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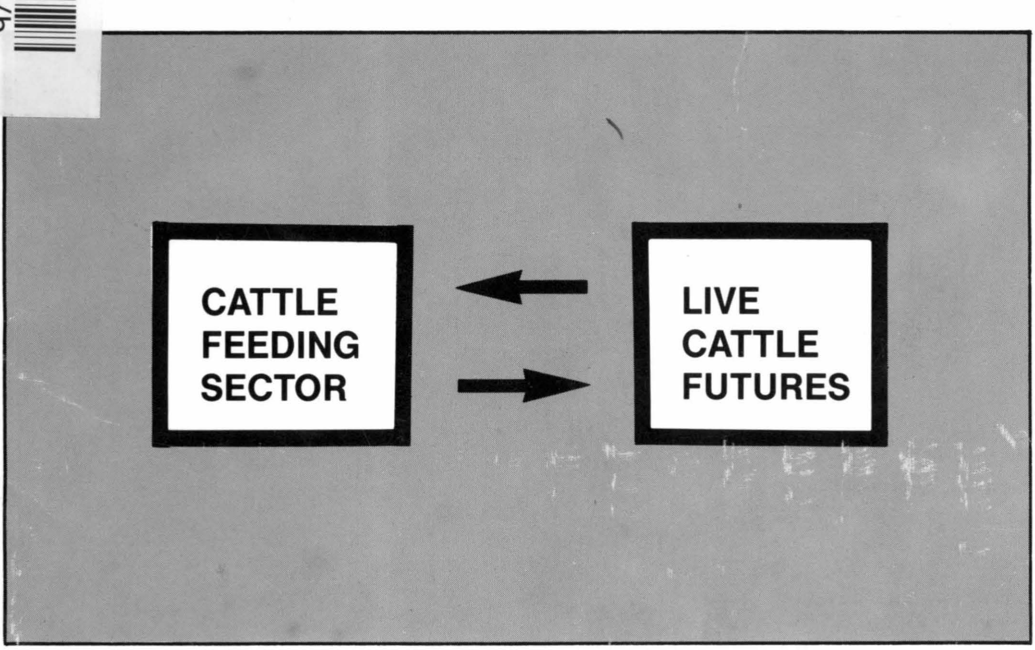

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The Virginia Agricultural and Mechanical College came into being in 1872 upon acceptance by the Commonwealth of the provisions of the Morrill Act of 1862 "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." Research and investigations were first authorized at Virginia's land-grant college when the Virginia Agricultural Experiment Station was established by the Virginia General Assembly in 1886.

The Virginia Agricultural Experiment Station received its first allotment upon passage of the Hatch Act by the United States Congress in 1887. Other related Acts followed, and all were consolidated in 1955 under the Amended Hatch Act which states "It shall be the object and duty of the State agricultural experiment stations . . . to conduct original and other researches, investigations and experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States, including the researches basic to the problems of agriculture and its broadest aspects and such investigations as have for their purpose the development and improvement of the rural home and rural life and the maximum contributions by agriculture to the welfare of the consumer . . . "

In 1962, Congress passed the McIntire-Stennis Cooperative Forestry Research Act to encourage and assist the states in carrying on a program of forestry research, including reforestation, land management, watershed management, rangeland management, wildlife habitat improvement, outdoor recreation, harvesting and marketing of forest products, and "such other studies as may be necessary to obtain the fullest and most effective use of forest resources."

In 1966, the Virginia General Assembly "established within the Virginia Polytechnic Institute a division to be known as the Research Division . . . which shall encompass the now existing Virginia Agricultural Experiment Station . . . "

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Stephen R. Koontz and Wayne D. Purcell

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The Current Situation

The live-cattle futures market has attracted interest and attention since the initiation of trade in 1964. Much of this attention has centered on the question of how the existence of a live-cattle futures market influences the performance of cash cattle markets.

Cattle feeders are exposed to substantial amounts of price risk. Up to six months are needed to produce a finished animal from a feeder steer. Prices eventually received for fed cattle can differ significantly from the anticipated cash price at the time the feeder cattle were placed on feed. What looked like a profitable program can be turned to significant losses if cash cattle prices are highly variable.

Does futures trading in live-cattle have stabilizing or destabilizing effects on the cash fed-cattle markets? The mid-1960's saw the beginning of trade in live-cattle and live hog futures. Also during this time period, U.S. agriculture underwent a degree of structural change, and prices for agricultural products have become more variable. The casual empiricist, unaware of the extent of the structural changes, may be inclined to deduce that futures trading has caused the increased variability. Producer attitudes appear to reflect this deduction, as evidenced in the following statement made by Peter Stubben at a research symposium discussing trade in livestock futures:

> Recently, I was in Sioux City, Iowa, with a group of about 75 cattle feeders. I asked how many of them felt that the cattle market in the 70s was more volatile than the cattle market in the 60s. Everyone put up their hands. I asked them how many of them felt that this additional volatility in the cattle market in the 70s was caused by the futures market. Everyone put up their hands. (quoted by Leuthold and Dixon, 1980, p 161.)

A second concern with respect to futures trading has been voiced by analysts who questions the legitimacy of the live-cattle futures market as a viable market. Bressler and King (1978) state that:

> The direct and fundamental goals for the market system are (1) to provide efficient and economical services and ownership transfers in the movement of commodities from producer to consumer, and (2) to provide an effective and efficient price making mechanism. Only insofar as the prices that are established through the marketing system transmit the demands of consumers back to producers and transmit the supply conditions forward to consumers with a minimum of lags,

imperfections, and distortions, can the economy achieve the efficient allocation and the economic use of resources in satisfying wants. (p vii.)

Trade in live-cattle futures establishes prices of contracts for the delivery of fed cattle for some time in the future. Prices formed in this market must accurately reflect current knowledge of future supply and demand conditions in order to meet the performance levels articulated by Bressler and King. Observers such as Helmuth (1981) and Walton (1983) (see Gilles (1983)), both critical of live-cattle futures markets, clearly do not feel the markets meet acceptable standards of performance and efficiency.

The Problem

Conceptually, if the live-cattle futures market efficiently gathers and incorporates emerging information on future economic conditions into the price discovery process for distant contracts, and if producers use these market-generated price expectations, then the existence of a futures market should act to stabilize placements of cattle on feed. Stable flows of animals into feedlots should result in more stable flows of fed cattle to slaughter channels and thereby reduce short run variability in cash slaughter-cattle prices. Such a result would help to protect the cattle industry from problems associated with variable supplies and variable cash prices. There appears to be a gap between what economic theory suggests and what is generally accepted by the public. Too little is known about the actual relationships between trade in live-cattle futures and the cash cattle markets.

Hypotheses

The three specific and interrelated hypotheses tested in this research are:

1. Variations in prices of distant live-cattle futures contracts, maturing near the completion of the current feeding period, should be important in explaining short-run changes in the number of cattle placed on feed.
2. Conversely, variations in the number of cattle placed on feed should be significant in explaining the variability in prices for the distant live-cattle futures contracts.
3. This recursive system created by the simultaneous response by cattle feeders to changes in live-cattle futures prices and by live-cattle futures prices to changes in anticipated supplies of fed cattle is stable.

The first two hypotheses are tested independently of one another. The information flows hypothesized in the two statements jointly make up a recursive economic system. The third hypothesis involves examining the feedback relationship inherent within the system. Acceptance of all three hypotheses would suggest that the live-cattle futures market and the cattle feeding sector interact in such a manner as to stabilize the placements of cattle on feed and thereby stabilize cash slaughter cattle prices.

Objectives

The specific objectives of this research were to:

1. Measure the response by cattle feeders to changing values of distant live-cattle futures contracts in the making of short-run placement decisions.
2. Examine the speed with which the emerging set of information on future supply conditions is incorporated into the live-cattle futures market and reflected in prices of distant futures contracts.
3. Examine the recursive interaction between the cattle feeding sector and the live-cattle futures market so that conclusions can be drawn with respect to the behavior of this system.
4. Establish a base for inference with regard to the impacts of live-cattle futures on short-run price variations in the cash slaughter cattle markets.

Review of the Literature

Theoretical writings suggest that the existence of futures markets for commodities is beneficial to society as a whole and to individual producers, processors, and handlers of these goods. Kaldor, Dow, and Hawtrey (1939), Working (1962 and 1970), and Telser (1979) provide excellent discussions of the conceptual benefits of futures trading. These authors argue that, conceptually, trade in futures improves market information, aids in the price discovery process, provides a risk transfer mechanism, and facilitates responses to anticipated market conditions.

Research has been conducted testing pure mathematical models which support these ideas. Grossman (1977) suggests that futures markets are beneficial in that they spread information from informed to uninformed firms, thus improving the intertemporal allocation of resources. Danthine (1978) proves that futures prices contain a complete summary of market information and, if futures markets perform a forward-pricing role, this informative view of futures implies that these markets have stabilizing influences on cash prices. Peck (1976) shows that if producers use futures prices in formulating production decisions for a particular commodity, then cash prices will be more stable with futures trading than without trading, at least in the long-run.

Empirical efforts appear to present results that are relatively mixed. Gray (1963) states that an organized futures market widens the opportunity to buy a commodity during the harvest surplus and sell it for later delivery. A decrease in the seasonal price range is therefore expected, on a priori grounds, in the presence of futures trading. This reduction is verified with historical price data for onions. Gray (1972) shows that potato futures perform well as forward pricing mechanisms because rational price formation takes place. Rational price formation means that during periods when production decisions are made, the appropriately distant futures contract price reflects costs of production rather than a price which might elicit a self-defeating supply response. Kofi (1973) also demonstrates that futures markets perform their forward pricing function well for a wide variety of commodities. The predictive reliability of a futures market improves as more accurate information on supply and demand becomes available. In this context, price formation in these markets reflects expert appraisal of changing economic information.

Taylor and Leuthold (1974) show that the variability of cash cattle prices actually fell, using annual, monthly, and weekly measures of variability, from the period 1957 through 1964 to the period of 1965 through 1972 after the advent of futures trade in 1965. The work of Powers (1970) and Cox (1976) further suggests that variation in cash livestock prices was reduced with the introduction of futures trading. Tomek (1979) reproduced the work of Powers and Cox with lengthened data sets and employed several additional statistical methods. His findings are contrary to those of Powers and Cox in general, but the research further suggests that results are sensitive to the data periods used and to the criterion used by the researcher to define when futures begin to have an influence on cash prices.

Leuthold (1974) examined the forecasting ability of live-cattle futures and found that these futures estimate subsequent cash cattle prices as efficiently as corn futures estimate subsequent cash corn prices. Leuthold stated that, with respect to distant futures, current cash prices were a more accurate indicator of future cash-price conditions than was the futures price. Leuthold concluded that the live-cattle futures market could be destabilizing to cash markets and could be allocating resources inefficiently.

Leuthold and Hartman (1979) performed a semi-strong form test of efficiency on the live-hog futures market. This test examines whether or not the prices in a market reflect publicly available information. An econometric forecasting model was constructed to serve as a norm against which to test the forward pricing abilities of the futures market. The authors suggest the live hog futures market is inefficient because the futures market fails to accurately and consistently reflect subsequent cash prices or available information on future supplies of hogs. Martin and Garcia (1981) make similar statements with regard to the live-cattle futures market. Cattle futures appear to add little forecasting information beyond that available in lagged cash prices. The performance of cattle futures as a rational price-formation agency is therefore suspect. Just and Rausser (1981) compare forecasts between futures prices and several available econometric forecasts. Livestock futures forecast better than econometric models in a single-month forecast horizon, but the accuracy of the econometric models improves immediately relative to futures prices if the forecast horizon is extended beyond a single month.

Koppenhaver (1983) suggests that risk premiums exist in the live-cattle futures market, as evidenced by a persistent downward bias. Koppenhaver also rejects weak-form hypotheses of efficiency. Kolb and Gay (1983) examined the performance of the live-cattle futures market using different tests and a data set which encompassed a shorter time period as compared to Koppenhaver's. These authors found no evidence of significant bias. They found no reason to conclude that live-cattle futures prices fail in any regard in performing the function of price discovery. Kolb and Gray conclude performance of the live-cattle futures market "appears to be exemplary."

Black (1976) asserts that price discovery may be the most important social role of futures markets. Price discovery is the process by which market participants interpret and incorporate information while seeking a price which will balance forces of supply and demand. Research by Purcell, Flood, and Plaxico (1979), Miller and Kenyon (1979), and Weaver and Banerjee (1982), all support an hypothesis that the futures markets for livestock commodities contribute toward more efficient price discovery processes. Hudson and Purcell (1984) further argued that, in the day-to-day process of price discovery, the market which is more efficient in receiving and registering information will discover the market clearing price before other markets for the same or a related commodity. There was strong evidence that the cash cattle markets, the futures market, and the carcass beef market all react with relative efficiency to changes in pertinent information.

Theoretical Cash-Futures Relationships

Conceptually, the live-cattle futures market gather and incorporate emerging information on future economic conditions. Cattle feeders must develop an expectation of future cash prices. Cattle feeders could use price forecasts from various organizations that provide outlook. They could develop expectations from past experience. A reasonable place to obtain price expectations would be from prices of live-cattle futures contracts that mature close to the time when cattle would be ready for slaughter. Futures prices for a particular contract represent a market consensus of what the cash prices are expected to be when the contract matures. Unlike all other sources of information, this market also gives the producer an ability to "lock-in" a price by hedging when production decisions are made.

Distant live-cattle futures, if used in formulating price expectations, can influence the number of cattle moving into the feedlot complex. Consider the scenario in which the number of cattle on feed is increasing and, if heavy rates of placement continue, threaten to generate large losses for cattle feeders via depressed cash prices in future months. If this emerging set of information is efficiently incorporated into the futures market, prices for distant live-cattle futures will decline. If cattle feeders do in fact use distant futures in developing price expectations, the resulting dampened expectations should curtail placements.

Conversely, when the number of cattle on feed is relatively small because of high feed costs, high interest rates, or losses on cattle recently finished, the market forces should run in the opposite direction. If this emerging information is incorporated quickly and accurately, distant live-cattle futures should rally to higher levels, providing incentive to place cattle, and head off the impending shortage in future months.

Models of the demand function for feeder cattle demonstrate the role of live-cattle futures in decision processes at the feedlot level. In general form, the quantity demanded of feeder cattle can be specified as:

Quantity Feeder Cattle =
f(Expected Output Prices,
Current Output Prices,
Current Input Prices,
Technical Factors of Production).

We expand on this general formulation as we seek to measure the relationship between placements and the distant futures as a price expectation.

Analytical and Modeling Issues:

Cattle Feeders Response

To empirically implement the general model, data are gathered on the appropriate series, and the model is specified in first differences. Intuitively, regression results from non-differenced data can be thought of as describing how the mean level of the dependent variable is influenced by changes in the independent variables around their respective means. Regression estimates produced using differenced data can be thought of as describing how changes in the dependent variable from period-to-period are influenced by changes in the independent variables from period-to-period. The use of differenced data possesses one potential hazard, a serially correlated error. Error terms must be examined and correction procedures taken if the error terms are not random.

The use of differenced data to model short-run behavior and response patterns is a conceptually sound approach. Any analytical technique used to expose short-run behavior is further improved by using a data set in which information is reported frequently. The data most commonly used in empirical studies of the cattle feeding industry are gathered and reported by the USDA United States Department of Agriculture (USDA). Cattle-on-feed reports for the seven major feeding states are released monthly. It is doubtful that an analysis of month-to-month changes in placements will correctly capture short-run behavior because cattle feeders may alter production several times per month in response to changes in economic information.

The Cattle Fax organization releases a weekly newsletter which provides numerous pieces of information on the production decisions and the prices paid and received for animals by member feedlots. All models built to examine the interaction between the cattle-feeding sector and the live-cattle futures market make use of data reported by Cattle Fax between January, 1979, and December, 1983. Estimation of the demand function for feeder cattle using differenced weekly data reveals which factors influence the week-to-week changes in numbers of animals placed on feed by feedlot operators who are members of Cattle Fax.

The cattle feeders who belong to Cattle Fax can be described as professional, year-round cattle feeders who operate relatively large feedlots. Some percentage of this group will have hedging programs to manage risk, and it is expected that all of these feeders will pay close attention, and react as quickly as possible, to changes in information on future economic conditions.

Analytical and Modeling Issues:

Futures Market Response

Analyzing the futures market response to changes in cattle placements involves examining whether the live-cattle futures market is efficient in gathering and incorporating new information into the price discovery process. The foundation on which most market efficiency studies have been based was formally constructed in an article by Fama (1970). Although Fama analyzed markets for securities and financial instruments, the logic developed applies to futures markets. Fama states that, "A market in which prices always 'fully reflect' available information is called 'efficient'" (p.383). An efficient market is thus one in which information is fully incorporated and utilized as soon as it becomes available.

Fama described and developed tests to examine the adjustment of prices in response to changes in three relevant information sets. Weak form tests examine whether the current price reflects information contained in the set of historical prices. Semi-strong form tests consider whether prices adjust efficiently to new information that is "obviously publicly available" (p.383). Strong form tests are concerned with whether given individuals or groups have monopolistic access to information relevant to price formation.

Prior to Fama, Working (1958) hypothesized that market participants' behavior should cause futures price changes to be nearly random. The actions of traders seeking to evaluate a nearly continuous flow of information would create conditions of nearly continuous price change, changes that would be random since the occurrence of new information is itself random. Working's description of market participant's behavior allows for some "gradualness of price changes, which must occur if a few traders acquire information ahead of the rest or if a few traders perceive the price significance in information before others see that it has such significance" (p.33). Samuelson (1965) formally develops this model and proves that, in a perfect market, futures prices will fluctuate randomly.

Empirical work on the efficiency of futures markets has concentrated in the area of performing weak form tests of efficiency. It has been generally hypothesized that serial correlation between successive price changes indicates that a particular market is slow to incorporate information, and is thus inefficient. Larson (1960) examined serial dependence in price changes of corn futures and found evidence of both positive and negative dependence. Schmit (1965) makes use of trading rule techniques, and Stevenson and Bear (1970) make use of statistical tests and trading rules. Both studies find some evidence of serial dependence, but results vary with the commodity and the time period under analysis. Cargill and Rausser (1975) reject the hypothesis that commodity futures prices follow a random walk, but do not specifically support the conclusion that the markets are inefficient.

The approach in this research will use the following suggestion made by Dewbre (1981). Dewbre suggests that the appropriate test of market performance is whether the price changes that occur in the futures markets are in response to changes in economic information consistent with economic theory. Following this suggestion, the most logical test of market efficiency would be to examine the strength and speed with which information on changes in numbers of cattle placed on feed influence changes in distant live-cattle futures prices.

The price discovery process in the live-cattle futures market involves the gathering and incorporating of information on future supply and demand conditions. Many factors are likely to influence live-cattle futures prices, but the information of substantial importance to contracts which will expire in five-to-six months should be cattle feeders' placement decisions. If the live-cattle futures market is to serve an economic purpose, it must accurately reflect the changing supply conditions. By modeling distant futures prices as a function of cattle placements, tests for a direct relationship between the two series can be conducted, and if the relationship does exist, the time lags associated with the movement of information can be examined. This procedure would be classified as a semi-strong form test of market efficiency.

In this research, placement decisions in the "cattle feeding sector" are represented by data on placement decisions in the Cattle Fax member feedlots. The Cattle Fax placement series is a subset (about one-third) of all placements of cattle on feed in the United States. Examination of the Cattle Fax placement series relative to the USDA's 7-state cattle onfeed report suggests that the Cattle Fax series is representative of the broader 7-state series. Variations in the Cattle Fax series should, therefore, "capture" any relationship between placements and the distant live-cattle futures.

Analytical and Modeling Issues:

Market Interrelationships

The test adopted for examining the direction and magnitude of relationships between placements and futures prices is based on Granger's development of "causal" flows, and was suggested by Geweke (1982). The general specification is as follows:

$$Y(t) = \alpha + \sum_{j=1}^{p} \gamma_j \; Y(t-j) + \sum_{i=0}^{q} \phi_i \; X(t-i) + \varepsilon(t)$$

where:

Y(t) = futures price series in time (t);

X(t-i) = placement series in time (t-i);

α = intercept term;

γ_j = coefficients attached to lagged futures-price variables where j=1,2,...,p;

ϕ_i = coefficients attached to placement variables, where i=0,1,...,q, and;

$\varepsilon(t)$ = random error term.

Examining the influence of placements on futures prices involves testing the hypotheses that various groups of coefficients attached to the placement variables are zero. If the hypothesis that the coefficients equal zero can be rejected, the model suggests that information contained in the placement series does in fact explain movements in futures prices. To satisfy the efficient market criterion discussed earlier, it is necessary for the futures market to gather and incorporate information quickly and efficiently. Thus, it is necessary for coefficients attached to the placement variables to be significantly different from zero at zero or small time lags. Several tests can be performed on these lead/lag models to reveal the time-related dimensions between the futures price variables and the placement variables. The speeds associated with these information flows are the basis for the efficiency tests. For more detailed discussions of these procedures, see Koontz (1985) or Hudson (1984).

Analytical and Modeling Issues:

Stability Measures

The input demand function model to explain placements and the lead/lag model to measure the futures-market response to changes in placements are essentially mathematical representations of an economic system. A single shock to the cattle-feeding sector, causing changes in placements, will result in changes in futures prices, which will in turn influence placement decisions, which will again influence futures price behavior, and so on. The process could also be initiated by a shock to the futures market. The stability of the system depends on the nature of this recursive behavior. If a shock to this system dampens and becomes negligible over time, the system is stable. New information which causes changes in the live-cattle futures price, or random shocks to the feeding sector, is transmitted between these two economic entities in such a manner that new equilibrium levels of live-cattle futures prices and placements are reached. On the other hand, if a shock to the system becomes more pronounced as time passes, then the system is explosive.

If the system constructed in this research exhibits characteristics of stability, then all points of our hypotheses will have been confirmed. It will have been shown that cattle feeders respond to changes in live-cattle futures prices, and that futures prices respond to changes in placements of cattle on feed, and that the system itself is stable.

Analytical and Modeling Issues:

Disaggregate Analyses

The data set upon which the overall analyses were conducted was disaggregated into two subsets. The first contains positive observations of the first differenced placement series, and the second contains negative observations of the placement series. The reason for the use of disaggregate data was that it allowed explicit examination of the economic forces motivating cattle feeders to increase or decrease placement activity. From these two data sets, the relationships between placements of cattle and the behavior of live cattle futures were investigated in more detail.

Model Specification and Estimation

The model explaining changes in placements was specified in linear form such that the differenced placement series was a function of categories of independent variables including (1) expected output price, (2) current output price, (3) current input prices, and (4) technical production factors. For the variables in the first three categories, a possible lag structure from zero to three weeks was considered. Values from some of the independent variables, such as distant futures prices, are recorded on the Monday of each week, and these values are aligned with the number of cattle placed across the entire week. It is possible that cattle feeders who have convenient access to feeder animals could respond to changing signals within the week of the change; thus the rationale for the zero time lag. Using a lag structure from zero to three weeks allows cattle feeders approximately one month to complete a response to the economic signals.

A shorter lag structure of zero and one week was considered for the shipment variable. The logic for this structure is that changes in economic variables which are determined in a marketplace (e.g. variables in the first three categories) cannot be well anticipated by the feedlot management. Operators must react to changes, and the reactions take time. On the other hand, marketings of slaughter cattle can be projected by the management with a relatively high degree of certainty.

The initial specification of the model is presented below:

$$PLACE(t) = B_0 + \sum_{i=0}^{3} B_{1i}\ CLOSE(t-i) + \sum_{i=0}^{3} B_{2i}\ EXMARGIN(t-i)$$

$$+ \sum_{i=0}^{3} B_{3i}\ STEER(t-i) + \sum_{i=0}^{3} B_{4i}\ CRMARGIN(t-i)$$

$$+ \sum_{i=0}^{3} B_{5i}\ FEEDER(t-i) + \sum_{i=0}^{3} B_{6i}\ CORN(t-i)$$

$$+ \sum_{i=0}^{3} B_{7i}\ INTEREST(t-i) + \sum_{i=0}^{1} B_{8i}\ SHIP(t-i)$$

$$+ \sum_{i=2}^{14} D(i) + \varepsilon(t)$$

where:

PLACE (t) = Differenced Placements in time (t),

CLOSE (t-i) = Differenced Futures Price in time (t-i),

EXMARGIN (t-i) = Differenced Expected Margin in time (t-i),

STEER (t-i) = Differenced Slaughter Steer Price in time (t-i),

CRMARGIN (t-i) = Differenced Current Margin in time (t-i),

FEEDER (t-i) = Differenced Feeder Price in time (t-i),

CORN (t-i) = Differenced Corn Price in time (t-i),

INTEREST (t-i) = Differenced Slope Shifting T-Bond Yield in time (t-i),

SHIP (t-i) = Differenced Shipments in time (t-i),

$D(i)$ = Monthly and Bi-Monthly Dummy Variables, and

$\varepsilon(t)$ = Random Error Term.

The following iterative procedure is then used to estimate a final model from the above specification:

1. The function is estimated via ordinary least squares (OLS) to start the process.
2. Serial correlation and collinearity diagnostics are examined. If serial correlation is present then the function is reestimated, using a two-step full transformation method described by Harvey (1981), and Judge et al. (1980).
3. All coefficients are examined to see if they have the hypothesized sign. Variables with incorrect signs are deleted from the model, and step (2) is repeated. No more than two variables are deleted during any one iteration so that behavior of the coefficients, in terms of magnitude and sign, can be examined.
4. All variables are examined for significant differences from zero using a 0.15 significance level as a cut-off value, given the use of differenced data. Insignificant variables are deleted, and the procedure returns to step (2). The exception to this rule pertains to the seasonal variables. If one of the seasonal variables is significant, then all are kept.

The information flows from the feeding sector to the live-cattle futures market will be examined with the following model:

$$CLOSEL2(t) = \alpha + \sum_{j=1}^{p} \gamma_j \; CLOSEL2(t-j) + \sum_{i=0}^{q} \phi_i \; PLACE(t-i) + \varepsilon(t)$$

where:

CLOSEL2 (t) = Futures Price in time (t-2) minus the Futures Price in time (t);

PLACE (t) = Differenced Placement Series in time (t);

α = intercept term;

γ_j = coefficients attached to lagged values of CLOSEL2 where j=1,2,...,p;

ϕ_i = coefficients attached to the PLACE variables, where i=0,1,...,q, and;

$\varepsilon(t)$ = random error term.

In the causal model it is necessary to choose adequate lag lengths for the regressor variables. The lag lengths of the dependent variable must be long enough to remove serial correlation from the error term, and the lengths of the placement variable must be adequate to expose the information flows from the cattle-feeding sector to the live-cattle futures market. The choice can be based on theoretical arguments or mechanical techniques. The method to be used here is an analytical technique suggested by Hsiao (1979) which makes use of Akaike's final prediction error (FPE) criterion.

Hsiao suggests the following three-step procedure for a bivariate process:

1. Minimize the FPE on a pure autoregressive process initially, i.e. select the lag length (p) of the lagged dependent variable without incorporating the second independent variable.
2. Minimize the FPE of a function incorporating the second set of variables into the model while simultaneously using the autoregressive lag length found in step (1); i.e., select lag length (q) using (p).
3. Reselect the autoregressive lag length incorporating the lag length of the independent variable found in step (2); i.e., reestimate (p) using (q) from step (2).

This three-step procedure will not guarantee that the error term will exhibit no serial correlation when the lag length estimates for the dependent and independent variables are incorporated into the lead/lag model. But the procedure is preferred to a random search method because it is less expensive computationally and it is based on a prediction criterion. If serial correlation remains after this procedure, additional lagged values of the dependent variable will need to be added to the model.

In this research, the minimum lag length of the second set of variables, the placement series, was set at one week. The two placement variables, contemporaneous and lagged one period, will provide the analysis with the minimum amount of information needed to examine whether causal flows from the cattle-feeding sector to the live-cattle futures market occur instantaneously or with a lag in time.

The actual estimation can only be carried out after two final problems with this specification are recognized and corrective procedures considered. The two models have a statistical problem. The differenced placement series and the futures price series are dependent variable and independent variable in the first model and independent variable and a portion of the dependent variable in the second model. These two specific variables are defined as endogenous to the system while all other variables are exogenous to the system. It is well known that the estimation of these two models individually via Ordinary Least Squares (OLS) will result in biased and inconsistent estimators (Johnston, 1984). However, the use of Two Stage Least Squares (2SLS) will correct for this problem. A second possible problem emerges in the form of cross-equation correlation of error terms. Cross-equation correlation may result in inefficient estimators. Three Stage Least Squares (3SLS) will correct this problem and will be incorporated into the procedure if the estimates of cross equation correlation are greater than five percent in absolute value.

Procedures to examine for stability were developed by Theil and Boot (1962). The placements model and the lead/lag model showing relationships between placements and the futures prices can be represented in algebraic form as:

$$PLACE(t) = B_{10} \; CLOSE(t) + \ldots + B_{13} \; CLOSE(t-3)$$

$$CLOSEL2(t) = \phi_0 \; PLACE(t) + \ldots + \phi_q \; PLACE(t-q)$$

$$+ \gamma_1 \; CLOSEL2(t-1) + \ldots + \gamma_p \; CLOSEL2(t-p)$$

It is important to note that the intercept terms and the exogenous variables are unimportant in the analysis of stability -- only the interactions between endogenous variables are considered. Also, it is possible for any of the independent variables to be absent from the estimated model. The coefficients of these variables would be equal to zero.

The futures price variables of the second equation above can be expanded into their basic components using the identity:

$$CLOSEL2(t) = CLOSE(t) + CLOSE(t-1)$$

The two equations can be rewritten as:

$$PLACE(t) = B_{10} \; CLOSE(t) + \ldots + B_{13} \; CLOSE(t-3), \quad \text{and}$$

$$CLOSE(t) = \phi_0 \; PLACE(t) + \ldots + \phi_q \; PLACE(t-q)$$

$$+ \psi_1 \; CLOSE(t-1) + \ldots + \psi_{p+1} \; CLOSE(t-p-1).$$

All endogenous variables in both equations are then moved to the left hand side of the equal sign.

$$PLACE(t) - B_{10} \; CLOSE(t) = B_{11} \; CLOSE(t-1) + \ldots + B_{13} \; CLOSE(t-3)$$

$$-\phi_0 \; PLACE(t) + CLOSE(t) = \phi_1 \; PLACE(t-1) + \ldots + \phi_q \; PLACE(t-q)$$

$$+ \psi_1 \; CLOSE(t-1) + \ldots + \psi_{p+1} \; CLOSE(t-p-1).$$

Using the following column vectors and matrices:

$$y(t) = \begin{bmatrix} PLACE(t) \\ CLOSE(t) \end{bmatrix} \qquad y(t-s) = \begin{bmatrix} PLACE(t-s) \\ CLOSE(t-s) \end{bmatrix}$$

$$\Pi = \begin{bmatrix} 1 & -B_{10} \\ -\phi_0 & 1 \end{bmatrix} \qquad \Gamma(s) = \begin{bmatrix} 0 & B_{1s} \\ \psi_s & \phi_s \end{bmatrix}$$

where s = 1,2,..., max $\{3, q, (p+1)\}$,

The two equations can simplified to a single equation:

$$\Pi \; y(t) = \Gamma_1 \; y(t-1) + \ldots + \Gamma_s \; y(t-s), \text{ or}$$

$$y(t) = \Pi^{-1}\Gamma_1 \; y(t-1) + \ldots + \Pi^{-1}\Gamma_s y(t-s).$$

This equation represents the analytically derived, reduced-form equation of the system. Using the following identify, $A(s) = \Pi^{-1}\Gamma_s fori = 1, \ldots, s$, the reduced form equation can be simplified to:

$$y(t) = A(1)\, y(t\text{-}1) + \ldots + A(s)\, y(t\text{-}s).$$

The system in this equation can be written in condensed form as:

$$Y(t) = A^{*}\, Y(t\text{-}1)$$

where:

$$Y(t) = \begin{bmatrix} y(t) \\ y(t-1) \\ \cdot \\ \cdot \\ \cdot \\ y(t-s+1) \end{bmatrix} \qquad Y(t-1) = \begin{bmatrix} y(t-1) \\ y(t-2) \\ \cdot \\ \cdot \\ \cdot \\ y(t-s) \end{bmatrix}$$

$$A^{*} = \begin{bmatrix} A(1) & A(2) & A(3) & \cdots & A(s-1) & A(s) \\ I & 0 & 0 & \cdots & 0 & 0 \\ 0 & I & 0 & \cdots & 0 & 0 \\ 0 & 0 & I & \cdots & 0 & 0 \\ \cdot & \cdot & \cdot & & \cdot & \cdot \\ \cdot & \cdot & \cdot & & \cdot & \cdot \\ \cdot & \cdot & \cdot & & \cdot & \cdot \\ 0 & 0 & 0 & \cdots & I & 0 \end{bmatrix}$$

Within the A^{*} matrix an "I" represents a 2x2 identity matrix, and "0" represents a 2x2 matrix of zeros. The dominant latent root of A^{*} determines the behavior of the system. For the system to be stable, it is necessary that none of the latent roots be greater than one. If the roots are complex, then this condition requires that all moduli must be less than one.

Results: Placements Model

The final results for the placements model are presented in Table 1. Collinearity is present, but at levels that are not detrimental to model quality. Monte Carlo studies have shown that if variance inflation factors and condition indices, calculated from any OLS data set, exceed levels of ten and thirty respectively, then collinearity is severe and the accuracy of all parameter estimates is eroded (Belsley et al. 1980). Diagnostics calculated from the data set of the input demand function revealed values far below these thresholds. Serial correlation was present in the final model, and the results reported are therefore from the two-step, full-transformation method of correction discussed earlier.

The F statistic for the entire regression is significant. Those variables that are present in the final model maintained significance and stability in terms of parameter magnitude across the iterations necessary to arrive at this model. The iterations leading up to the final model are presented in Appendix B. The parameter estimates across these models suggest stability in the placement-price interrelationships. The final model explains 49.22% of the total variation in differenced placements. The R-square for the final model appears relatively small for time series data, but a large R-square is not expected with differenced data because the dependent variable series contains more variation than would the nondifferenced series.

The monthly dummy parameter estimates are consistent in sign and magnitude with prior knowledge of placement patterns. As expected, placements revolved around average in the early portion of the year, were slightly less than average in the months of June and July, above average in September, and again less than average in November and December. Also there were large consistent reductions in placements during the last eleven days of both November and December, coinciding with the Thanksgiving and Christmas holidays.

During the estimation procedure, experimentation was carried out with slope-shifting interest-rate variables in which the value that causes the shifts was varied. Prior to the late 1970s, interest rates were not an important element in production costs. The slope-shifting dummy variable is used in the model to help explain the changing role of interest rates. The variable which fit the model best, in terms of

Table 1. Coefficient Estimates from the Input Demand Function for Feeder Cattle

DEPENDENT VARIABLE: Differenced Placements (1000 Head)

F VALUE 11.490 PROB > F 0.0001
R-SQUARE 0.4922 ADJUSTED R-SQUARE 0.4493
DEGREES OF FREEDOM 237

	PARAMETER ESTIMATE	t RATIO	P *VALUE**
Intercept	2.6913	0.690	0.4912
Futures Price (t-2)	2.7794	3.219	0.0015
Expected Margin (t)	0.2191	2.306	0.0220
Expected Margin (t-1)	0.1567	1.589	0.1134
Cash Steer Price (t-1)	3.3034	3.417	0.0007
T-Bond Yield (t)	-0.0119	-3.161	0.0018
Shipments (t)	0.7290	9.996	0.0001
Shipments (t-1)	0.2116	3.089	0.0022
February	-3.40	-0.631	0.5288
March	5.27	0.981	0.3275
April	-7.08	-1.317	0.1891
May	3.08	0.586	0.5581
June	-8.20	-1.553	0.1217
July	-2.40	-0.460	0.6460
August	1.05	0.202	0.8399
September	6.31	1.163	0.2460
October	1.02	0.190	0.8495
November (first 20 days)	-13.55	-2.228	0.0268
November (last 11 days)	-20.84	-2.632	0.0091
December (first 20 days)	-4.53	-0.772	0.4408
December (last 11 days)	-19.58	-2.419	0.0163

* P Value: Probability that the true value of the coefficient is zero.

significance level, was kept and is in the final run of the general model. The slope shifting variable takes on zero values if the T-bond yield rate is below 9.5%. If the yield rate is above, or equal to, 9.5% then the variable takes on the values of the differenced interest rate series.

Results: Futures Price Model

The Geweke-type model to measure the relationship between placements and futures prices as the dependent variable contains eight lagged values of the dependent (futures price) variable and two values of the independent (placement) variable, the contemporaneous and a one-period lag. The specification was suggested following the FPE minimization procedure. A second Geweke-type model was also estimated. This second model contained identical lagged values of the dependent variable, but three placement variables were used: contemporaneous, lagged one period, and lagged two periods. The second model, which contains a larger FPE than the first, will provide additional insight as to when information on placement numbers in Cattle Fax member feedlots is incorporated into prices of live-cattle futures contracts. The added insight can be achieved through a comparison of the relative significance levels of coefficients attached to the placement series variables.

The causality tests from these two models are presented in Table 2. In the first model, which contains two placement variables, the instantaneous information flow was significant only at the 0.31 level. A lagged information flow of one period was much more important, with a 0.054 significance level. Diagnostics suggest collinearity is not a problem. The Ljung-Box Q statistic measures serial correlation within the error term, and for this model none appears to be present.

The bottom half of Table 2 contains the results of the second model. An instantaneous information flow was identified with a 0.296 significance level, a lagged information flow of one period was identified with a 0.136 significance level, and a lagged information flow of two periods was identified with only a 0.58 significance level. Again, collinearity is not a problem, and the Ljung-Box Q statistic indicates no serial correlation is present in the error term of this model.

Tests for information flows suggest that changes in the rate of placements influences changes in the prices of distant live-cattle futures. The tests also reveal there is a slight lag between emergence of the information and its incorporation into the price discovery process. Both models reveal that the majority of placement information is incorporated between one and two weeks after its emergence. The second model suggests that the majority of this information is incorporated after the passage of one week.

Table 2. Geweke Model Causality Tests Examining the Influence of Placements on Futures Prices

MODEL ONE RESULTS		
Instantaneous Information Flow Test:	F VALUE	1.0259
PROB > F	0.3112	
One Week Lag Information Flow Test:	F VALUE	3.7385
PROB > F	0.0543	
LJUNG-BOX Q STATISTIC CHI SQUARE	2.670	
DEGREES OF FREEDOM	6	
PROB > Q	0.850	
MODEL TWO RESULTS		
Instantaneous Information Flow Test:	F VALUE	1.0974
PROB > F	0.2959	
One Week Lag Information Flow Test:	F VALUE	2.0143
PROB > F	0.1357	
Two Week Lag Information Flow Test:	F VALUE	0.3010
PROB > F	0.5838	
LJUNG-BOX Q STATISTIC CHI SQUARE	2.640	
DEGREES OF FREEDOM	6	
PROB > Q	0.852	

There is, as the models indicate, a time lag of one week between the placement of cattle on feed and the incorporation of this information into the prices for live-cattle futures. The time lag should not, however, be construed as market inefficiency. The Cattle Fax newsletter is received by subscribers in mid-week, after the week for which it contains information. The futures market appears to be absorbing the Cattle Fax information within the week, or possibly prior to the time, the information is made "public." The futures market should, and does, adjust rapidly to new information revealed through the Cattle Fax report.

The findings suggest that the live-cattle futures market is, in Fama's terminology, semi-strong form efficient because the market absorbs new information during and possibly prior to the time when the information becomes "obviously publicly available." The live-cattle futures market does adjust quickly once placement information is made available in the Cattle Fax newsletter; thus the second hypothesis is confirmed.

Results: Stability Measures

Table 3 presents multipliers which reveal the pure interaction between the placements model and the futures price model in the stability analysis. The top half of Table 3 presents the results from a random shock to the model of changing rates of placements, and the bottom half presents the results from a random shock to the model of futures price behavior.

The most important result of Table 3 is that a $1.00 per cwt. increase (decrease) in the distant live-cattle futures contract price between the weeks (t-1) and (t) will cause an increase (decrease) in the number of animals placed in Cattle Fax member feedlots of 2779 head, a 2.5% change from average placement levels, between weeks (t+1) and (t+2). The p-value on the multiplier suggests that cattle feeders respond consistently to changes in distant futures prices. Thus, hypothesis one, that cattle feeders use the live-cattle futures market in the making of placement decisions, is positively confirmed. A second notable feature is that the system adjusts rapidly to random shocks in placement and futures price changes. The interaction within this system given a random shock to the input demand function reveals a highly stable set of multipliers. The initial change in the futures price of $1.00 quickly shrinks in an oscillatory fashion to values of less than 20 cents. The same phenomenon takes place within the placement model during this shock. There is a large initial response of 2779 additional cattle placed in response to the change in futures prices, which quickly reduces to a few hundred additional cattle in subsequent time periods.

Finally, the stability of the system was examined. Calculations revealed that the largest eigen value of the A^* matrix within this system was -0.88772. Thus, when new information enters the system, the system adjusts in a stable, oscillatory fashion towards new equilibrium levels of placements and futures prices. This result confirms hypothesis three.

Table 3. Multipliers Measuring Interaction of the Input Demand Function and the Lead/Lag Model When Shocked From a Random Source

RANDOM SHOCK TO THE PLACEMENT MODEL		
MULTIPLIERS	PLACE (1000 Head)	CLOSE ($/cwt.)
IMPACT	1.0	0.0
INTERM 1	0.0	-0.0086
INTERM 2	0.0	0.0029
INTERM 3	-0.0237	-0.0061
INTERM 4	0.0064	0.0037
INTERM 5	-0.0017	-0.0002
INTERM 6	0.0010	0.0015
INTERM 7	-0.0004	-0.0008
INTERM 8	0.0042	0.0003
TOTAL	0.982	-0.0064
RANDOM SHOCK TO THE FUTURES PRICE MODEL		
MULTIPLIERS	PLACE (1000 Head)	CLOSE ($/cwt.)
IMPACT	0.0	1.0
INTERM 1	0.0	-0.2680
INTERM 2	2.7794	0.0718
INTERM 3	-0.7448	-0.0429
INTERM 4	0.1996	0.0179
INTERM 5	-0.1194	-0.1778
INTERM 6	0.0496	0.0946
INTERM 7	-0.4942	0.0381
INTERM 8	0.2629	-0.1582
TOTAL	2.095	0.7538

Results: The Disaggregate Analyses

The placements model for increasing and decreasing placements does not perform as well as the general model. F statistics for both models are significant at the 0.01 level, however. Collinearity is present in both models but the diagnostics are well below threshold levels. Serial correlation is present in both models; thus, the results presented are from the two-step, full-transformation corrective procedure. The results to the two input demand functions are presented in Tables 4 and 5. The final two models explain 32.5% and 25.65% of the variation in the differenced placement series during those periods where placements are increasing and decreasing, respectively.

The contemporaneous value of the futures price variable in both disaggregate models was found to be insignificant and of wrong sign during the iterative process. The removal of this variable enables the subsequent coefficients and significance levels to be interpreted directly, without transformation through the analytically derived reduced form equation.

During weeks when placements are increasing, the model presented in Table 4 shows these increases are in response to changes in the distant live-cattle futures price, feeder cattle prices, cash steer prices, shipments from feedlots, and the expected margin.

An important feature revealed by Table 4 is that changes in live-cattle futures prices and changes in cash feeder-cattle prices are the dominant force driving cattle feeders to increase placements. The coefficients and the significance levels attached to the slaughter-steer price variables show that cattle feeders respond only marginally and with a high degree of inconsistency to changes in cash prices for finished animals.

For periods when placements are decreasing, the model presented in Table 5 indicates that cattle feeders respond to changing futures prices, shipments, cash steer price, and the expected margin. But this model also shows that cattle feeders do not respond consistently to changes in slaughter steer prices, as evidenced by the weak t-ratios of the cash steer price variables. Two other models (not reported) show that if the futures price variables at lags (t-1) and/or (t-2) are left out of the model, then the slaughter price variables at lags (t-1) and (t-2) will become statistically significant. But, in the presence of futures price variables, with similar lags, the slaughter steer prices are of questionable value to the modeling procedure.

Two important pieces of information were generated by these disaggregate models. The first is that live-cattle futures prices appear to be an important factor in production decisions made by cattle feeders, and the response to live-cattle futures prices is largely symmetric

Table 4. Coefficient Estimates from the Input Demand Function for Feeder Cattle where Placements Are Increasing

DEPENDENT VARIABLE: Deseasonalized Differenced Placements (1000 Head)

F VALUE 5.4779 PROB > F 0.0001
R-SQUARE 0.3248 ADJUSTED R-SQUARE 0.2573
DEGREES OF FREEDOM 120

	PARAMETER ESTIMATE	t RATIO	P VALUE
Intercept	13.8818	1.762	0.0001
Futures Price (t-1)	1.9870	1.634	0.1049
Futures Price (t-2)	2.1422	1.278	0.2037
Expected Margin (t)	0.2363	2.308	0.0227
Expected Margin (t-2)	0.2500	1.618	0.1084
Cash Steer Price (t)	1.1576	0.802	0.4241
Cash Steer Price (t-1)	0.5268	0.389	0.6981
Cash Steer Price (t-2)	0.0382	0.028	0.9778
Feeder Price (t)	-3.1716	-2.163	0.0326
Shipments (t)	0.4853	5.825	0.0001
Shipments (t-1)	0.1957	2.831	0.0054

P Value: Probability that the true value of the coefficient is zero.

between periods of increasing and decreasing placements. The live-cattle futures market not only motivates placements in anticipation of reduced supplies of fed cattle, a desirable performance, but also works to curtail placements, discouraging overreactions, a desirable and critically important function.

The second piece of information evolves from the evidence on the relative importance of the futures market versus the cash market. The cash market, represented by slaughter steer prices, does not play a strong role in causing Cattle Fax member feedlot operators to increase or decrease placement rates. The minor role of the cash market should not be a surprising because of the following factors. The membership of Cattle Fax are likely to be professional feeders who operate a single enterprise; thus they will be motivated to keep abreast of changing economic information and will most likely make

Table 5. Coefficient Estimates from the Input Demand Function for Feeder Cattle where Placements Are Decreasing

DEPENDENT VARIABLE: Deseasonalized Differenced Placements (1000 Head)

F VALUE 6.7848 PROB > F 0.0001
R-SQUARE 0.2565 ADJUSTED R-SQUARE 0.2187
DEGREES OF FREEDOM 118

	PARAMETER ESTIMATE	t RATIO	P VALUE
Intercept	-22.2992	-10.085	0.0001
Futures Price (t-1)	2.2125	2.431	0.0166
Futures Price (t-2)	2.6712	2.706	0.0078
Expected Margin (t)	0.2597	2.641	0.0094
Cash Steer Price (t)	0.6015	0.481	0.6315
Shipments (t)	0.3350	4.608	0.0001
Shipments (t-1)	0.1232	1.660	0.0996

P Value: Probability that the true value of the coefficient is zero.

production decisions based on expectations of future conditions. Second, when cattle feeders are evaluating a specific decision, in which the profitability of the outcome is uncertain, these operators should make choices based on expected future output prices, average variable costs (i.e. current input prices), and physical constraints (i.e. number of open pens). The appearance of slaughter steer prices in the general model is likely to be due to the fact that, over a long period of time and across a more diverse environment, cash product prices exert influence on the levels of cash available after total costs are paid. But in a very short-run environment where specific decisions are examined (i.e. increasing or decreasing placements), current cash prices play a small and indirect role.

The lead/lag models of futures prices from periods of increasing placements revealed no surprising results. The temporal dimensions associated with information flows containing news of increasing placements were similar to those of the models estimated under general conditions. The individual coefficients on the placement variables were not as significant as were the coefficients in the lead/lag model of general conditions, but again this was expected because the data set is reduced by approximately one-half by the disaggregation. Both models suggest that information on increasing placements is registered in the live-cattle futures market within the week the information is made public through the newsletter.

The lead/lag models for periods when placements were decreasing did reveal surprising results. The coefficients on the placement series lagged at least one week were not highly significant. The significance level observed was 0.495. The results suggest that if the live-cattle futures market is registering information on decreasing placements, it does so during the same time periods of the decrease, i.e. instantaneously. But the significance levels of the placement parameters with zero lag are still weak (.26), suggesting the futures market has more trouble registering information on decreasing rates of placements of cattle.

Summary and Conclusions

Cattle feeders respond to changes in the price levels of distant live-cattle futures by adjusting the number of cattle placed on feed. More generally, for the time period under examination, January 1979 through December 1983, Cattle Fax cattle feeders were found to respond to several technical and economic forces:

1. Changes in the numbers of cattle shipped from Cattle Fax feedlots;
2. Seasonal influences on the availability of cattle, feed, and labor;
3. Changes in the prices of distant futures contracts;
4. Changes in the cash prices of cattle coming out of the feedlot; and
5. Changes in an expected profit margin made up of distant live cattle futures prices, and current corn and feeder cattle costs.

Increases in distant live-cattle futures prices prompt positive and significant changes in the placement of cattle on feed. Decreases in distant live-cattle futures prices dampen price expectations and constrain placements. Such responses are consistent with theoretical expectations and are the behavior necessary to stabilize supplies of fed cattle, and fed cattle prices, over time. The recursive economic system described mathematically by models with differenced placements and differenced live-cattle futures prices as dependent variables is stable. A shock to this system works its effects back-and-forth between the two models as time passes and eventually becomes negligible.

When the data under examination were disaggregated into one subset in which placement levels are increasing, and a second subset in which placement levels are decreasing, the results show that placements increase primarily in response to increasing futures prices and decreasing feeder steer prices. Placements decrease in response to decreasing futures prices. Cattle feeders do not respond to changes in cash slaughter steer prices with any degree of consistency either when placements are increasing or decreasing. The responses to futures prices in the two specific cases, placements increasing and placements decreasing, also appears to be symmetric.

The analysis of forces that influence distant live-cattle futures price changes suggests that one week is needed for the live-cattle futures market to gather emerging placement information from Cattle Fax member feedlots and incorporate it into a new price. This information is incorporated into prices mostly during the same week the information becomes obviously available to the public through the release of the Cattle Fax newsletter, suggesting the live-cattle futures market is semi-strong form efficient.

Additional analysis of futures price changes reveal that the live-cattle futures market performs the process of gathering and incorporating placement information when placements are increasing at approximately the same speeds at which it performs these processes in the general environment. But the results when placements are decreasing suggest that the futures market has some trouble gathering and incorporating the information that placements are decreasing. There is some reason to conclude, therefore, that the live cattle futures market is more effective in registering the impact of increased placements (to help prevent excessive placements) than in registering the impact of decreased placements (to help stimulate more placements).

The results support acceptance of hypotheses that (1) cattle feeders respond to distant live-cattle futures prices in making placement decisions, (2) live-cattle futures prices reflect changes in placements of cattle on feed quickly, and (3) the "system" comprised of placements and live-cattle futures prices interacts in a stable manner. This research, therefore, supports the argument that, because of the nature of the interaction between the live-cattle futures market and the cattle-feeding sector, the existence of the live-cattle futures market aids in stabilizing the flow of cattle placed on feed. The results of stable flows of cattle placed on feed should be relatively stable flows of fed cattle marketings, and relatively more stable cash slaughter cattle prices.

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Appendix A

This appendix presents the steps through which the lead/lag equation containing the variables CLOSE are derived for the lead/lag equation containing CLOSEL2. First, the CLOSEL2 equation is reproduced:

$$CLOSEL2(t) = \phi_0 \ PLACE(t) + \ . \ . \ . \ + \phi_q \ PLACE(t-q)$$

$$+ \gamma_1 \ CLOSEL2(t-1) + ... + \gamma_p \ CLOSEL2(t-p) \qquad (A1)$$

Using the following identity:

$$CLOSEL2(t) = CLOSE(t) + CLOSE(t-1) \qquad (A2)$$

equation (A1) can be transformed into:

$$CLOSE(t) \ + \ CLOSE(t-1) \ = \ \phi_1 \ PLACE(t-1) + \ . \ . \ . \ + \phi_q \ PLACE($$

$$+ \ \gamma_1 \ \{CLOSE(t-1) + CLOSE(t-2)\}$$

$$+ \ \gamma_2 \ \{CLOSE(t-2) + CLOSE(t-3)\} \ + \ . \ . \ .$$

$$+ \ \gamma_d \ \{CLOSE(t-p) + CLOSE(t-p-1)\} \qquad (A3)$$

Multiplying the γ coefficients through and collecting the CLOSE variables of equation (A3) gives:

$$CLOSE(t) = \phi_1 \ PLACE(t-1) + \ . \ . \ . + \phi_q \ PLACE(t-q)$$

$$+ (\gamma_1 \ - \ 1) \ CLOSE(t-1)$$

$$+ (\gamma_1 \ + \ \gamma_2) \ CLOSE(t-2) + \ . \ . \ .$$

$$+ (\gamma_{p-1} \ + \ \gamma_p) \ CLOSE(t-p)$$

$$+ (\gamma_p) \ CLOSE(t-p-1) \qquad (A4)$$

Now simplifying terms gives:

$$CLOSE(t) = \phi_1 \ PLACE(t-1) + \ . \ . \ . + \phi_q \ PLACE(t-q)$$
$$+ \psi_1 \ CLOSE(t-1) + \psi_2 \ CLOSE(t-2) + \ . \ . \ .$$
$$+ \psi_p \ CLOSE(t-p) + \psi_{p+1} \ CLOSE(t-p-1) \qquad (A5)$$

where:

$$\begin{aligned}
\psi_1 &= (\gamma_1 - 1) \\
\psi_2 &= (\gamma_1 - \gamma_2) \\
&\vdots \\
\psi_p &= (\gamma_{p-1} - \gamma_p) \\
\psi_{p+1} &= (\gamma_p)
\end{aligned}$$

Equation (A5) is the equation used in the analytically-derived, reduced form equation.

Appendix B

Table B1. Coefficient Estimates from the Input Demand Function for Feeder Cattle: Three Iterations from the Final Model

DEPENDENT VARIABLE: Differenced Placements (1000 Head)

F VALUE 9.7317 PROB > F 0.0001
R-SQUARE 0.5006 ADJUSTED R-SQUARE 0.4492

	PARAMETER ESTIMATE	t RATIO	P VALUE
Intercept	2.8286	0.721	0.4719
Futures Price (t-1)	-4.9863	-1.583	0.1147
Futures Price (t-2)	2.6441	3.040	0.0026
Expected Margin (t)	0.1546	1.459	0.1458
Expected Margin (t-1)	0.5766	2.073	0.0393
Cash Flow Margin (t)	0.1396	0.826	0.4098
Cash Flow Margin (t-1)	-0.4810	-1.511	0.1322
Cash Steer Price (t)	0.4347	0.342	0.7327
Cash Steer Price (t-1)	7.9493	2.355	0.0194
T-Bond Yield (t)	-0.0113	-2.929	0.0037
Shipments (t)	0.7231	9.876	0.0001
Shipments (t-1)	0.2169	3.142	0.0019
February	-3.37	-0.613	0.5403
March	4.36	0.791	0.4300
April	-6.36	-1.103	0.2711
May	2.84	0.532	0.5949
June	-9.09	-1.699	0.0906
July	-1.69	-0.322	0.7479
August	0.00	0.000	0.9999
September	7.05	1.292	0.1976
October	0.45	0.084	0.9330
November (first 20 days)	-13.71	-2.232	0.0266
November (last 11 days)	-21.14	-2.658	0.0084
December (first 20 days)	-7.18	-1.182	0.2385
December (last 11 days)	-19.72	-2.421	0.0163

P Value: Probability that the true value of the coefficient is zero.

Table B2. Coefficient Estimates from the Input Demand Function for Feeder Cattle: Two Iterations from the Final Model

DEPENDENT VARIABLE: Differenced Placements (1000 Head)

F VALUE	10.470	PROB > F	0.0001
R-SQUARE	0.4950	ADJUSTED R-SQUARE	0.4477

	PARAMETER ESTIMATE	t RATIO	P VALUE
Intercept	3.0065	0.721	0.4447
Futures Price (t-2)	2.6890	3.089	0.0023
Expected Margin (t)	0.1614	1.522	0.1292
Expected Margin (t-1)	0.1578	1.593	0.1125
Cash Flow Margin (t)	0.1310	0.786	0.4327
Cash Steer Price (t)	0.5485	0.447	0.6554
Cash Steer Price (t-1)	2.7824	2.595	0.0101
T-Bond Yield (t)	-0.0119	-3.125	0.0020
Shipments (t)	0.7270	9.921	0.0001
Shipments (t-1)	0.2200	3.189	0.0016
February	-4.20	-0.768	0.4435
March	4.30	0.785	0.4333
April	-8.66	-1.561	0.1198
May	2.64	0.498	0.6191
June	-8.02	-1.508	0.1328
July	-1.92	-0.365	0.7155
August	0.61	0.116	0.9081
September	6.60	1.210	0.2274
October	1.11	0.204	0.8383
November (first 20 days)	-14.04	-2.284	0.0233
November (last 11 days)	-21.42	-2.692	0.0076
December (first 20 days)	-5.08	-0.859	0.3914
December (last 11 days)	-20.10	-2.471	0.0142

P Value: Probability that the true value of the coefficient is zero.

Table B3. Coefficient Estimates from the Input Demand Function for Feeder Cattle: One Iteration From the Final Model

DEPENDENT VARIABLE: **Differenced Placements (1000 Head)**

F VALUE	10.998	PROB > F	0.0001
R-SQUARE	0.4946	ADJUSTED R-SQUARE	0.4496

	PARAMETER ESTIMATE	t RATIO	P VALUE
Intercept	2.9686	0.758	0.4495
Futures Price (t-2)	2.6693	3.075	0.0023
Expected Margin (t)	0.1628	1.540	0.1250
Expected Margin (t-1)	0.1546	1.567	0.1184
Cash Flow Margin (t)	0.1695	1.190	0.2353
Cash Steer Price (t-1)	2.9386	2.903	0.0040
T-Bond Yield (t)	-0.0120	-3.187	0.0016
Shipments (t)	0.7300	10.021	0.0001
Shipments (t-1)	0.2206	3.204	0.0015
February	-3.92	-0.723	0.4703
March	4.21	0.770	0.4420
April	-8.52	-1.542	0.1245
May	2.52	0.477	0.6341
June	-7.90	-1.490	0.1374
July	-1.97	-0.376	0.7069
August	0.69	0.131	0.8959
September	6.54	1.202	0.2307
October	1.05	0.195	0.8454
November (first 20 days)	-13.75	-2.254	0.0251
November (last 11 days)	-21.33	-2.687	0.0077
December (first 20 days)	-5.15	-0.873	0.3835
December (last 11 days)	-19.91	-2.456	0.0148

P Value: Probability that the true value of the coefficient is zero.

Virginia's Agricultural Experiment Stations

1—Blacksburg
Virginia Tech, Main Station
Dairy, Poultry, and all other topics

2—Steeles Tavern
Shenandoah Valley Agricultural Experiment Station
Beef, Forages, Fruit, Insect and Pest Control, Sheep

3—Orange
Northern Piedmont Agricultural Experiment Station
Alfalfa, Corn, Crops, Small Grains

4—Winchester
Winchester Agricultural Experiment Station
Fruit, Insect and Pest Control

5—Middleburg
Middleburg Agricultural Experiment Station
Beef, Forages

6—Warsaw
Eastern Virginia Agricultural Experiment Station
Field Crops, Insect and Pest Control

7—Holland Station, Suffolk
Tidewater Agricultural Experiment Station
Corn, Peanuts, Pest Control, Small Grains, Soybeans, Swine

8—Blackstone
Southern Piedmont Agricultural Experiment Station
Forages, Horticulture Crops, Small Grains, Tobacco, Turfgrass

9—Critz
Reynolds Homestead Agricultural Experiment Station
Aquaculture, Forestry, Wildlife

10—Glade Spring
Southwest Virginia Agricultural
Experiment Station
Beef, Burley Tobacco, Sheep

11—Hampton
Virginia Seafood Agricultural Experiment Station
Seafood

12—Virginia Beach
Hampton Roads Agricultural Experiment Station
Ornamentals, Vegetables, Insect and Pest Control

13—Painter
Eastern Shore Agricultural Experiment Station
Fruit, Field Crops, Herbs, Insect and Pest Control, Vegetables