed in the summer and fed roughage in the fall. Under this regime, feeder animals reach market weight by the next summer. Hence, farmer-feeders must hedge in the summer contracts, i.e., hedge with the June and August contracts. This implies that the squeeze analysis, as it applies to farmer-feeders, should be restricted to those summer contracts.

the other hand, the feedlot-operator's yearly income is influenced by basis gains and losses associated with hedging in all six maturities. The effects of one unusually wide basis could force the farmer-feeder, who is short in the market, out of business, while it would influence a relatively small (one-sixth) proportion of a large feedlot-operator's income.

Frequent hedgers, who generally are large, would also seem to be in a better position to avoid or anticipate the effects of an aberrant basis than the smaller-farmer hedgers. By taking frequent positions in the market, these large hedgers gain invaluable market experience. Undoubtedly, it takes a lot of knowledge and practical experience in the live cattle market to make hedging pay. Therefore, experienced hedgers might have been able to anticipate, and hence avoid, situations that might not have been as obvious to less experienced hedgers.

In summary, the empirical results strongly suggest that many hedgers failed to "lock in" an anticipated return when 14 of 78 contracts were used, although short hedgers would have benefited from 10 of these cases. Thus, while (short) hedging use appears relatively large, basis risk may have discouraged the smaller producers from short hedging and meatpackers and food retailers from long hedging.

III. PRICE BEHAVIOR OVER THE LIFE OF THE CONTRACT

The idea that price changes are random in efficient financial markets existed at the turn of the century. A Frenchman, Louis Bachelier, developed a mathematical theory to explain why changes in stock prices are random, but the significance of Bachelier's work was largely unrecognized until Holbrook Working (1934) and Maurice Kendall (1953) analyzed stock and commodity prices.

If market prices follow a random walk, the presumption is that the market is efficient. Fama (1970) has categorized efficient markets by their ability to use existing information. His categories are weak, semi-strong, and strong form efficiency. The weak form of the efficient market hypothesis states that current prices reflect all the information embodied in historical prices. Since truly new information occurs randomly, price changes occur randomly, and old information (reflected in historical prices) is useless for predicting future price changes. Hence, tests of weak-form efficiency rely only on historical prices.

The semi-strong form of the efficient market hypothesis states that market traders base their expectations on all available public information (e.g., Leuthold and Hartmann 1981), while the strong form of the efficient market hypothesis posits that avoidable error doesn't exist in the marketplace. For strong-form efficiency to exist, no trader can have a monopoly on information; all public and private information is used in price formation. Individual traders cannot consistently outperform the market, although unavoidable pricing errors will occur because truly new information cannot be anticipated.

The purpose of this section is to appraise the forward-pricing efficiency of the live cattle contract. As suggested in the first section, some critics believe that futures prices have been biased downward. A forward-pricing (weak-form efficiency) model is used to analyze whether or not futures prices are unbiased estimates of maturity month prices. If historical price changes are indeed random, then a market is considered weak-form efficient. But this model cannot distinguish between avoidable and unavoidable error if prices are found to have been biased. The theoretical underpinnings of the random walk or, more broadly, the martingale model are discussed next. The subsequent subsection examines the methodology used by several researchers in papers evaluating the forward-pricing efficiency of livestock futures. Ways to improve upon past methodologies are considered and incorporated into the forward-pricing models to be fitted in this chapter. Finally, the empirical results drawn from this forward-pricing model are analyzed.

Random Walk Concept

The random walk can be symbolized by

$$(1) \quad P_t = P_{t-i} + \varepsilon_t,$$

where P_t represents price in period t and P_{t-i} is an observation from the same price series i periods earlier. The error term (ε_t) is assumed to have a constant variance through time (i.e., to be homoscedastic) and to be uncorrelated with error terms from previous time periods. The mean of the error term is zero.18/

Equation (1) can be rewritten as

$$(2) \quad P_t - P_{t-i} = \varepsilon_t.$$

This equation conveniently highlights an important result of the random walk theory: expected price changes are equal to zero since the expected value of ε_t is zero and these price changes are not autocorrelated.

Of course, market imperfections exist; it is commonly assumed that the market can immediately adjust to new information but, in practice, several days may be required before the market has fully taken new information into account. Hence, some degree of autocorrelation might be expected for short-term price changes, i.e., daily price changes.

18/ The critical martingale assumptions are that the price changes have a constant expected value and that the error terms are not autocorrelated. Technically this does not require that the successive price changes have a constant variance as maturity approaches, and Samuelson (1976) has hypothesized that the variance of price changes increases as maturity approaches. For the purpose of exposition, however, it is convenient to talk in terms of a random walk.

In addition, some analysts (Keynes 1930; Stein 1981) have argued that hedgers "pay" speculators to accept risk. Thus, if a market were dominated by short hedgers who wish to avoid downward price risk, prices would be biased downward, but the empirical evidence does not fully support this notion (see Gray 1961; Houthakker 1957; Dusak 1973; Telser 1967). It is also possible in principle, though it seems unlikely in fact, that a market consistently undervalues (or overvalues) a particular type of information. This could lead to bias, and Helmuth (1981) argues that the dominance of short hedging and the importance of insider trading may bias cattle prices downward.

It is not necessary, however, that each trader possess the same information to make the market efficient. To the contrary, the diversity of information available to traders imparts randomness to the market. Frequently, short-run fluctuations in futures prices result from such diversity. Working (1958) puts this phenomenon into perspective:

> The amount of pertinent information potentially available to traders in most modern markets is far beyond what any one trader can acquire and use to good effect. Circumstances and inclination lead different traders to seek out and use different sorts of available information; and if at any time some sort of available and useful information is being generally neglected, someone is likely soon to discover that that neglect offers him a profitable field to exploit. In short, traders are forced and induced to engage in a sort of informal division of labor in their use of available information. Using different information, traders must find themselves often in different opinion, one buying at the same time that another is selling, even though all may stand at an equal high level of intelligence, steadiness of judgement, and quality of information at their command.

Forward-Pricing Model

The forward-pricing (weak-form) efficiency of a particular market is often analyzed by making the cash or futures price at contract maturity a function of previous futures lagged i periods before the delivery month.

$$(3)\quad P_{jt} = \alpha_{ji} + \beta_{ji}P_{jt-i} + \varepsilon_{jt}$$

where P = futures prices,

t = 1, 2, ..., T years,

i = 1, 2, ..., I monthly lags,

j = 1, 2, ..., J contracts.

For a given i and j each equation is assumed to be subject to the classical OLS assumptions, over T observations. The notion behind this model for testing bias is simple: if the slope coefficient (β_{ji}) is one, the intercept term (α_{ji}) is zero, and the error term (ε_{jt}) is not autocorrelated, then the market is efficient.

Leuthold (1974) uses a model like the one represented in equation (3) to test the pricing performance of the live cattle contract. He compares the forward-pricing efficiency of the live cattle contract (representing a nonstorable commodity) to that of the corn futures contract (representing a storable commodity). This was accomplished by regressing pooled closing futures prices on monthly futures prices for eight lagged periods (i.e., the data are not disaggregated as in (3)). Leuthold's data consisted of 36 live cattle contracts maturing from April 1965 through February 1971 and 35 corn contracts maturing from 1964 through 1970. The dependent variable for each equation represented the second-to-last trading day's closing price. The explanatory variable represents the closing futures price that is closest to the 15th of the "regression" month. The OLS results for several of the cattle equations are reproduced below.

Leuthold found that the cattle and corn regression schemes yielded remarkably similar results. Both regression models showed that live cattle futures and corn futures are efficient for short time lags, but not for long lags.

Aggregation problem

There are at least three undesirable side effects of pooling data in the foregoing model. Pooling data (a) may give misleading increases in regression t-ratios, (b) thereby exaggerating aberrant observations, and (c) assume, perhaps incorrectly, that the contract's pricing performance does not vary seasonally or cyclically. Because of these problems, the decision was made to use disaggregated data for the forward-pricing analysis. The problems associated with pooling versus using disaggregated data are discussed below.

The (desired) effect of pooling data is to increase degrees of freedom, but the pooled prices are not independent drawings from the population of prices. A problem arises to the degree that the added observations contain little or no new information (i.e., are redundant). The result of pooling redundant observations is large t-ratios, biased towards rejecting null hypotheses. This point can be illustrated by a simple example. If the sample observations are 1, 2, and 3, the sample mean is 2, and its standard deviation is 0.58. The computed t-ratio, under the null hypothesis that the true mean is zero, is 3.45. If another sample consists of the very same observations and if these two samples are pooled, the mean of the new sample (of six observations) is still 2, but its standard error is 0.36. Accordingly, the t-ratio is 5.56. The results from pooling are, of course, appropriate if the second set of observations was an independent drawing from the same population. But, if the second set of observations are merely redundant, then the t-ratio of 5.56 exaggerates the statistical significance of the results. Pooling futures prices for different contract maturities of the same commodity contain an element of this problem, as the prices for the different contracts respond to the same information in about the same way.

A second, but related, problem is that market errors, whether avoidable or unavoidable, also tend to be imparted to the entire constellation of prices. For example, the effects of wage and price controls in the summer of 1973 can be seen in the entire constellation of futures prices for live cattle. Thus, in general, an aberration is likely to occur in the six (or more) price series for the contracts being traded at the time the event occurred. Such an aberration, combined with the t-ratio effect discussed above, can result in the conclusion that futures prices provide significantly biased estimates of maturity-time prices, when in fact they do not. If the price series contains unavoidable errors, such as those imparted by wage and price controls, and if the weak-form efficiency tests involve pooling, clearly erroneous conclusions could be drawn about possible market inefficiencies.

Third, when pooling data, one has to assume that the live cattle contract's pricing performance does not vary seasonally or with respect to different segments of the cattle cycle. Martin and Garcia (1981) hypothesized that the forward-pricing performance is more accurate when the general level of beef prices is trending upward than when trending downward. They reason that more uncertainty surrounds the liquidation of cattle inventories during a cycle than when there is an accumulation of inventories. Hence, this affects the forward-pricing performance of the contract.

Because of the potential problems of pooling, our econometric analysis relies on disaggregated data to measure contract performance. Each forward-pricing equation regresses a delivery month futures price on one lagged futures price. There are four forward-pricing equations associated with the February contract (i.e., $j = 1$ and $i = 2, 4, 6, 8$ in equation 3), the April contract, and so on. Thus, there is just one observation per variable per year.

There is, however, a major disadvantage to disaggregating the data used in the forward-pricing regressions: few degrees of freedom. For example, only 13 contract years (i.e., 1969-81) are analyzed in this study. Thus, each forward-pricing equation is estimated with just 11 degrees of freedom, but this is a realistic measure of the information content of the sample. If the variance of the hypothesized population--the random walk equation--is large, then a particular small sample could give estimates for forward-pricing equations that are quite different from their hypothesized values. Therefore, one must interpret the results from the forward-pricing estimates with caution. The only solution to this degrees-of-freedom problem is to let time pass so that the analysis can be done over a larger number of observations.

Contemporaneous covariance problem

The OLS regression framework, typically used by analysts, may not be appropriate for handling futures price data. The residuals across the forward pricing equations are perhaps correlated, and if this is so and if the explanatory variable for the equations differ, as they do in this application, then the OLS estimator would not be efficient (Zellner 1962).

If the November cattle-on-feed report contained surprising "news," futures prices will change. This "news" is incorporated into the December price of the February futures (i.e., P_{1t-2}), but couldn't have been used in prior observations on February futures in October, August, or June (i.e., P_{1t-4}, P_{1t-6}, and P_{1t-8}, respectively). This suggests that the error terms for these February regressions have a common component. In general since new market information is imparted to the entire constellation of futures prices (Tomek and Gray 1970), the residuals across equations likely are related. The error terms for different contracts have certain time intervals in common. For example, the August and June contracts with eight month lag lengths span a common six month period, and these two equations have residuals with common elements.

Model specification

Price changes are unpredictable for a price series that follows a random walk. To emphasize this point, a variant of equation (3) is introduced, viz.

$$(4) \quad P_{jt} - P_{jt-i} = \alpha_{ji} + \delta_{ji}P_{jt-i} + \varepsilon_{jit}$$

where P_{jt} = (nominal) futures price for the first trading day in the delivery month,

P_{jt-i} = futures price on or closest to the 15th day of the t-i pre-delivery month,19/

$\delta_{ji} = \beta_{ji}-1$,

$t = 1, 2, \ldots 13$ (T) years,20/

$i = 2, 4, 6, 8$ (I) monthly lags,

$j = 1, 2, \ldots 6$ (J) contracts.

Changes in futures prices, not changes in cash prices, are explained by lagged futures. Cash prices could have been used, but with a variety of par delivery points the identification of an appropriate spot price series is not obvious. Nominal prices are used under the assumption that the market should accurately forecast inflation up to eight months in advance.

Using the random walk model as a norm, this forward-pricing model says that futures price changes should not be predictable from the level of

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19/ The price is assumed to be representative of prices discovered that month. Note that t = 2 implies a six week lag, etc.

20/ The data set used for the forward pricing model consists of all those futures contracts that matured between January 1, 1969 (i.e., t=1) and December 31, 1981 (i.e., t=13). The January contracts traded during this period of time were excluded from the data set.

prices. The null hypothesis for an efficient market formally is

$$E[P_{jt}-P_{jt-i} \mid P_{jt-i}] = 0,$$

where E is the expectation operator. If this hypothesis is rejected, then separate tests for market bias and inefficiency would be appropriate, i.e., the respective simple null hypothesis would then be $\alpha_{ji}=0$ and $\delta_{ji}=0$ (Mincer and Zarnowitz 1969).

Equation (4) is fitted 24 (JxI) times by OLS, then the OLS regressions are repeated with observations deleted to take into account the wage and price controls of 1973.

Correlation coefficient tables are constructed for the OLS regressors and residuals across equations. These tables indicate whether or not the OLS structure is an appropriate framework for estimating these forward-pricing equations. If the residuals, but not regressors, are highly correlated across equations then the OLS estimator is no longer asymptotically efficient. This implies that Zellner's (1962) seemingly unrelated regression estimator (SUR) should be used (provided that the residuals are not autocorrelated).

Results and Appraisal

The results, using OLS and SUR estimators, are given in this section. These estimators were applied to the original data set and one that had deleted observations.21/

OLS results

A striking aspect of the estimated equations is the consistent negative signs of the slope coefficients and positive values of the intercept coefficients. The OLS regression results appear in Tables 11-14. Hypothesis testing notwithstanding, this pattern of negative slope coefficients, taken at face value, suggests that some market bias did exist. This so-called "bias" tends to get larger with longer lags. Furthermore, the results appear to follow a seasonal pattern; "bias" is most evident in the April and June contracts while virtually nonexistent in the October contract.22/

Interpreting the t-ratios is a little more difficult. The t-ratios for most equations are rather small (between one and two), but usually get larger with longer lags. A preliminary and superficial conclusion would be that the cattle market is inefficient, at least over long time intervals.23/

21/ The August 1973 through June 1974 observations were deleted from the data set. In preliminary tests, all the observations representing 1973 and 1974 were deleted before OLS estimation. However, dropping the additional year's observations had little effect on the results.

22/ This empirical fact argues against pooling contracts with similar lags.

23/ We shall argue, however, that these results also can be consistent with a (weak-form) efficient market.

Table 11. Forward-pricing equations for contracts with a two-month lag, 1969-81

	OLS				SUR	
Contract	intercept	slope	$\bar{R}^2$ a/	D.W. b/	intercept	slope
February	6.76 (1.79) c/	-0.15 (1.86)	0.17	1.56	15.815 (4.79)	-0.36 (5.24)
April	4.88 (1.28)	-0.10 (1.26)	0.05	2.42	13.08 (4.22)	-0.29 (4.44)
June	6.62 (1.37)	-0.14 (1.42)	0.08	3.22	16.67 (4.14)	-0.35 (4.42)
August	6.19 (0.96)	0.13 (0.97)	0.00	1.81	15.37 (3.22)	-0.33 (3.45)
October	2.58 (0.38)	-0.06 (0.40)	-0.08	1.83	14.98 (2.54)	-0.33 (2.69)
December	3.53 (0.94)	-0.09 (1.20)	0.03	1.73	10.28 (3.34)	-0.24 (3.83)
Pooled	5.11 (2.67)	-0.11 (2.81)	0.08		16.07 (9.65)	-0.35 (10.26)

See Table 14 for notes.

Table 12. Forward-pricing equations for contracts with a four-month lag, 1969-81

	OLS				SUR	
Contract	intercept	slope	$\bar{R}^2$ a/	D.W. b/	intercept	slope
February	9.38 (1.91) c/	-0.21 (1.94)	0.19	1.32	20.66 (5.22)	-0.47 (5.56)
April	9.08 (1.80)	-0.18 (1.69)	0.13	1.81	19.66 (5.21)	-0.42 (5.45)
June	11.00 (1.74)	-0.21 (1.60)	0.12	2.71	24.52 (5.08)	-0.50 (5.25)
August	9.52 (1.34)	-0.22 (1.50)	0.09	2.26	20.83 (4.14)	-0.46 (4.70)
October	1.02 (0.21)	0.04 (0.35)	-0.08	2.38	7.93 (1.82)	-0.16 (1.77)
December	7.75 (1.13)	-0.18 (1.30)	0.05	1.32	15.21 (2.72)	-0.35 (3.05)
Pooled	7.91 (3.44)	-0.17 (3.47)	0.13		21.65 (11.37)	-0.47 (12.02)

See Table 14 for notes.

Table 13. Forward-pricing equations for contracts with a six-month lag, 1969-81

	OLS				SUR	
Contract	intercept	slope	$\bar{R}^2$ a/	D.W. b/	intercept	slope
February	12.06 (1.94) c/	-0.27 (1.98)	0.20	1.18	23.09 (4.51)	-0.52 (4.81)
April	10.88 (1.73)	-0.22 (1.58)	0.11	1.50	21.96 (4.72)	-0.47 (4.87)
June	12.57 (2.04)	-0.22 (1.71)	0.14	2.31	25.65 (5.49)	-0.51 (5.43)
August	8.37 (1.51)	-0.18 (1.56)	0.11	2.76	18.31 (4.50)	-0.39 (4.91)
October	2.78 (0.51)	-0.07 (0.59)	-0.06	2.97	13.81 (2.88)	-0.31 (3.12)
December	3.21 (0.82)	-0.07 (0.82)	-0.03	2.09	10.18 (3.04)	-0.22 (3.20)
Pooled	8.54 (3.82)	-0.17 (3.68)	0.14		21.96 (11.88)	-0.47 (12.39)

See Table 14 for notes.

Table 14. Forward-pricing equations for contracts with an eight-month lag, 1969-81

	OLS				SUR	
Contract	intercept	slope	$\bar{R}^2$ a/	D.W. b/	intercept	slope
February	8.58 (1.68) c/	-0.17 (1.49)	0.09	1.53	19.70 (4.64)	-0.43 (4.64)
April	15.24 (1.94)	-0.31 (1.85)	0.17	1.56	24.79 (4.23)	-0.53 (4.39)
June	14.64 (2.08)	-0.26 (1.76)	0.15	2.00	27.04 (4.93)	-0.54 (4.83)
August	10.05 (1.88)	-0.19 (1.71)	0.14	2.08	20.34 (4.82)	-0.42 (4.90)
October	5.38 (0.83)	-0.12 (0.87)	-0.02	2.55	17.91 (3.25)	-0.39 (3.47)
December	6.28 (1.22)	-0.15 (1.42)	0.08	2.72	13.18 (2.88)	-0.30 (3.21)
Pooled	10.26 (4.20)	-0.21 (3.96)	0.16		23.65 (11.62)	-0.51 (11.94)

a/ R-squared adjusted for degrees of freedom. b/ Durbin-Watson statistic.

c/ Numbers in parentheses are t-ratios.

Some large price changes can occur, however, which the market cannot predict, such as the effect of red meat wage and price controls in 1973-74, and the observations associated with this episode were deleted (illustrated in Tables 15-16). These deletions, however, had little affect on the estimated forward-pricing equations. Chronic underestimation persists whether or not deletions were made. To understand why, the observations used for estimating the June forward-pricing model with a six month lag are presented in Figure 2. As suspected, the 1974 observation has a large error, but the effect on the coefficients is small because this outlier is roughly in the middle of the data.

Other "outliers" exist in this particular data set. For example, visual inspection indicates that the 1978 and 1980 observations have large errors. These apparent outliers may have been caused by market uncertainties surrounding inflationary expectations 24/ and the cattle cycle. 25/ When the June model was reestimated with the 1974, 1978, and 1980 points deleted, the t-ratios were much smaller (Table 17). Clearly the regression results are sensitive to "aberrant" observations in a small sample.

Unfortunately, a strong justification does not exist for dropping the 1978 and 1980 observations. Furthermore, visual inspection of the data suggests that the pattern of observable outliers changes over lagged contracts, although the August 1973-June 1974 observations consistently appeared to be aberrant. The results, however, emphasize the importance of individual observations in determining coefficients in a small sample.

The general null hypothesis introduced above was, however, founded on the idea that price levels should not be able to forecast subsequent price changes. In light of the evidence obtained so far, formal hypothesis testing procedures can help determine whether or not P_{jt} can accurately forecast $P_{jt} - P_{jt-i}$. (H_0: $E[P_{jt} - P_{jt-i} \mid P_{jt-i}] = 0$.) If these tests produce relatively low test statistics, then one is led to believe that futures price changes are unpredictable. On the other hand, high test statistics are further evidence that the market is inefficient.

The information appearing in Tables 11-14 suggests that the October contract would be least likely, of all the contracts, to be biased, while the April and June contracts would be most likely to be biased. In Appendix C test statistics are calculated for the October contract with a two month lag and the April and June contract with eight month lags. 26/ None of the calculated test statistics turned out to be "significantly" large. In fact, they are surprisingly low, and the null hypothesis cannot be rejected even using large levels of Type I error.

The results presented up to this point perhaps appear to be contradictory, but before considering the interpretation in detail, we examine the SUR results. This framework is logically more correct.

24/ Inflation in the U.S. was at its zenith during the late 1970s.

25/ The cattle cycle was completing its liquidation phase in the late 1970s.

26/ The Durbin-Watson (DW) statistic varies across equation. The DW statistic for these three equations is reasonably close to two.

Table 15. Forward-pricing equations with a two-month lag, 1969-81, with one observation deleted a/

	OLS			SUR	
Contract	intercept	slope	$\bar{R}^2$ b/	intercept	slope
February	6.53 (1.73) c/	-0.15 (1.88)	0.19	13.73 (4.69)	-0.32 (5.20)
April	5.01 (1.38)	-0.09 (1.23)	0.04	12.08 (3.93)	-0.25 (3.95)
June	7.49 (1.80)	-0.14 (1.69)	0.14	14.72 (3.87)	-0.29 (3.87)
August	5.65 (0.90)	-0.13 (1.02)	0.00	12.49 (2.56)	-0.28 (2.87)
October	1.16 (0.20)	0.00 (0.01)	-0.10	10.15 (2.16)	-0.20 (2.07)
December	4.03 (1.31)	-0.09 (1.40)	0.08	9.27 (3.30)	-0.20 (3.54)

See Table 16 for notes.

Table 16. Forward-pricing equations with an eight-month lag, 1969-81, with one observation deleted a/

	OLS			SUR	
Contract	intercept	slope	$\bar{R}^2$ b/	intercept	slope
February	8.58 (1.61) c/	-0.17 (1.44)	0.09	16.80 (4.01)	-0.37 (4.05)
April	12.99 (1.75)	-0.24 (1.43)	0.09	22.42 (3.98)	-0.46 (3.83)
June	14.45 (2.35)	-0.23 (1.77)	0.16	24.82 (4.73)	-0.47 (4.26)
August	7.47 (1.85)	-0.16 (1.91)	0.20	14.65 (4.13)	-0.32 (4.39)
October	5.51 (0.80)	-0.12 (0.84)	-0.03	14.99 (2.78)	-0.33 (3.01)
December	6.86 (1.30)	-0.16 (1.44)	0.09	13.57 (2.79)	-0.30 (3.04)

a/ See text for explanation.

b/ R-squared adjusted for degrees of freedom.

c/ Numbers in parentheses are t-ratios.

FIGURE 2. OBSERVATIONS FOR ESTIMATING THE JUNE MODEL WITH SIX-MONTH LAG

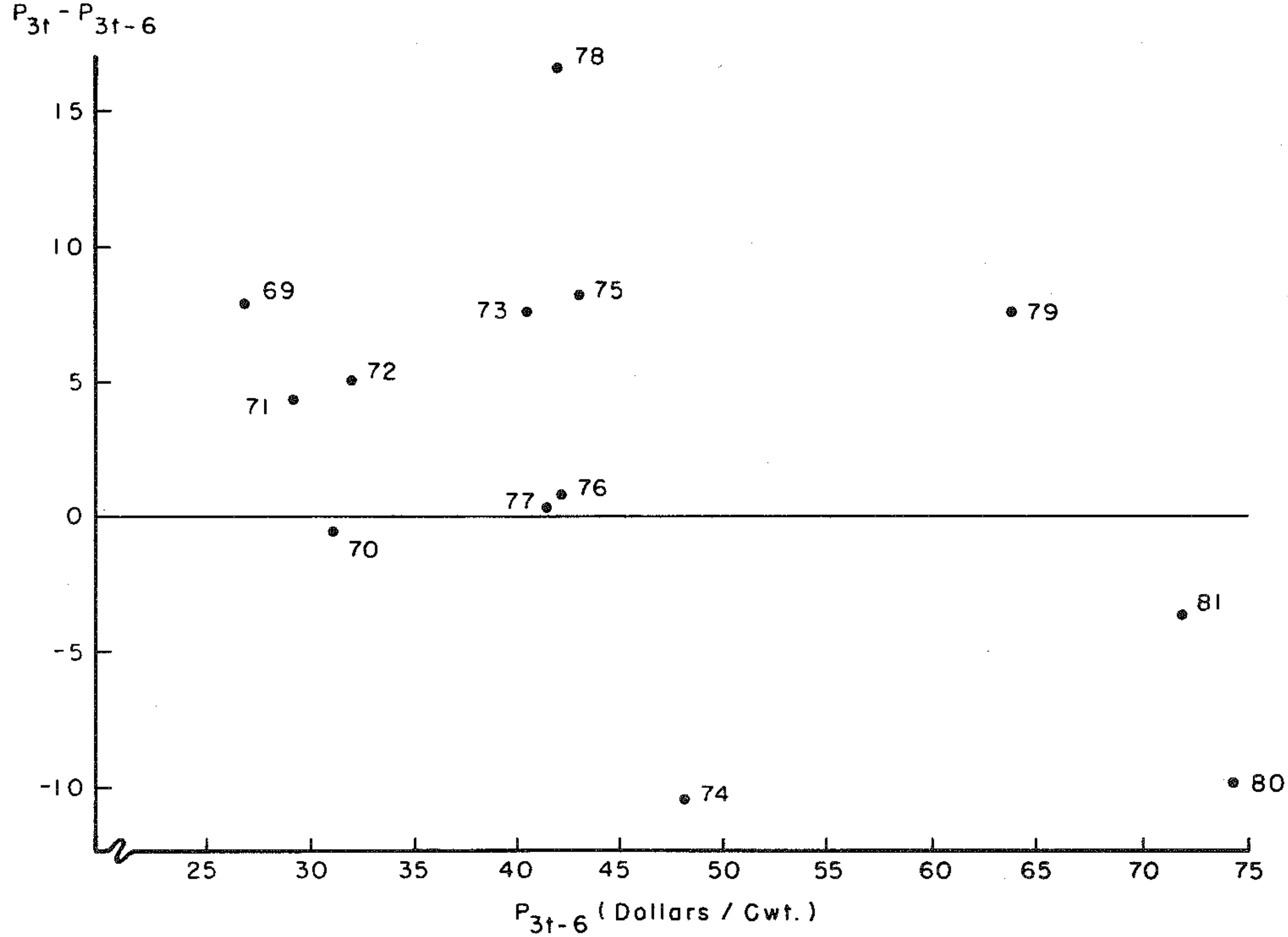


Table 17. Estimates of June forward-pricing equation, six month lag, for various samples

Sample	intercept	slope	$\bar{R}^2$ b/
1969-81	12.57 (2.04) a/	-0.22 (1.71)	0.14
1969-81; 74 deleted	13.00 (2.40)	-0.21 (1.82)	0.17
1969-81; 74, 78, 80 deleted	7.39 (1.75)	-0.09 (0.92)	-0.02

a/ Numbers in parentheses are t-ratios.

b/ Adjusted for degrees of freedom.

SUR results

A difficulty with using the SUR framework is the inescapable degrees-of-freedom problem. There are 13 observations per equation and 24 equations in the system. Mathematically, it is impossible to use the SUR estimator for a system of equations if the number of observations is smaller than the total number of equations.

The SUR framework, however, can be applied to a subset of equations, i.e., those equations that have the most highly correlated residuals. It appears from Table 18 that the blocks of equations along the main diagonal of the matrix of residuals have the highest correlation coefficients. These are the four equations for a given contract with differing lags. Also, the explanatory variables in these blocks of equations are not perfectly correlated, i.e., they are indeed different (Table 19).27/ Thus, it seems reasonable to use the SUR framework for the subsystems of equations, one four equation system per contract.

The results from these equations are placed next to the OLS results in Tables 11-16. The prima facie results of the SUR equations follow the same sort of pattern found in the OLS results; however, the degree of "bias" is much more pronounced in the estimated coefficients and t-ratios.

In addition, aggregating data tends to accentuate estimated forward-pricing bias. The pooled contracts that were estimated by OLS suggest more bias in price performance than the individual lagged contracts. Furthermore, the combined consequences of aggregation and SUR estimation are to accentuate estimated bias, what one would expect if the SUR estimation of aggregated models were appropriate.

27/ The fact that the regressors for most of these equations are highly correlated suggests that SUR may not be much more efficient than OLS (Zellner 1962).

Table 18. Correlation coefficients for residuals of OLS equations reported in Tables 11-14

		Feb.				Apr.				June				Aug.				Oct.				Dec.			
	lag→ ↓	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8
Feb.	2	1.0	.873	.735	.857	.260	.640	.681	.548	-.191	-.050	.236	.324	.328	-.007	.074	.440	-.105	.245	-.141	.040	-.224	-.217	-.021	-.232
	4		1.0	.931	.885	.338	.690	.845	.752	-.003	.105	.365	.544	.198	.058	.147	.457	-.027	.133	.019	.185	-.216	-.116	-.078	-.038
	6			1.0	.830	.407	.720	.863	.880	.158	.262	.478	.654	.076	.091	.198	.427	.119	.104	.152	.334	-.150	.016	-.102	.082
	8				1.0	.488	.726	.823	.759	.072	.205	.424	.544	.130	.061	.193	.456	.004	.125	.063	.257	-.148	-.152	-.107	-.040
Apr.	2					1.0	.874	.763	.764	.506	.850	.904	.865	-.570	-.271	.139	.159	.593	.199	.383	.775	.588	.445	.293	.429
	4						1.0	.941	.899	.302	.648	.842	.870	-.342	-.264	.078	.278	.470	.249	.219	.625	.381	.342	.247	.261
	6							1.0	.951	.293	.548	.752	.864	-.196	-.117	.147	.362	.359	.210	.241	.559	.206	.244	.155	.256
	8								1.0	.394	.627	.780	.887	-.252	-.059	.195	.329	.439	.177	.335	.641	.223	.311	.104	.320
June	2									1.0	.838	.712	.662	-.102	.535	.787	.589	.382	.201	.835	.793	.290	.274	.275	.782
	4										1.0	.945	.874	-.479	.057	.441	.318	.624	.189	.658	.898	.600	.523	.362	.713
	6											1.0	.963	-.432	-.038	.360	.379	.570	.186	.514	.837	.524	.466	.324	.589
	8												1.0	-.365	.001	.353	.414	.504	.141	.483	.789	.399	.408	.236	.548
Aug.	2													1.0	.736	.481	.604	-.562	.169	-.037	-.377	-.703	-.585	-.166	-.260
	4														1.0	.897	.802	-.319	.119	.503	.120	-.472	-.385	-.089	.284
	6															1.0	.902	-.092	.188	.675	.457	-.218	-.226	.031	.477
	8																1.0	-.243	.147	.430	.305	-.377	-.374	-.061	.255
Oct.	2																	1.0	.652	.594	.788	.869	.935	.753	.627
	4																		1.0	.583	.526	.448	.525	.794	.408
	6																			1.0	.856	.449	.488	.587	.893
	8																				1.0	.667	.650	.584	.823
Dec.	2																					1.0	.911	.792	.645
	4																						1.0	.804	.659
	6																							1.0	.692
	8																								1.0

Table 19. Correlation coefficients for lagged prices (the regressors) of OLS equations reported in Tables 11-14

		Feb.				Apr.				June				Aug.				Oct.				Dec.			
	lag→ ↓	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8
Feb.	2	1.0	.976	.924	.973	.972	.997	.998	.936	.923	.978	.997	.977	.912	.931	.976	.996	.938	.932	.929	.975	.944	.915	.935	.933
	4		1.0	.975	.976	.935	.979	.998	.981	.888	.950	.981	.999	.857	.901	.955	.984	.893	.873	.898	.956	.887	.864	.876	.903
	6			1.0	.946	.866	.929	.963	.998	.815	.894	.933	.971	.753	.836	.909	.937	.831	.777	.833	.914	.801	.794	.778	.838
	8				1.0	.935	.967	.973	.961	.878	.951	.973	.976	.833	.893	.957	.977	.888	.861	.895	.961	.896	.854	.872	.903
Apr.	2					1.0	.977	.937	.883	.956	.996	.977	.938	.903	.963	.990	.972	.959	.933	.964	.988	.967	.941	.945	.966
	4						1.0	.981	.940	.924	.982	.999	.981	.906	.932	.979	.997	.942	.924	.930	.978	.941	.918	.928	.934
	6							1.0	.970	.897	.950	.983	.999	.874	.908	.953	.986	.893	.887	.904	.952	.894	.866	.888	.910
	8								1.0	.829	.910	.944	.977	.761	.849	.924	.948	.843	.788	.847	.928	.817	.805	.791	.852
June	2									1.0	.959	.932	.895	.927	.998	.954	.931	.906	.956	.996	.952	.950	.902	.965	.995
	4										1.0	.983	.951	.891	.969	.998	.980	.954	.927	.970	.997	.957	.935	.939	.972
	6											1.0	.984	.907	.940	.982	.999	.939	.926	.938	.981	.943	.915	.931	.942
	8												1.0	.864	.906	.955	.987	.894	.878	.903	.956	.893	.865	.880	.908
Aug.	2													1.0	.915	.876	.905	.905	.989	.909	.873	.960	.910	.984	.911
	4														1.0	.966	.939	.913	.947	.999	.965	.948	.907	.958	.999
	6															1.0	.979	.948	.915	.968	1.000	.947	.928	.927	.970
	8																1.0	.928	.923	.937	.979	.939	.903	.928	.941
Oct.	2																	1.0	.934	.916	.946	.965	.996	.941	.919
	4																		1.0	.944	.912	.975	.939	.998	.944
	6																			1.0	.968	.949	.910	.956	1.000
	8																				1.0	.946	.925	.925	.970
Dec.	2																					1.0	.960	.982	.952
	4																						1.0	.944	.912
	6																							1.0	.957
	8																								1.0

Again, based on the arguments given above, the general null hypothesis is tested for the same equations that were tested in Appendix C. However, a variant of the conventional test statistic is used, since each equation tested is part of a larger system of equations (Johnston 1972). As in the OLS case, none of the calculated test statistics turn out to be significantly large. Thus, the live cattle market appears to be efficient in the sense that the hypothesis that the conditional mean of the price change is zero cannot be rejected.

Interpreting results

In interpreting results, two ideas should be kept in mind: first, the sample period is short and the observations for the different contracts and lags are not independent of each other. Second, the hypothesis that the conditional mean of the price change is zero is a different hypothesis than that the individual parameters are zero. The more general hypothesis is whether the price level has predictive power or not.

With respect to the first concept, the 24 equations help describe the sample, but they do not provide 24 times more information than if one had fitted a single equation. In this context, one should expect the observed internal consistency of regression results--the positive intercepts and the negative slopes, the seasonal pattern of results, the pattern associated with lags, the effect of aggregation, and the effect of SUR. These all are a part of the interrelated prices and pricing errors in a sample from a 13-year period.

Moreover, an implication of the coefficients of determination being small is that the residual errors are large relative to the variance of price changes. In terms of the random walk equation, the variance of the errors may be sufficiently large so that a particular small sample (like the one used in this study) could give an intercept and a slope quite different from zero. Conceptually, if this same 13-year sample period could be replicated with the same (large) error term, quite different price observations would likely occur.

The larger t-ratios for the individual coefficients in the equations with the longer time lags also could be consistent with an underlying random walk price behavior. In a random walk, the longer the time interval over which prices are allowed to change, the larger the variance of the price change. Given any initial price and a (fixed) variance of daily price changes, a price series has more scope to wander over eight months (160 days) than over two months (40 days). In a 13-year sample, we have 13 initial prices (P_{jt-i}'s), which vary from year to year. In a particular year, it is quite possible that a high initial price is associated with a subsequent large price decrease or that a low initial price is associated with a large price increase, when eight months are allowed for prices to change. A few observations like this, in the context of 13 observations, could result in a slope and an intercept significantly different than zero. This is less probable in an equation with a two-month lag, because the variance of the dependent variable is smaller than for an eight-month lag.

The empirical results obtained in this study could, of course, have been generated by an inefficient market, but since the hypothesis that the conditional mean of the price change is zero cannot be rejected, the evidence favors weak-form market efficiency even for the equations with long time lags. We turn next to further discussion of the hypothesis tests.

After inspecting the regression results, it is clear that this study's overall sample estimate may be characterized by the line drawn in Figure 3. In this figure, the horizontal axis represents the hypothesized population, i.e., the efficient market hypothesis. The broken line with the nonzero slope represents the estimated relation. The negative slope coefficient implies that the intercept coefficient could not equal zero. But this result can be consistent with the null hypothesis that the conditional mean of the price change is zero, where the conditioning prices are within the range of the sample data. This would be true if the variance of the forward-pricing equation is large.

Thus, the hypotheses about the individual parameters differ from the one about a conditional mean. The hypothesis that the intercept coefficient equals zero is interesting by itself if the slope coefficient equals zero; in this case the simple hypothesis would test for bias. But, if the slope coefficient differs from zero, the test of the intercept being zero (as a simple single hypothesis) is misleading, because this is equivalent to testing that the price change is zero when the price level is zero--not a meaningful question. Rather, one should see if the estimated price <u>change</u> is significantly different from zero within the range of observed prices. The (general) hypothesis of a zero price change cannot be rejected. In other words, the equations are not profitable forecasters, and, in this sense, the market is efficient.

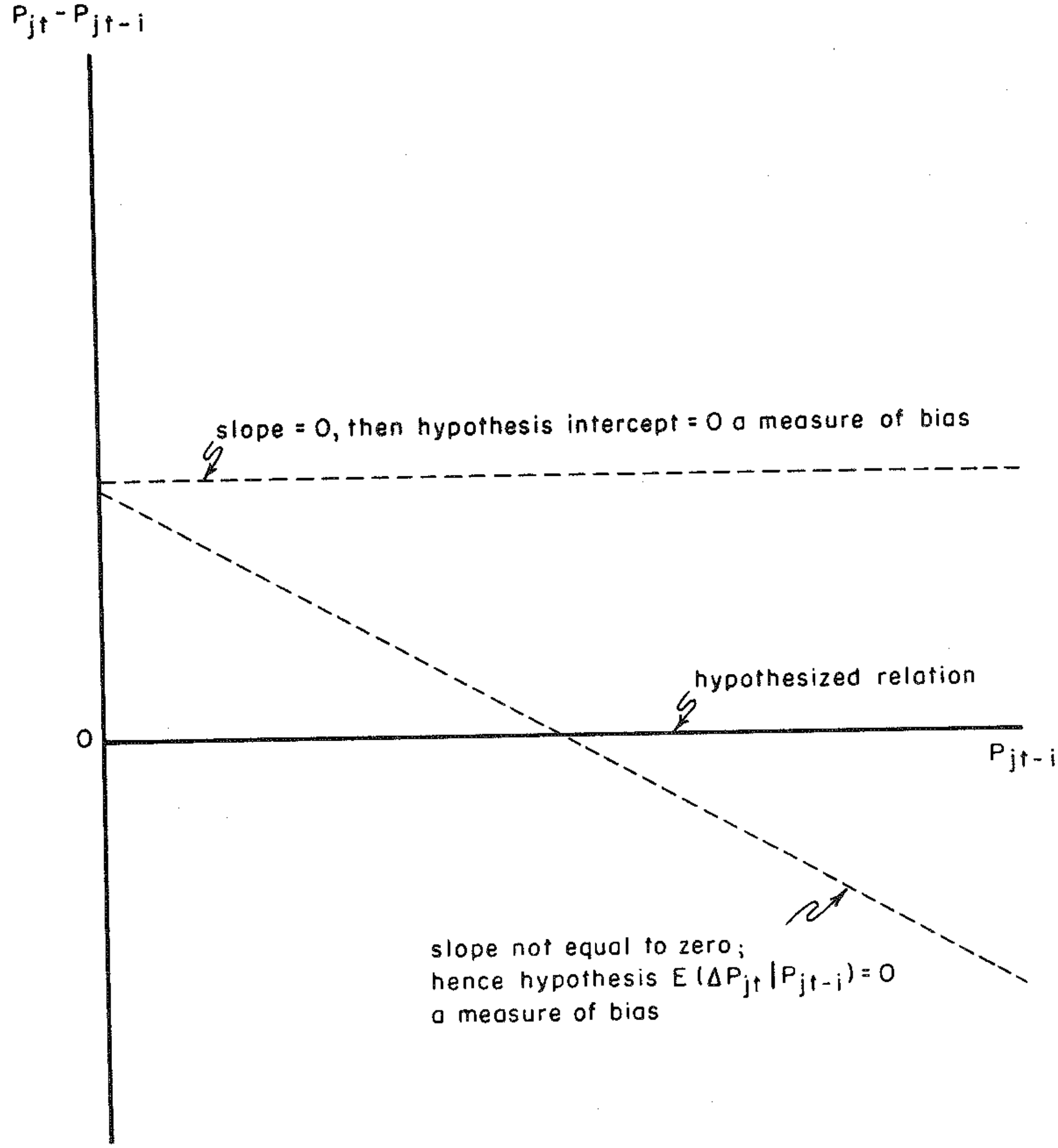
Putting the Results into Perspective

Our results suggest why past empirical measures of the efficient market hypothesis have been mixed. The efficient market theory holds only on average. This implies that a fair test of this conjecture requires many observations. Unfortunately, the relatively recent creation of the live cattle contract has precluded such a mature price series. Instead, past efficient-market studies have had to rely upon a short sample from a period with highly variable prices. Hence, the empirical results have been greatly influenced by a particular sample period's anomalies.

Given the inadequacies of a small sample, it is important to use the correct methodology when testing the efficient market hypothesis. A methodology that relies on pooled data multi-counts redundant and, perhaps aberrant, information and, hence, is more likely to reject the efficient market hypothesis. Also, the use of different hypothesis test procedures may account for some of the differences in conclusions among studies.

Table 20 was constructed to show whether or not the live cattle contracts forecasting performance have changed from the time of Leuthold's (1974) study. Leuthold hypothesized that the contract's forecasting performance would improve as volume of trading and liquidity in the live cattle

FIGURE 3. ALTERNATE HYPOTHESES ILLUSTRATED



market increased. The pooled regression results are placed next to selected results from Leuthold's study. Therefore, the only difference in methodology between the two studies is the sample period used. (Leuthold's sample covered a period of time from 1965 through 1971.)

The live cattle contract in the more recent sample is perhaps more efficient than it was in Leuthold's (1974) earlier sample. Although the t-ratios for the coefficients of the models estimated over the more recent sample period tend to be larger, the intercept coefficients are somewhat closer to zero as are the slope coefficients. The larger t-ratios may have been caused by the larger number of observations used in our pooled regressions.

The live cattle futures contract has, historically, had the tendency to systematically underestimate actual futures prices--especially for those discovered away from the nearby delivery months. Still, the pitfalls associated with using pooled data preclude one from drawing strong inferences from the evidence presented in Table 20.

Table 20. Comparing forward-pricing equations for pooled data, various time lags

Lag-- months prior to maturity	Leuthold[a/]		this study		
	intercept	slope	intercept	slope	$\bar{R}^2$ [b/]
2	1.69 (0.43)[c/]	0.04 (0.25)	5.11 (2.67)	-0.11 (2.81)	0.08
4	10.32 (2.10)	-0.35 (1.92)	7.91 (3.44)	-0.17 (3.47)	0.13
6	17.18 (2.98)	-0.59 (2.80)	8.54 (3.82)	-0.17 (3.68)	0.14
8	21.04 (3.25)	-0.74 (3.10)	10.26 (4.20)	-0.21 (3.96)	0.16

a/ Slopes computed by subtracting 1 from original estimates in Leuthold (1974), and t-ratio based on H_0: slope = zero.

b/ Adjusted for degrees of freedom.

c/ Numbers in parentheses are t-ratios.

A priori, one would think that the results derived from this study should be in closer agreement with those found in Martin and Garcia's (1981) paper. This is because (a) both studies used disaggregated data, and (b) both studies used data from a more similar time period. And, indeed, the results are similar.

This report's empirical findings and those of the aforementioned papers conclude that, during the period 1965-81, when lagged futures prices fell below their historical mean, delivery month futures prices were underestimated, and vice versa if they were greater than their mean. Indeed, if the results are viewed as descriptive statistics, this is the nature of the sample period. However, from a forecasting standpoint, the estimated forward-pricing models are poor predictors of future price changes.28/ One cannot reject the null hypothesis that the conditional mean of price changes is zero. In this sense, the market was a fair game. Or put differently, knowing the price level "today," one cannot make an accurate or profitable forecast of a price change.

IV. SUMMARY, LIMITATIONS, AND FUTURE RESEARCH

Summary

The purpose of this study was to describe the performance of the live cattle contract through an empirical analysis of basis behavior in the delivery month and price behavior over the life of the contract. Descriptive statistics and regression techniques were used in the evaluation of contract performance. The sample period used in this study represented prices discovered from 1969 through 1981.

The success of a futures contract can be gauged by its use for hedging. The evidence shows that large hedgers were quite active on the short side of the market during the late-1970s and early-1980s. However, long hedging was relatively small. This may be due to (a) institutional disincentives (e.g., direct marketing, formula pricing, etc.) faced by meatpackers and (b) a lack of hedging experience in the food retail industry. Nevertheless, large (short) hedgers appeared to have used the market because it is profitable for them to do so.

Unfortunately, few statistics exist on small hedger usage of the live cattle contract. Surveys (Leuthold 1975; Helmuth 1977) have found that few farmer-feeders use the contract. Helmuth (1981) conjectures that relatively few small feeders can lock in a profitable futures market hedge, but Hayenga et al. (1983) found that profitable hedging opportunities have existed.

28/ Martin and Garcia (1981) did suggest that the seasonal pattern of results implies some market bias associated with seasonality of cattle marketings and of volume of trading in cattle futures. Logically, however, little reason exists for a market to have varying degrees of efficiency related to a particular contract maturity, and unpublished results for other commodities in work by Kahl and Tomek suggest a similar pattern of "bias." Perhaps the events of the 1970 sample period imparted a similar pattern of errors to a variety of commodity prices. Until more data are available, we would be careful about reading too much into the seasonal pattern of coefficients.

The analysis of basis behavior at contract maturity does give insight into basis risk for potential hedgers. Five cash prices were used in the analysis: Interior Iowa; Sioux City, Iowa; Omaha, Nebraska; East St. Louis, Illinois; and Peoria, Illinois. Delivery-month bases were computed for these markets for six futures contracts over 13 years. The bases can be characterized as having different levels, but related changes. All were variable from year to year. But the East St. Louis bases were noticeably "different" from the rest; i.e., their level and variability were especially large.

A criterion developed for diagnosing a delivery month "squeeze" was based on identifying months where the futures price was "out of line" with most or all spot prices. After applying the criterion, 14 out of 78 contracts (18 percent) appeared to have had anomalous bases. These bases were unexpectedly narrow for 10 of these 14 contracts, while the balance were unexpectedly wide. Furthermore, the aberrant size seemed to be associated with large daily variability within the month.

It appears that the short hedger could have benefited from the narrowing of basis in 10 of the 14 contracts identified as having aberrant behavior. This is because the net return from the combined futures and spot transactions is greater than the amount anticipated from using a normal (average) basis. In contrast, long hedgers would have been harmed. Perhaps this explains, in part, why the market has been unable to attract more long hedging. It does appear though that farmer-feeders could have profitably used the contract if they were experienced in hedging.

The effects of one unusually wide basis, however, could force a farmer-feeder, but probably not the large feedlot operator, out of business. One unusual basis would affect a relatively small proportion of a large operator's income, but a relatively large proportion of a farmer-feeder's income. Thus, the potential for financial ruin from a hedge may discourage small producers, particularly those inexperienced in using futures, who might have been potential hedgers.

Could more market regulation be effective in curbing this sort of problem? Improvements in the contract may correct some potential squeeze incidents, but probably not all of them. Also, the evidence does not support manipulation in the final few days of trading as a major problem. In this sense, regulation is not the answer. Apparently the squeezes described above can be categorized as being "natural."

Overall, the empirical results show that problems existed with 14 of 78 live cattle contracts, but it would be an overstatement to say that this same ratio of contracts will experience problems in the future and will favor short hedging. The Chicago Mercantile Exchange appears to be sensitive to the possibility of improving contract provisions, as evidenced by past changes.

The success of a futures contract can also be gauged by its ability to facilitate spot price discovery, i.e., its ability to provide an efficient forward-pricing mechanism. Hence, this report has attempted to evaluate the forward-pricing performance of the live cattle contract. Using a statistical model to explain the forward-pricing efficiency of the live cattle contract, it was established that knowing the futures price level "today," the hypothesis that "tomorrow's" price change is zero cannot be rejected. This was true when "tomorrow" was defined in terms of lags from two to eight months. It is true, however, that the market made some large individual errors. Market prices six or more months before maturity have not been especially good guides to prices at maturity.

The analysis does provide insights into the use of futures prices in forward-pricing models. By definition, if the random variability is large relative to the systematic variability in the series, then the estimates of the systematic components can be widely different from one small sample to the next. This problem is not overcome by pooling prices from different contracts. A particular event is imparted to the entire constellation of prices, and pooling can exaggerate the effect of an aberration. In general, the pooled prices are not independent samples, but rather are highly related, thereby providing little additional information beyond that contained in a particular disaggregated series.

Empirical Limitations

A weakness of the study of basis behavior in the delivery month is the reliance on an empirical rule of thumb. But such a rule had to be used since neither theory nor available data permit a precise definition of abnormal behavior. The difficulty of measuring "normal" basis behavior is obviously compounded when measuring "abnormal" basis behavior. Thus, the conclusion that a "squeeze" occurred in 14 of the 78 months is based strictly on empirical analysis and not on a detailed analysis of the events surrounding each month.

Fortunately, the methodology used to describe price behavior over the life of the contract is based more heavily on logic. The model is suggested by the flow of information, and the methodological framework used in this study incorporates the use of the seemingly unrelated regression estimator and disaggregated data based on theoretical grounds. Yet, problems exist.

First, the SUR framework cannot be used for the entire 24 equation model. This is because there are too few observations. Hence, the system was divided into four equation subsystems, involving the four lag lengths for a contract. This approach does not take account of contemporaneous correlations across contracts. The only solution to this problem is to let time pass in order to have more observations.

Second, the small number of observations in the data set, by itself, makes it difficult to accurately estimate the forward-pricing equations. The data set contains influential observations that have a strong effect on the regression results, but it is difficult to justify discarding particular data points. That is, it is difficult to discriminate between avoidable and unavoidable forward-pricing errors.

The residual errors were relatively large as compared with the variance of the price changes. Thus, these markets were categorized as being efficient, but perhaps an econometric model, using publicly available information, could have explained these errors. If this were indeed the case, then the market is inefficient.

But in all fairness to the contract, one has no proof, given the empirical results, that avoidable errors have characterized pricing in the market. The existence of such errors cannot be detected without additional analysis.

Conclusions and Suggestions for Further Research

Our results suggest that the live cattle contract is partially fulfilling its hedging function, while it is fulfilling a forward-pricing function. Hedgers have faced substantial basis risk at contract maturity, but this apparently has not precluded the use of the market by short hedgers. And, although some large individual forward-pricing errors have occurred, the evidence indicates that the live cattle market has been efficient on average. The final verdict on market performance, however, will require additional research.

Of the 78 delivery months studied, 14 had unusually large or small bases relative to the norm (averages) for the five cash markets used in our study. These particular months also were characterized by variable daily bases compared with the "typical" maturity month. These empirical results are historical facts, but they do not explain the anomalous behavior. Perhaps an econometric model could be developed to explain basis variability. Ideally, such a model would contain variables that can account for the exceptional behavior and perhaps be used to forecast future instances of such behavior.

Alternatively, a case study approach might be used. It would be useful to know, for example, whether the months identified in this study as possible squeezes coincided with those identified by the industry or by the Commodity Futures Trading Commission as possible problem months. Depending on the availability of information, the case study approach may be more useful in identifying the sources of the observed behavior than an econometric model.

Clearly, if the basis at maturity is unexpectedly small or large or unusually variable, the value of the market for hedging is effected. Our research illustrates this point and also indicates that short hedgers, such as farmers, would often have benefited from unexpectedly small bases. But more research needs to be done on the effects of basis instability on hedging strategies. It would be useful to know if one particular hedging strategy was superior to others or whether any are better than none at all. Further analysis also is needed on how basis risk may influence cattle producers of varying sizes and whether a formal forecasting model, such as the one proposed above, could reduce basis risk. Such analyses are needed before one can certify which groups, if any, are disadvantaged when hedging in the live cattle market.

The cattle market appears to have been weak-form efficient; that is, given an initial price within the range of historical observations, no statistical basis exists for forecasting a price change from this price level. Studies that have found "significant" bias usually have pooled redundant observations, which is a questionable methodology. The correct approach to weak-form tests would involve the fitting of individual equations to disaggregated observations by a seemingly unrelated regression technique.

But there are typically too few degrees of freedom to fit a full SUR system. Moreover, results from small samples drawn from populations with highly variable prices are difficult to interpret. Thus, there are limits to the usefulness of weak-form analyses, and further exploration of semi-strong tests would be appropriate. Clearly markets--both futures and cash--make errors. These errors are often unavoidable, but if pricing errors have occurred that could have been avoided, this would be useful to know. Market performance can be improved by learning from past experiences.

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APPENDIX A

Trend Analysis of 30 Interyear Bases ($/cwt)

Market		Contract	Intercept	Slope	$\bar{R}^2$[a/]
Interior Iowa	(1)	Feb.	1.47 (2.46)[b/]	-0.09 (2.18)	0.22
Sioux City	(2)	Feb.	0.98 (0.12)	0.01 (0.15)	-0.08
Omaha	(3)	Feb.	0.97 (0.62)	-0.02 (0.40)	-0.07
East St. Louis	(4)	Feb.	0.51 (0.93)	0.07 (1.12)	0.02
Peoria	(5)	Feb.	-0.20 (1.54)	0.06 (1.63)	0.11
	(1)	Apr.	1.07 (0.20)	0.03 (0.57)	-0.05
	(2)	Apr.	0.74 (1.85)	0.08 (2.37)	0.26
	(3)	Apr.	0.36 (1.87)	0.15 (2.12)	0.21
	(4)	Apr.	0.39 (2.40)	0.20 (2.70)	0.33
	(5)	Apr.	-0.41 (3.32)	0.22 (3.54)	0.47
	(1)	June	0.67 (0.23)	0.02 (0.42)	-0.07
	(2)	June	0.15 (1.14)	0.08 (1.28)	0.05
	(3)	June	0.30 (0.99)	0.06 (1.16)	0.03
	(4)	June	0.49 (1.86)	0.17 (2.12)	0.22
	(5)	June	-0.24 (2.29)	0.16 (2.43)	0.29

(continued)

APPENDIX A (continued)

Market	Contract	Intercept	Slope	$\bar{R}^{2}$ a/
(1)	Aug.	1.05 (0.85)	-0.06 (0.73)	-0.04
(2)	Aug.	1.12 (0.57)	-0.08 (0.52)	-0.06
(3)	Aug.	0.59 (0.77)	-0.06 (0.74)	-0.04
(4)	Aug.	0.20 (2.07)	0.14 (2.31)	0.26
(5)	Aug.	-0.24 (1.16)	0.11 (1.22)	0.04
(1)	Oct.	0.95 (1.29)	-0.05 (1.11)	0.02
(2)	Oct.	0.46 (0.48)	0.03 (0.65)	-0.05
(3)	Oct.	0.32 (0.20)	0.02 (0.31)	-0.08
(4)	Oct.	-0.57 (2.55)	0.13 (2.61)	0.33
(5)	Oct.	-1.04 (2.31)	0.17 (2.30)	0.26
(1)	Dec.	1.83 (1.69)	-0.07 (1.32)	0.06
(2)	Dec.	1.34 (0.03)	0.02 (0.40)	-0.08
(3)	Dec.	1.42 (1.07)	-0.03 (0.71)	-0.40
(4)	Dec.	0.75 (1.71)	0.16 (1.98)	0.21
(5)	Dec.	0.24 (2.55)	0.14 (2.84)	0.37

a/ Adjusted for degrees of freedom.

b/ Numbers in parentheses represent t-ratios of attendant parameters assuming $H_0=0$.

APPENDIX B

Deliveries as a Percentage of Contract High Open Interest[a/]

Year	Futures Contracts					
	Feb.	Apr.	June	Aug.	Oct.	Dec.
	%					
1969	2.85	2.42	0.33	0.49	1.27	2.91
1970	0.88	1.15	0.78	4.09	2.59	3.70
1971	3.03	1.15	1.33	0.60	1.45	1.26
1972	0.14	0.79	1.20	0.29	0.16	6.94
1973	5.30	0.52	1.63	11.00	1.59	11.26
1974	5.68	3.48	3.59	5.70	1.98	3.88
1975	1.07	1.71	1.59	0.43	1.23	2.20
1976	0.47	4.43[b/]	10.10[b/]	3.79[b/]	1.74[b/]	1.45[b/]
1977	0.00	1.92	1.90	0.51	0.54	0.35
1978	0.01	0.75	1.12	1.38	0.29	5.53
1979	2.37	1.98	0.78	2.39	9.07	3.96
1980	0.85	1.96	1.09	1.30	1.54	4.82
1981	6.87	5.99	5.49	2.75	3.36	2.81

a/ Delivery and open interest statistics taken from the Chicago Mercantile Exchange *Yearbook*, various issues.

b/ Effective February 23, 1976, new contract definitions were introduced. Thus, trading occurred in both "old" and "new" contracts for the April through December 1976 maturities. Hence, a decision had to be made as to which open interest and delivery statistics would be used to compute the percentage in this cell. The denominator, open interest, of this percentage was calculated by taking the "new" contract's high open interest and add to it the "old" contract's open interest. The two open interest numbers came from the same trading day. Similarly, the numerator, deliveries, of this percentage was calculated by adding together the total number of deliveries on each contract.

APPENDIX C

Test Statistics for the General Null Hypothesis

In section III, the general null hypothesis of an efficient market is $\alpha_{ji} + \delta_{ji} P_{jt-i} = 0$. The conditioning variable, P, is set at 60 dollars per cwt, a value within the range of prices, but near the upper extreme. Test statistics are calculated for each general null hypothesis that uses OLS and SUR estimates from select equations. The statistics appear in Table C1.

A test criterion was established for hypothesis testing and assuming a two-tail alternative hypothesis. Two critical values, one for the null hypothesis that dealt with OLS estimated equations and the other with SUR estimated equations, were established prior to hypothesis testing.

The first critical value was based on an arbitrary level of significance of 0.30, a relatively large level of type I error. Thus, the critical "t-value" for the null hypothesis test is 1.09.

The second critical value is different from the one just described since a SUR equation is part of a system of equations. Johnston (1972, page 406) proposed a test statistic--Hotelling's T^2 statistic--that can be used as a critical value. The square root of this statistic gives a critical "t-value" of 3.27 for the 25 percent level of significance (a convenient level for this computation). This number is derived from the following formula, which cannot be found directly in published tables.

$$T^2 = F \left[\frac{(N-K)M}{N-K-M+1}\right]$$

where N = number of observations,

K = number of exogenous variables in the system,

M = number of equations, and

F = F-statistic for M and N-K-M+1 degrees of freedom at the alpha level of significance.

When comparing the test statistics in Table C1 to the critical values, it is obvious that the general null hypothesis cannot be rejected, and varying the level of the conditioning price levels within the range of the sample would not change this conclusion.

Table C1. Selected test statistics

Contract-Lag	Standard deviation (S)	Test statistic[a/]
	$\sqrt{Var(\hat{\alpha})+P^2_{jt-i}Var(\hat{\delta})+2P_{jt-i}Cov(\hat{\alpha}\hat{\delta})}$	$\frac{\hat{\alpha} + \hat{\delta} P_{jt-i}}{S}$
(a) OLS results		
Apr.-8	$\sqrt{(61.60)+(60)^2(0.029)+(2)(60)(-1.265)}$	$\frac{15.24-0.314(60)}{3.734} = 0.967$
June-8	$\sqrt{(49.57)+(60)^2(0.022)+(2)(60)(-0.996)}$	$\frac{14.64-0.263(60)}{3.206} = 0.358$
Oct.-2	$\sqrt{(45.78)+(60)^2(0.020)+(2)(60)(-0.923)}$	$\frac{2.480-0.057(60)}{2.802} = 0.292$
(b) SUR results		
Apr.-8	$\sqrt{(34.41)+(60)^2(0.015)+(2)(60)(-0.643)}$	$\frac{24.79-0.533(60)}{3.199} = 2.240$
June-8	$\sqrt{(30.04)+(60)^2(0.013)+(2)(60)(-0.559)}$	$\frac{27.04-0.541(60)}{2.826} = 1.909$
Oct.-2	$\sqrt{(34.69)+(60)^2(0.015)+(2)(60)(-0.680)}$	$\frac{14.98-0.328(60)}{2.598} = 1.818$

a/ Equality may not hold exactly because of rounding error; computations carried out to six places, but rounded to three.