Interaction Between The Cattle Feeding Sector And The Live Cattle Futures Market: Implications To The Stability Of Short-Run Cash Slaughter Cattle Prices

by

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Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Agricultural Economics

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June, 1985

Blacksburg, Virginia

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(ABSTRACT)

The short-run interaction between the cattle feeding sector, as represented by Cattle Fax member feedlots, and the live cattle futures market is examined. The purpose of this research is to explore the simultaneity between placement decisions made in the cattle feeding sector and the price discovery process for distant contracts within the live cattle futures market. The efficiency of these processes will have implications to variability in supplies and thus, cash market prices for fed cattle.

Input demand functions for feeder cattle were estimated as a function of numerous economic and technical factors. These modeling efforts reveal that cattle feeders consistently use distant futures prices in the formulation of expected prices when making placement decisions.

Lead/lag analyses were conducted between the Cattle Fax placement series and the live cattle futures price series. Results from Granger type models reveal the live cattle futures market efficiently gathers and incorporates information on future supply conditions in the price discovery process for distant contracts.

The recursive system created by these two models was examined and was found to be stable. The emergence of new information, pertinent to the feeding sector and the live cattle futures market, will cause orderly shifts to new equilibrium levels of placements of cattle on feed and distant live cattle futures prices.

This research supports the conclusion 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.

ACKNOWLEDGEMENTS

First and foremost thanks must go to my mentor, Dr Wayne Purcell. He has given me the opportunity to learn much: the workings of these markets, an appreciation of economic theory, and a desire to protect the best interests of people at the grassroots level. He has been the dominant force which has made my college career successful, I will always be indebted. The efforts put forth by the remainder of my committee, Dr. David Kenyon and Dr. Daniel Kauffman, also deserve thanks. Their input has markedly improved this research.

I wish to formally thank the National Cattlemen's Association Foundation, Inc. for funding the research project from which this thesis was written. I am also very grateful to of the National Cattlemen's Association for his involvement in making this project a reality. The Cattlemens' interest in objective and scientific research has bettered the understanding of the economic forces within this complex.

Sincerest thanks go to my parents for opening all the doors that they could for me and never once doubting. They, and my kin at , have given much to make sure that all burdens were by my own choice.

To my friends at Tech I am indebted for their years of energy, and enthusiasm. To , a true friend, and , a fellow big game hunter, I owe special thanks.

Finally, a very special thank you goes to , who's friendship and company has made the past year seem to pass by much too quickly.

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CHAPTER 1: INTRODUCTION

1.1 The Current Situation

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

Cattle feeders are subject to substantial amounts of price risk. Up to six months are needed to produce a finished animal from a feeder steer once the feeding process is initiated. Prices received for fed cattle can differ substantially from the anticipated cash price formulated when production decisions were made. Increases in cash price variability do not translate directly to increases in levels of risk exposure experienced by cattle operations, but the ability to anticipate future cash market prices may be hampered by any increase in variability. Indirectly, therefore, the level of risk exposure may increase with increasing variability in cash prices.

A worthy question now arises: Does futures trading in live cattle have stabilizing or destabilizing effects on the cash slaughter 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 whereby 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 this increased variability, specifically with regard to the cattle and beef markets. Producer attitudes appear to reflect this, 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 70's was more volatile than the cattle market in the 60's. Everyone put up their hands. I asked them how many of them felt that this additional volatility in the cattle market in the 70's was caused by the futures market. Everyone put up their hands. Then I asked how many people felt that the grain markets have been more volatile in the 70's than in the 60's. Everyone put up their hands. Then I asked the obvious -- how many people felt that this volatility is due to the grain futures market? No one raised a hand. (Stubben in Leuthold and Dixon, p161.)

A second area of public concern with respect to futures trading questions the legitimacy of the live cattle futures market as a viable market. Bressler and King 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 and acceptance of delivery of live cattle for some time period in the future. There is a need for prices which are formed in this market to accurately reflect current knowledge of future supply and demand conditions in order to meet minimum performance levels demanded by those affected by this market. The following are statements from two industry representatives which reveal they do not believe the live cattle futures market is meeting these needs. In late 1983, John Helmuth, an economist with the House Committee on Small Business, speaking to a group of cattle industry representatives concerned about the futures market, comments that:

> The live cattle futures market is generally inadequate at forecasting cattle prices. You can tell more about what is going to happen to cattle prices by looking only at cash prices than by using the futures at all. This means the cattle futures prices are putting inaccurate, misleading signals into the marketplace and adding to the confusion rather than performing a useful economic forecasting function.
>
> Cattle futures have been traded for almost twenty years. I know of no market that has been studied, by more different researchers, from every possible angle. The bulk of these studies keep coming up with the same results: cattle futures are an inefficient, biased market. There is clearly something wrong in the cattle futures market.
>
> Cash prices, which should reflect real supply-demand conditions, were generally unchanged or going up when futures price drops occur. This indicates that the predicted futures price drops are independent of cash prices and do not reflect fundamental changes in supply-demand conditions. Such artificial futures price moves increase the instability between cash and futures prices and raise serious questions about whether cattle futures are serving any economic purpose.
>
> (The live cattle futures market is) a market which is inadequate at price forecasting and which does not provide useful price signals to help with cattle feeding decisions or make risk shifting possible through hedging. From all this I conclude that the live cattle futures market is not serving any economic purpose. (Parenthesis added.)

The following is an excerpt from an interview with Hank Walton, a former member of the Chicago Mercantile Exchange's Feeder Cattle Advisory Council, published by the Stockman Record in September of 1983:

> Cattle futures per se have gone so far to the technical side of the market and away from the fundamentals.
>
> Factors which have nothing to do with the value of beef or the worth of cattle are used to justify ticks in the futures board.

These statements by Stubben, Helmuth, and Walton reveal the concerns that some cattlemen and industry members have about the performance of the live cattle futures market.

1.2 Problem

The concerns presented in the previous section illustrate that there is strong sentiment within the industry that the live cattle futures market has adverse influence on the economic events within the cattle feeding sector. This research was initiated to analyze how trade in live cattle futures influences cash slaughter cattle prices.

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 simultaneously use these market generated prices in the development of expectations of future cash prices, 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. Thus, there appears to be a gap between what economic theory dictates and what is generally accepted by the public. Too little is known about the degree with which conceptual benefits of trade in live cattle futures are actually extended to the operation of cash cattle markets.

1.3 Hypotheses

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

1. Variations in prices of distant live cattle futures contracts, maturing after the completion of the current feeding period, should be instrumental 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 distant live cattle futures contracts, which mature after the completion of the current feeding period.

The first two hypotheses are tested independently of one another, but it is easily seen that the information flows hypothesized in these first two statements (i.e. between the cattle feeding sector and the live cattle futures market) jointly make up a recursive economic system. The third hypothesis involves examining the feedback relationship inherent within this system. Hypotheses (1) and (2) must be accepted or the third is not applicable.

3. 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 creates a recursive system. If the live cattle futures market is to provide an economic service to the

cattle feeding sector, this recursive system must be stable. Given the conceptual argument presented in the problem statement, it is therefore hypothesized that the recursive system is stable.

If all three hypotheses are accepted, this 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.

1.4 Objectives

The specific objectives of this research are 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 made 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.

1.5 Thesis Overview

The structure of the thesis is as follows. Theoretical considerations are discussed in Chapter 2. Conceptual developments for modeling the supply response by cattle feeders to live cattle futures prices, modeling the incorporation of information on future supply conditions into live cattle futures prices, and examining the stability of the interaction between these two economic entities are discussed.

Chapter 3 presents the models to be estimated based on the foundations discussed in Chapter 2. Applications of the theory and methods from Chapters 2 and 3 are documented in Chapter 4.

The findings of this research are summarized in Chapter 5. Several points are emphasized in this chapter: (1) the supply response phenomenon within the cattle feeding sector; (2) the efficiency of the live cattle futures market in gathering and incorporating emerging information; (3) the stability of the interaction between the cattle feeding sector and the live cattle futures market; and (4) inferences with respect to whether the live cattle futures market is serving an economic purpose.

CHAPTER 2: THEORETICAL CONSIDERATIONS

2.1 Introduction

The purpose of this chapter is to present the theoretical framework upon which the remainder of the study will be based. The chapter begins with a brief review of the pertinent literature. Section 2.3 discusses the simultaneity between the cattle feeding sector and the live cattle futures market, and presents a detailed discussion of some of the conceptual issues which will further help focus the research.

Sections 2.4 and 2.5 address model development topics. Sèction 2.4 specifically discusses the procedure used to examine the response by the cattle feeding sector to prices in the live cattle futures market. The procedure to measure the response by the live cattle futures market to the production decisions made by cattle feeders is given in Section 2.5. Section 2.6 lays out the concept of stability in the cattle feeding sector / live cattle futures market system, and the final section, 2.7, discusses the underpinnings behind a disaggregate analysis of this system.

2.2 Review of the Literature

The concerns presented in the previous chapter, as well as professional interest, have sparked research into the study of futures markets. Theoretical writings suggest the existence of futures markets for commodities are beneficial to society as a whole and to the 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 conceptions. 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) formally 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 these markets have stabilizing influences on spot prices.[1] 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. Although these research efforts did not explicitly address the live cattle futures markets, but the results should be generally applicable.

The remainder of this section will review some of the more commonly cited empirical research. Gray (1963) states an organized futures market widens the opportunity to buy a commodity during the harvest surplus and sell it for later delivery. A decrease in seasonal price range is

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[1] A forward pricing mechanism is defined as a market which reflects current information on future supply and demand conditions.

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. In potatoes, Gray argues, futures prices have reflected a market expectation of acreage stability, and to the extent they have been taken as guides, futures markets have helped to impart acreage stability. A final point made by Gray is that the characteristics of potatoes, combined with rational price formation in the potato futures market, will provide income stability for producers if they are willing to routinely hedge production prior to planting.

Kofi (1973) also demonstrated that futures markets perform their forward pricing function well for a wide variety of commodities. The prediction reliability of a futures market improves as more accurate information on supply and demand becomes available. In this context, price formation in these markets reflect expert appraisal of changing economic information.

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 therefore concluded that the live cattle futures market could be destabilizing to cash markets and could be allocating resources inefficiently.

Taylor and Leuthold (1974) show that, contrary to public opinion, 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. The work of Powers (1970) and Cox (1976) further suggested 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 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.[2]

Leuthold and Hartman (1979) perform 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 state 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 fu-

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[2] Livestock futures were thinly traded for the first two years after their introduction, thus these years are often grouped with price data categorized as occurring <u>prior</u> to the beginning of futures trading.

tures 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.

Recently, Koppenhaver (1983) suggested risk premiums exist in the live cattle futures market, as evidenced by a persistent downward bias. Koppenhaver also rejected 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. These authors find no evidence of significant bias. They find no reason to conclude that live cattle futures prices fail in any regard in performing the function of price discovery and 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 (Forker). 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. The authors' concluded that if there is a single most important seat of price discovery in the beef complex, it is in the live cattle futures market. There was, however, 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.

Conceptual improvements to physical commodity markets through the introduction of futures trading were summarized in the first part of this section. The degree to which these improvements are extended to the operation of cash markets has been questioned by the empirical studies reviewed in the last part of this section. This is particularly evident with regard to the live cattle futures market and the cash fed cattle markets.

2.3 Conceptual Foundations

Ideally, the live cattle futures market should efficiently gather and incorporate emerging information on future economic conditions. Simultaneously, cattle feeders should develop some type of expectation of future cash prices for finished animals when making production decisions. Cattle feeders could use price forecasts suggested by various organizations which provide outlook. They could develop expectations from past experience, but a reasonable place to obtain price expectations would be from prices of live cattle futures contracts which mature close but not prior to the time when cattle placed currently would be ready for slaughter. Futures prices for a particular contract represent a market consensus of what the cash prices are expected to be at delivery points when the contract matures. Unlike all other sources of information, this market also gives the producer an ability to "lock-in" a price when production decisions are made, i.e. hedge. If these processes of incorporating information into futures prices and the use of futures prices as expectations are accurate and are rapid in nature, then the existence of a futures market should act to stabilize flows of animals through the production channel.

Figure 1 diagrams the simultaneity between the cattle feeding sector and the live cattle futures market. The left half of the figure represents the production channel which traces the movement of animals from cow-calf operations to slaughter. The solid vertical arrows represent all major product flows. The blocks represent the possible production stages. The numbers within the production stage blocks represents an average range on the amount of time, in months, before the animals which are entering that stage will reach the slaughter stage. For example, within the **Feedlot Complex**, t equals 4.5 to 6; the bulk of all finishing operations feed cattle for 4.5 to 6 months before shipping the animals to slaughter.

The right half of the figure represents the live cattle futures market and the continuum of contracts traded in this market. The numbers within the contract blocks represent the time prior to expiration of the contracts under that classification. For example, contracts which mature 5 to 6 months in the future are classified **Distant Contracts**.

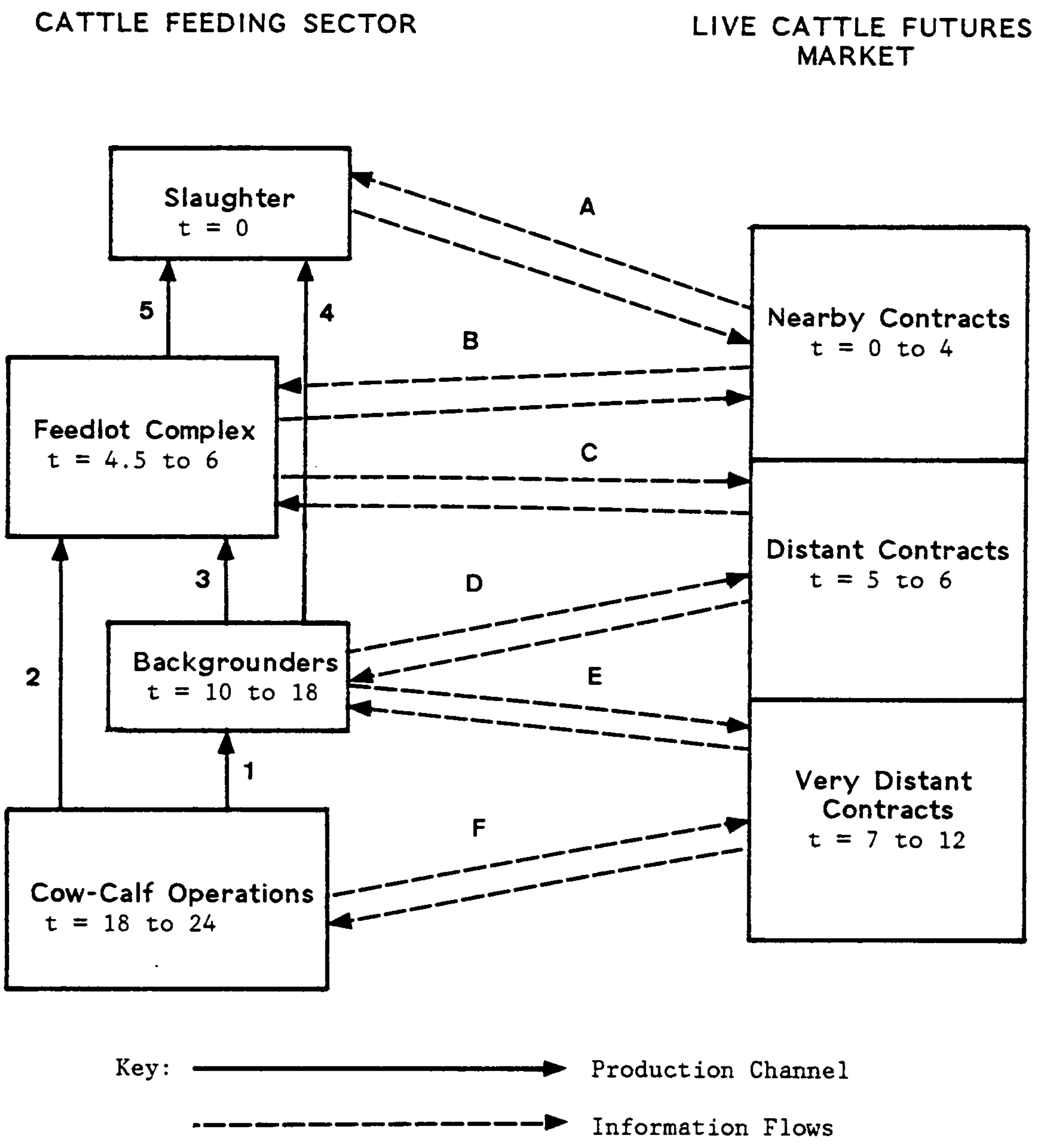

Figure 1. An Illustration of the Simultaneity Between Product Flows in the Cattle Feeding Sector and Price Discovery within the Live Cattle Futures Market.

The horizontal arrows represent information flows between the live cattle futures market and the cattle feeding sector. More specifically, the arrows from the live cattle futures market denote the use of futures prices by cattle feeders in making production decisions. The arrows from the cattle feeding sector to the live cattle futures market denote the gathering and incorporating of information on pertinent future supply conditions into the price discovery processes for the various contracts traded. The figure reveals, through the temporal alignment of production stages and various contracts, the simultaneity between decision making within the cattle feeding sector and price discovery in the live cattle futures market.

The presence of live cattle futures prices on contracts deliverable up to a year in the future have two potential avenues of influence on production decisions and therefore on fed cattle supplies:

1. Nearby contracts, (i.e. those maturing within three months), play an allocative role on feeding and marketing decisions. This is represented by the two pair of arrows labeled A and B in Figure 1. If current flows of fresh beef through processing and distribution channels are relatively light compared to expected future flows, then prices of nearby futures contracts will rise relative to more distant contracts. Cattle feeders would be stimulated to feed a ration of higher energy or increase the feeding rate, producing quicker gains, allowing the cattle to be marketed earlier, and thus alleviating the current shortage of fresh beef. The opposite should also occur. If fresh beef channels are currently flooded and are expected to return

to more normal levels in a few weeks, nearby contract prices should be low relative to distant contract prices, signaling feeders to decrease the intensity of feeding programs, and stretch the length of time cattle are on feed so that they will be marketed later than originally expected.

2. Distant contracts, (i.e. those maturing five to six months in the future), and very distant contracts, (i.e. those maturing seven months to one year in the future), play a forward pricing role on the number of cattle moving into the feedlot complex, the numbers of calves produced, and the numbers of small animals moving into backgrounding operations. This is represented by the four pair of arrows labeled C, D, E, and F in Figure 1.

    Consider the scenario where 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 use distant futures in developing price expectations, the resulting dampened expectations should curtail placements. The first reaction by feeders may well be to try to buy feeder cattle at lower prices, but other demands for stocker and feeder cattle limit the possibilities of immediately passing this change in expectations down the derived demand ladder. Clearly, those investors who feed cattle only when they can forward price at a profit would not place cattle when distant futures dip below break-even levels. 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 of fresh beef in future months.

Very similar conceptual arguments could be made with respect to the relationship between the very distant contracts, the number of calves produced, and the movement of cattle from cow-calf to backgrounding operations and finally to the feedlot complex. Very distant contracts should behave as rational price formation agencies because of the possibility of eliciting self-defeating supply responses. Therefore, the prices of these contracts should trade near average variable costs within the feedlot complex. Futures prices represent a national price, and a futures contract must trade at a single price. Because of comparative advantages between feeding locations, national average feeding costs will not be represented by a single figure but by a range. Therefore, when current information reveals potential future beef supplies are abundant, very distant contract prices will dip to the low end of the average variable cost range. Conversely, when current information on future beef supplies shows potential shortages, very distant contract prices will trade up into the high end of the national average variable cost range.

Hoffman (1978) and Leuthold (1979) have documented the response by producers, in their marketing of fed cattle, to changes in the level of basis, i.e. the allocative role.[3] Yet, there are biological and physical limits to the speed which cattle of feeder weights can be brought to slaughter weights and limits to the amount of time cattle can spend in a feedlot before their quality deteriorates and/or the cost of further feeding would be better spent on younger cattle. High quality, finished cattle are perishable products. The range on the weight, quality, and number of animals which a cattle feeder can sell in cash slaughter markets, without substantial discounting of price, is much more restrictive than the range of cattle which can be placed on feed. Thus, it appears that the dominant source of variability in the flow of cattle through the production channel is not initiated in the flows between the feedlot complex and slaughter, but somewhere in the earlier stages of the channel.

Figure 2 shows the percent of total slaughter which was non-fed from 1979 to 1985, i.e. the product flow labeled #4 in Figure 1. Feeder cattle from 500 to 800 pounds can either be moved into the feedlot complex, put on grass, or slaughtered, but because they must have a minimum level of "finish" in order to graded and sold as fed animals they are to a degree perishable, therefore these cattle must eventually be moved into the feedlot or slaughtered before they weigh much more than 800 pounds. The combination of fluctuations in this series and the relatively constant breeding herd size suggests that the variability in the number of animals entering slaughter markets is not due to variability in numbers of calves

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[3] Basis = cash price minus distant futures contract price.

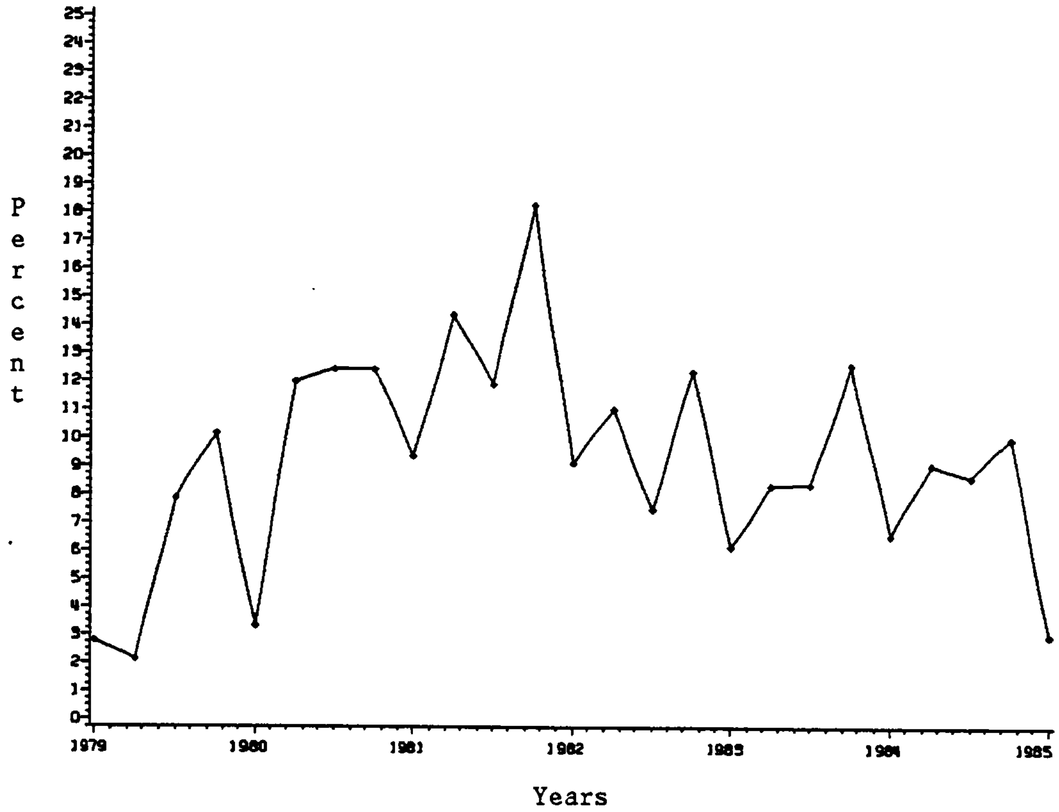

Figure 2. The Percent of Total Steer and Heifer Slaughter Which Was Composed of Non-fed Cattle.

produced or the flows of animals from cow-calf or backgrounding operations. An example to contrast this would be the events which take place in the hog industry. All pigs farrowed are eventually slaughtered as fed animals with the exception of herd replacements and death losses. There is no non-fed slaughter of hogs. Therefore, the forces which drive the variability in the numbers hogs arriving in the marketplace would stem from the variability in farrowing decisions.

Fluctuations in fed cattle supplies are primarily due to variation in the number of animals placed on feed, not the ability of cattle feeders to adjust feed rations or adjust the length of the feeding period, or the availability of feeder cattle. For this reason, this research concentrates on the interaction between the placement decisions made within the cattle feeding sector and the live cattle futures market.

The response by cattle feeders to changes in live cattle futures prices of both distant and nearby contracts may be the force which prevents the live cattle futures market from predicting accurately. Any degree of a supply response phenomenon would create at least a partial self-defeating prophecy, suggesting that performance of futures markets should not be based solely on their ability to predict.

The remainder of this section will discuss the necessity of examining the interaction between the cattle feeding sector and the live cattle futures market in as short-run a framework as possible. Peck (1973) provides a rigorous piece of research examining futures markets, supply response, and price stability. Her results suggest that benefits of cash market price stability are realized in commodities with active futures markets, at least in a long-run time frame. Further research examining the interaction between the cattle feeding sector and the live cattle futures market in a similar long-run framework would be a partial and unnecessary duplication of Peck's work, and would provide only marginal benefits to the body of literature on the influences of futures trading. On the other hand, examination of the short-run behavior of this system would complement existing research.

A second and formidable reason to perform these analyses in a short-run context is that cattle feeders and other market participants must interact with the markets in the short-run. Purchases and sales of inputs and outputs are made on particular days and usually at a single price. Market transactions can be spread over time, and average prices received may approach underlying long-run levels, but there are rational limits to the frequency of market transactions. This research recognizes that it is distinctly possible that long-run prices can be stabilized while the variability of short-run prices remain the same or increase. Since the primary interest of market participants would be how the introduction of a futures market effects them directly, short-run price behavior is an important question.

Finally, a priori, interaction between the cattle feeding sector and the live cattle futures market is expected to be rapid. This again draws on the fact that short-run price behavior may substantially differ from long-run price behavior. Some of the most dominant forces which influence behavior of both futures market prices and cattle feeding decisions would be masked if the analysis ignored short-run influences.

2.4 The Response by Cattle Feeders to Distant Futures Prices

This section discusses the conceptual framework which will be used in constructing an empirical model to test the first hypothesis: that variations in distant live cattle futures prices are instrumental in explaining variations in the placement of cattle on feed.

2.4.1 Derived Input Demand

Cattle feeding operations can be thought of as firms which produce a single product from multiple inputs. Decisions to place cattle on feed by individual firms generates a demand for a particular input, feeder cattle. Changes in the levels of feeder cattle placed are then due to changes in a variety of factors. Neoclassical production theory suggests that for a firm operating under profit maximization and with certainty, the output price and the input prices are the key elements used to determine optimal input levels (Henderson and Quandt).

Feder, Just, and Schmitz (1980) examine the behavior of a competitive firm under price uncertainty where a futures market exists for the commodity produced by the firm. The model applies well to the operation of a feedlot because the following assumptions are made: at the time production decisions are made, input prices are known, future quantities of output are known with a high degree of certainty, and output prices are uncertain. If the producer is willing to take positions in the futures market, the authors show that with the existence of a futures market, production decisions are only affected by output futures prices and input costs. Output levels are positively related to changes in delivery period futures prices and negatively related to changes in input costs.

Models of an input demand function for feeder cattle will make use of: expected output prices, cash output prices, and current input prices. Knowledge of the operation of feedlots aids in identifying "technical factors of production" as a forth category which could influence placements. In general, the input demand function will be specified as:

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

The main result of interest from the input demand function is the supply response behavior exhibited by cattle feeders to changes in distant futures prices. Cattle feeders are expected to respond to changes in a price which reflects anticipated future supply and demand conditions. The existence of such behavior is crucial if the live cattle futures market is to serve an economic function, and help prevent over supplies or under supplies of fed beef.

2.4.2 Short-Run Model Specification

Short-run behavior of cattle feeders is the primary interest of this study. Specifying statistical models with first differenced data is one method of exposing short-run behavior. The logic behind this method follows.

All linear least squares regression procedures will produce the following general results:

$$\bar{Y} = \beta_0 + \beta_1 \bar{X}_1 + \beta_2 \bar{X}_2 + \ldots + \beta_n \bar{X}_n \qquad (2.1)$$

where:

$\bar{Y}$ = the average value of the dependent variable;

$\bar{X}_i$ = the average value of independent variable i for all i = 1,2,3,...,n variables;

β_0 = intercept; and

β_i = coefficient estimate associated with variable i for all = 1,2,3,...,n variables.

Linear least squares techniques will always fit the regression equation through the mean values of the data. The i^{th} beta coefficient in equation (2.1) is defined as the partial derivative of the dependent variable with respect to the i^{th} independent variable, or similarly the change in the dependent variable given a one unit change in the i^{th} independent variable holding all other variables constant. The beta coefficients from regression techniques do measure changes in Y given a change in a particular X, but simultaneously least squares techniques also solves (2.1). If a regression technique is used to model an input demand function for feeder cattle with non-differenced data, the results will partially describe any relationship which exists between mean values in the data set, -- long-run relationships.

Differencing produces data series which have expected values of zero. The long-run relationships between the variables are purged, but the short-run relationships between variables, as exposed by the movements of the individual series, are perfectly preserved. 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 though of as describing how <u>changes</u> in the dependent variable from period-to-period is influenced by <u>changes</u> in the independent variables from period-to-period. The use of this specification possess one potential hazard, a non-random error term. Error terms must be examined explicitly for this problem and correction procedures taken if necessary.

2.4.3 Variables and Data for Modeling Input Demand

The use of differenced data to expose short-run behavior is a conceptually sound approach. An analytical technique used to expose short-run behavior is further improved by using a data set where information is reported frequently. The data which are most commonly used in empirical studies of the cattle feeding industry are gathered and reported by the USDA. The most frequent of these reports pertaining to cattle are released monthly. It is doubtful that an analysis of month-to-month changes in placements will expose short-run behavior because cattle feeders most likely alter production several times per month in response to changes in economic information. An example follows using arbitrary figures. In month (m) placements totaled 500,000 head in several southwestern cattle feeding states. Because of increasing slaughter steer prices in month (m), placements in the first two weeks of month (m+1) have increased to such levels that the total number of animals placed during month (m+1) will be 1,000,000 head if current rates continue. These increased placements come at a time of adequate future supplies so that distant live cattle futures prices fall. The dampened expectations then result in sharp declines in the numbers of animals placed during the last two weeks of month (m+1) such that the total number placed in the region is 500,000 head. Analyzing this scenario with month-to-month data would altogether miss these two strong short-run responses by cattle feeders to changing cash and futures prices. One other source of information exists which is reported on a more frequent basis.

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 examining the interaction between the cattle feeding sector and the live cattle futures market will 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 will reveal what 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 which belong to this organization 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.

Theory indicates a need for four types of independent variables:

1. Expected Output Price Variables:

a. Five-to-Six Month Distant Futures Contract Price: If cattle feeders use futures prices as an expectation of the cash price at slaughter or if cattle feeders hedge production, then changes in the number of cattle placed on feed are expected to vary directly with changes in the five-to-six month distant futures price. This five-to-six month period is consistent with the amount of time necessary to bring a feeder steer from 650 pounds to 1,050 pounds. These two weights are the average weight of feeder steers placed and the average weight of a choice quality finished animal. The alignment of chronological time with futures contract months are as follows:

Placements During	Futures Contracts Used
December, January	June
February,March	August
April, May	October
June, July	December
August, September	February
October, November	April

The closing futures price, measured in dollars per cwt., on Monday is aligned with the number of head placed during the week. The argument could successfully be made that the Monday-to-Monday change is not the most accurate variable to describe cattle feeder's use of futures prices. Cattle feeders likely use more information provided by the futures market than a single price per week. Cattle feeders may also recognize there is noise in the daily variation of futures prices. Therefore, a more accurate variable may be an average weekly futures price, but problems develop in the use of an average price.

First, the temporal dimensions of an average price are uncertain, because when the price actually occurred during the week is masked. It is possible that much of the information contained within a differenced average futures price between the weeks (t-1) and (t) will emerge late in week (t). It would then be very unlikely that information emerging late in the week will influence placements during the same week. If this is the case then a contemporaneous futures price is actually the futures price variable which is lagged one week. Conversely, if the information contained in a differenced average futures price between week (t-1) and (t) emerges early in week (t), then it is likely that this information could influence placements during week (t). If this is the case then a contemporaneous futures price is represented by a variable with zero lags. Therefore, there is some difficultly defining the contemporaneous futures price variable and all subsequent lagged variables, and difficultly interpreting regression results if the variable is defined arbitrarily.

On the other hand, temporal dimensions of a Monday-to-Monday variable are known exactly. The difference between the price on Monday in week (t) and the price on Monday in week (t+1) occurs early enough in week (t+1) to exert more influence on placements through the week than any other particular day. The second advantage of this variable is that the variable used in modeling the input demand function must also be used later in the lead/lag analysis of futures price changes. In performing lead/lag analyses, understanding the temporal dimensions of the data exactly is crucial to interpretation of the results. Thus, the use of a Monday-to-Monday difference is the next best choice of a futures price variable for the input demand function. Despite short comings, this variable does provide a measure of the direction of change in futures prices between weeks and will likely contain much of the same information contained in a differenced average futures price series.

b. Expected Margin: This margin is calculated as follows:

$$\begin{aligned}\text{Expected Margin(t)} = & \{\text{Distant Futures Price(t)} \times 10.5 \text{ cwt.}\} \\ & - \{\text{Current Feeder Price(t)} \times 6.5 \text{ cwt.}\} \\ & - \{\text{Current Corn Price(t)} \times 45 \text{ bu.}\} \qquad (2.2)\end{aligned}$$

Changes in the placement of cattle on feed should be directly related to changes in expected margin. Cattle feeders may observe the live cattle futures market but be disinterested in the changes of distant futures prices in isolation from changes of the costs of production.

2. Current Output Price Variables:

a. Current Slaughter Steer Price: These figures are weighted average prices received by Cattle Fax member feedlots, measured in dollars per cwt. Changes in placements of cattle on feed should vary directly with changes in slaughter steer prices because: (1) changes in slaughter steer prices will likely influence the levels of cash flow to the feedlot, and (2) some producers could use slaughter steer prices as expectations of future cash prices.

b. Cash Flow: This is a margin variable measured in dollars and calculated as:

$$\begin{aligned}\text{Cash Flow (t)} = &\{\text{Slaughter Steer Price(t)} \times 10.5 \text{ cwt.}\}\\ &- \{\text{Current Feeder Price(t)} \times 6.5 \text{ cwt.}\}\\ &- \{\text{Current Corn Price(t)} \times 45 \text{ bu.}\}\end{aligned} \tag{2.3}$$

Increases or decreases in this type of variable provides a proxy for increases or decreases in the amounts of cash available to cattle feeders for making further purchases. Cash on hand in week (t) will depend on prices for fed animals in week (t) verses the costs of replacing inputs. Changes in cash on hand will change cattle feeders reliance on bank financing of production purchases, therefore increases or decreases in cash on hand are expected to stimulate feeders to increase or curtail placements.

3. Current Input Cost Variables:

The major cost components to feeding cattle are expected to cause placements to vary inversely with their changes. The components to be used in this study are:

a. Feeder Cattle Prices. This series is a weighted average of prices paid by Cattle Fax members, measured in dollars per cwt.

b. Cash Corn Prices. These prices are for #2 Yellow Omaha recorded on the Monday of the week as reported in Grain Market News.

c. Interest Rates. This series is for 9% treasury bond yields recorded on the Monday of the week as reported in Chicago Board of Trade Interest Rate Futures Statistical Annual.

4. Production Technology Factors:

a. Shipments of Finished Cattle from Feedlots to Slaughter: This series is the number of fed cattle marketed, measured in thousands of head, from Cattle Fax member feedlots. Changes in the number of cattle shipped from feedlots should have a direct influence on the changes in placements of cattle on feed.

b. Seasonal Influences: Placements of cattle on feed exhibit seasonal patterns. These patterns are due primarily to the effects of weather and the availability of feed, operating markets, and labor. Monthly dummy variables (intercept shifters) will be used to capture the pattern across the years of the data set. Two dummy variables will be used in November and in December to account for the changes in placements associated with the holiday periods. The first dummy variable in each month will represent shifts in the numbers of animals placed prior to the twentieth of each month and the second dummy variable will represent shifts which occur in the remaining eleven days of each of these two months.

Due to a relatively short interval between observations, it is very likely that the effects of changing values of any independent variable, with the exception of the monthly dummies, will have prolonged influence on the changes in the dependent variable. Once a producer decides that changes in economic variables are signaling that it is favorable to place cattle, it will necessarily take time to locate feeder cattle, arrange financing, purchase the feeders, arrange transportation, and receive feeder animal shipments, then report the placements to Cattle Fax. Conversely, once signals are given to curtail placements, it may take equally as long for contractual obligations made prior to the signals to be completed. For variables within the first three categories, and the shipment variable from the forth category, a time lag structure must be considered to allow for the cumulative impact of changes in the independent variables on the dependent variable. Time lag issues will be discussed in more detail in Chapter 3.

2.5 The Response by Distant Futures Prices to Placement Decisions

This section discusses the theoretical framework which will be used in constructing an empirical model to test the second hypothesis: variations in placements of cattle on feed are significant in explaining variations in distant live cattle futures contract prices.

2.5.1 The Concept of Market Efficiency

Testing the above hypothesis 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 referred to 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'" (Fama p.383). An efficient market is thus one in which information is fully incorporated and utilized as soon as it becomes available. In other words, the best estimate of a future price for a security or a futures contract given current information, should be the current trading price.

Fama hypothesized tests to examine the adjustment of prices due 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" (Fama 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 lead 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 participants 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" (Working 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, 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 works 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.

It is apparent that examining the randomness of successive price changes or the success of trading rules will be an unsatisfactory method of examining the efficiency of the live cattle futures market. The approach in this research will use the following suggestion made by Dewbre (1981). Dewbre states the appropriate test of market performance is whether price changes which 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 such that a market clearing price is achieved. 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.

Previous research examining behavior of prices have typically assumed properties of the relevant information set, without considering the actual physical emergence of information. By modeling distant futures prices as a function of cattle placements, tests can be conducted to examine for a direct relationship between the two series, and if the relationship does exist, examine the time lags associated with the movement of information. This would be classified a semi-strong form test of market efficiency.

2.5.2 Cattle Fax Feedlot Capacity Compared to National Feedlot Capacity

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 of all placements of cattle on feed in the United States. In the process of modeling changes in live cattle futures prices as a function of changes in the number of animals placed on feed in Cattle Fax member feedlots, it is possible that changes within such a subset of placements may not be a large enough portion of the total set to significantly influence prices. The remainder of this subsection presents summary statistics comparing the feedlot capacity of the Cattle Fax membership and the USDA'S Seven States Cattle-On-Feed Report, and comments on the distribution of placement figures in the Cattle Fax newsletter.

Weekly Cattle Fax observations, summed for each month, were found to be 33.7% of the seven states placements, with a 3.1% standard error. If estimates that these seven states contain 70% of total U.S. feeding capacity are correct, then Cattle Fax member feedlots hold 24% of total U.S. feeding capacity. The average number of animals placed per week in the Cattle Fax series was 111,534 head. The standard error of this figure was 2307 head, but placements did dip as low as 24% of average (27,192 head) and rise as high as 204% of average (227,331 head). A description of the distribution of placement figures follows. The first column gives five groups, measured in thousands of head, used to separate the domain, and the second column reports the approximate percentage of observations within the particular groups.

Placement Groupings	Percentage
less than 80	18.77%
80 - 100	21.10%
100 - 120	23.00%
120 - 140	16.90%
greater than 140	20.27%

The tails of the distribution of placements appears to be quite heavy, thus variations of this size within 24% of the U.S. cattle feeding capacity should be large enough to be registered by the futures market.

2.5.3 Analysis of Market Efficiency

Modeling short-run price behavior within the live cattle futures market presents several difficulties. The classic approach to modeling prescribed in most time-series analysis texts, and followed in estimating the input demand function, is to conceptualize all variables which could potentially influence price changes, gather the necessary data or proxies thereof, and iterate through an estimation procedure to identify those variables with statistically significant impacts. The causality criterion developed by Granger (1969) and made operational by Sims (1972), Sargent (1976), and Geweke (1982) provide alternatives to such an approach. These methods provide model specifications, develop tests for the existence of relationships, and measure the associated temporal dimensions between two variables using a bivariate framework. Such an approach can simplify an analysis, especially if the dependent variable is influenced by a large number of factors.

The definition of causality which will provide the basis for tests of market efficiency follows Granger (1969). Granger defined four causal relationships which may occur between economic time series: (1) causality; (2) feedback; (3) instantaneous causality; and (4) causality lag. Feedback relationships between the live cattle futures market and the cattle feeding sector are the essence of this research, but not in the framework as defined by Granger.[4] The general definitions follow from letting U(t) represent an information set accumulated since time (t-1) and letting U(t) - Y(t) denote the information set U(t) apart from the specific series Y(t).

<u>Definition 1: Causality.</u> If $\text{var}(X|U) < \text{var}(X|\overline{U - Y})$, we say that Y is causing X. In simple terms, Y(t) is causing X(t) if we are better able to predict X(t) using all available information than if Y(t) had not been used.

<u>Definition 2: Instantaneous Causality.</u> If $\text{var}(X|\overline{U}, Y) < \text{var}(X|\overline{U})$, we say that instantaneous causality is occuring. The current value of X(t)

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[4] Granger's definition of feedback is simple and allows for the identification of lead/lag relationships between two variables. In this research, feedback is examined more thoroughly through the combination of the input demand function and the models of futures price behavior. To examine feedback in the Granger sense would be redundant.

is better predicted if the current value of $Y(t)$ is included in the prediction than if it is not included.

<u>Definition 3: Causality Lag.</u> If $Y(t)$ is said to cause $X(t)$, we define the causality lag m to be the least value of k such that $var(X|U - Y(k)) < var(X|U - Y(k+1))$. The definition suggests that knowing values of $Y(t-j)$, $j=0,1,2,\ldots,m-1$, will be of no help in improving the prediction of $X(t)$ (Granger 1969, pp. 428-429).

In the above definitions, X and Y are stationary time series, and $var(X|U - Y)$ is the variance of the prediction errors in forecasting X based on the information set U - Y. To make operational the above definitions requires the selection of a relevant subset of the information set $U(t)$. The bivariate framework, which will be employed in this study, assumes all information, other than the past histories of the two variables, is either irrelevant or is incorporated in one of the included variables and therefore redundant.

The intuitive interpretation of this modeling technique is to first explain that part of the futures price series which can be explained by its own past. A model is then built to explain the remaining variability in futures prices using the placement series, and identifying how quickly (by lag structure), and how strongly (by statistical significance) the placement series adds to the predictive power of the model. Thus, we will be able to determine whether the futures market reflects changes in placements quickly, with some substantial time lag, or not at all.

Hudson (1984) makes use of this technique and suggests Granger causality provides a useful technique for the analysis of lead/lag relationships between two economic time series. Hudson applies the concept in a study of price discovery for agricultural commodities. The accuracy of information registration in a market has a timing dimension and a market capacity dimension. If markets are to some degree temporally efficient in information registration, lead/lag relationships between price quotes of two markets provides insight into which market is first in discovering the market clearing price. In this regard, Hudson suggests, the presence of lead/lag relationships also provides insight into the informational capacity and the relative informational efficiency of the particular markets under examination.

The same fundamental arguments apply to the current research; the registration of information on future beef supply conditions in the live cattle futures market has capacity dimensions and timing dimensions. The use of Granger methods will expose the strength and speed behind information flows on future supply conditions from the cattle feeding sector to the price discovery processes of distant contracts in the live cattle futures market. It is likely that other variables, such as current slaughter steer prices, interest rates, and cash corn prices, will exhibit effects on the trading price of live cattle futures, but the influence of these economic variables is primarily indirect because their direct effect is on the number of cattle placed on feed. Therefore, a bivariate model specification should be acceptable for the analysis of market efficiency.

The test adopted for examining causal flows from placements to futures prices was suggested by Geweke (1982) and has been shown to have appealing statistical properties by Geweke, Meese, and Dent (1982). The general specification is as follows:

$$Y(t) = \alpha + \sum_{j=1}^{p} \gamma_j \, Y(t-j) + \sum_{i=0}^{q} \phi_i \, X(t-i) + \varepsilon(t) \qquad (2.4)$$

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 $j=1,2,\ldots,p$;

ϕ_i = coefficients attached to placement variables, where $i=0,1,\ldots,q$, 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 cannot be rejected, the model suggests that information contained in the placement series does not explain movements in futures prices. To satisfy the efficient market criterion outlined in the previous section, it is necessary for the futures market to gather and incorporate information relevant to future economic conditions into the price discovery process quickly and efficiently. Thus, it is necessary for coefficients attached to the placement variables to be significantly different from zero at zero or small lags. Further reference to this gathering and incorporating process will be shortened to the phrase, "information flows". Several tests can be performed on these lead/lag models to reveal the temporal dimensions between the futures price variables and the placement variables. The speeds associated with these information flows are the basis for the efficiency tests. Instantaneous information flows[5] between the cattle feeding sector and the live cattle futures market can be concluded if the following hypothesis can be rejected:

$$\phi_0 = 0.$$

Information flows from the feeding sector to the futures market, which occur at least one week after the placement information has emerged, can be concluded if the following hypothesis is rejected:

$$\phi_1 = \phi_2 = \phi_3 = \ldots = \phi_q = 0.$$

Information flows from the feeding sector to the futures market, which occur at least two weeks after the placement information has emerged, can be concluded if the following hypothesis is rejected:

$$\phi_2 = \phi_3 = \ldots = \phi_q = 0.$$

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[5] Instantaneous in the sense of the smallest unit of time which elapses during the emergence of a single observation, thus in this research, one week.

2.5.4 Variables and Data for Lead/Lag Analyses

Using the guidelines suggested by Hudson (1984), the characteristics of the futures price and the placement data series were examined, and the following modifications will be necessary.

1. The futures price and the placement series were found to be nonstationary in their nondifferenced form, i.e. they contained time related dependencies such as trends. The use of nonstationary data for isolating lead/lag relationships in a bivariate model is known to decrease the chance of identifying the correct relationships (Hudson; Geweke, Meese, and Dent; Nelson and Schwert). Differencing the data will introduce stationarity, and improve the chances of identifying the true relationships. The placement series was first differenced. A procedure similar to differencing was performed on the futures price series to remove the nonstationarity. This process is described in part (2).
2. The temporal characteristics of the two series were found to differ. Understanding the alignment of observations between the two series is crucial in obtaining good estimates, and for correct interpretations of results. Problems were encountered in this data set that stem from the alignment of a weekly placement figure with a Monday price figure. The problem, and the procedure used to resolve it, are explained in detail using the arbitrary month, July 1979.

   The four Cattle Fax newsletters released during July, 1979, reported placements between the following days:

7/2 through 7/7
7/9 through 7/14
7/16 through 7/21
7/23 through 7/28.

Placements occur daily, thus the information contained in a single weekly observation has emerged across the entire week. First differencing the four data points listed above results in three observations, each of which contain information that has emerged across a two week period. The first differenced observations from July, 1979 provide information from:

7/2 through 7/14
7/9 through 7/21
7/16 through 7/28.

The price data, however, has different temporal characteristics. These observations provide price information from a specific point in time. For this example month, the prices were collected from the following dates:

7/2
7/9
7/16
7/23
7/30.

Differencing the futures price series gives changes in futures prices after one week's time has elapsed. For July, 1979 there are price changes between the following days:

7/2 and 7/9
7/9 and 7/16
7/16 and 7/23
7/23 and 7/30.

If both the price series and the placement series are first differenced to remove nonstationarity, without consideration of the temporal dimensions, any modeling results may be questionable. Two first differenced data series will not "mesh" temporally. Examining our arbitrary month of July, 1979 reveals that the first observation will align placement information that has emerged between 7/2 and 7/14, with a price change between 7/2 and 7/9. The second observation will pair placement information that has emerged between 7/9 and 7/21, with a price change between 7/9 and 7/16, and so on. Thus, to produce a futures price series which can be aligned with the differenced placement series, approximately matching its temporal dimensions, the following procedure was carried out. The price observation in time (t-2) was subtracted from the price observation in time (t). For the month of July, 1979 this procedure gives price change observations between the days of:

7/2 and 7/16
7/9 and 7/23
7/16 and 7/30.

The live cattle futures price series, <u>which now contains two overlapping weeks worth of price information</u>, is aligned with a first differenced placement series, which reflects changes in placements of cattle on feed across approximately the <u>same two weeks</u>.

2.6 The Concept of Stability

The input demand function model and the lead/lag model 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 back-and-forth 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. Severe over reactions to new information in either the live cattle futures market or the feeding sector could produce an explosive system.

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. The system as a whole interacts in such a manner that new equilibrium levels of futures prices and placement levels are established after the emergence of new information, and the live cattle futures market would be performing an important economic function.

2.7. Disaggregate Analysis

Two variations of the input demand function for feeder cattle and of the lead/lag modeling efforts will be of interest. The data set upon which the initial analyses are conducted will be 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. Using these two data sets, disaggregate input demand functions for feeder cattle will be estimated and disaggregate lead/lag analyses conducted. The mechanics of disaggregation are discussed in Chapter 3, section 3.5.

2.7.1 Disaggregate Analysis of Supply Response Behavior

The motivation for the disaggregate analysis is to isolate what economic forces cause cattle feeders to specifically increase or decrease rates of placements. Disaggregate data isolates specific responses within the feeding sector. The input demand function from aggregate models are a product of a more general environment. Thus, this analysis should expose characteristics of very short-run behavior by the feeding sector.

The symmetry or asymmetry of the response by cattle feeders to futures prices will be revealed. The live cattle futures market should provide cattle feeders with information on potentially profitable feeding opportunities and information on times when feeding will not be profitable. Thus, cattle feeders should be partly responding to changing futures prices when they are increasing or decreasing placements. If cattle feeders respond to increasing futures prices by increasing placements but do not respond to decreasing prices by decreasing placements, then an argument could be made that the live cattle futures market elicits positive supply responses but fails to perform the opposite service of curtailing placements. It could then be argued that trade in live cattle futures causes burdensome supplies of fed cattle to persist in this arena and potentially increases short-run supply variability.

2.7.2 Disaggregate Analysis of Futures Price Behavior

The two models will reveal whether the live cattle futures market is biased in the process of gathering and incorporating information on increasing or decreasing placements. There is no reason, *a priori*, to expect the magnitudes of coefficients, the significance levels, or the temporal dimensions associated with the price discovery process to be anything but symmetric between the two models.

CHAPTER 3: MODEL SPECIFICATIONS AND ANALYTICAL PROCEDURES

3.1 Introduction

This chapter presents the specifications and the procedures used to estimate the input demand function in Section 3.2, and lead/lag models in Section 3.3. The problems associated with estimating simultaneous systems and the techniques used for the correction of these problems are discussed in Section 3.4. Section 3.5 discusses the technique for creating the disaggregate data set. Section 3.6 presents the analytical techniques for examining the stability of the system, and the procedure for interpreting the estimates of this cattle feeding sector/live cattle futures market system.

3.2 Modeling Changes in Placement Levels

The input demand model was specified in linear form such that the differenced placement series was a function of the four categories of independent variables: expected output price, current output price, current input prices, and technical production factors. For the variables in the first three categories, a possible lag structure from zero to three weeks were 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 rational for the contemporaneous alignment. Using a lag structure from zero to three weeks allows cattle feeders approximately one month to respond to the economic signals. Although this choice was arbitrary, it is reasonable to expect that strong responses to changing signals which are more than a month old in a model using differenced data may be due to spurious correlation between variables.

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, thus 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 when the cattle are placed on feed. Secondly, when the shipment variables are used in a regression procedure, the estimated coefficient measures the response under ceteris paribus conditions. Therefore, changes in placements should respond very rapidly to changes in the shipments of fed cattle from feedlots, given that the shipments are anticipated and given economic conditions are held constant.

The initial specification of the model is presented below:

$$
\begin{aligned}
DPL(t) = \beta_0 &+ \sum_{i=0}^{3} \beta_{1i}\, DCLOSE(t-i) + \sum_{i=0}^{3} \beta_{2i}\, DEXMAR(t-i) \\
&+ \sum_{i=0}^{3} \beta_{3i}\, DSSP(t-i) + \sum_{i=0}^{3} \beta_{4i}\, DCRMAR(t-i) \\
&+ \sum_{i=0}^{3} \beta_{5i}\, DF600(t-i) + \sum_{i=0}^{3} \beta_{6i}\, DCORN(t-i) \\
&+ \sum_{i=0}^{3} \beta_{7i}\, DSYIELD(t-i) + \sum_{i=0}^{1} \beta_{8i}\, DSH(t-i) \\
&+ \sum_{i=2}^{14} D(i) + \varepsilon(t) \qquad (3.1)
\end{aligned}
$$

where:

DPL (t) = Differenced Placements in time (t),
DCLOSE (t-i) = Differenced Futures Price in time (t-i),
DEXMAR (t-i) = Differenced Expected Margin in time (t-i),
DSSP (t-i) = Differenced Slaughter Steer Price in time (t-i),
DCRMAR (t-i) = Differenced Current Margin in time (t-i),
DF600 (t-i) = Differenced Feeder Price in time (t-i),
DCORN (t-i) = Differenced Corn Price in time (t-i),
DSYIELD (t-i) = Differenced Slope Shifting T-Bond Yield in time (t-i),
DSH (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 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. (1984).

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. 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. As in step (3), no more than two variables are deleted at any one time so that behavior of the coefficients, in terms of magnitude and sign, can be examined. The variables are deleted in the order of least significance until all variables in the model are significant at the 15 percent level or smaller.

There will be a conscious attempt to delete margin variables prior to other independent variables. The components of each margin variable are present in the initial model and there is an interest in finding out which of the components within the margin variables are most influential in cattle feeder decision making. The margin variables will be deleted first in steps (3) and (4) unless their performance is exceptional in terms of statistical significance.

In the strictest sense, the deletion of variables in steps (2) and (3) may constitute "data dredging". Such a procedure is deemed necessary in this study for several reasons. The interest in the results of this model are two-fold: the first is for a positive description of what factors influence cattle feeders short-run placement decisions so that the significance of futures price variables can be tested. Second, this model will be used in examining the stability of the cattle feeding sector/live cattle futures market system. Unexpected signs on variables are of little consequence to the first interest, but the use of coefficients which are not significantly different from zero or are inconsistent with economic theory in constructing a system may inaccurately represent the true behavior of that system. It is assumed that unexpected signs are due to spurious correlation and insignificant coefficient estimates are actually equal to zero.

One final problem which will likely be encountered is that the initial model contains forty-six independent variables. In estimating a model with this number of variables it is likely that few if any of the variables will be significant. This is characteristic of the regression technique and will result in a relatively inconclusive model. A procedure must be employed to reduce the number of variables in order to achieve meaningful findings.[6]

---

[6] A 15% critical level is used partly to help combat any critical comments of "data dredging." The level most commonly found in econometric studies is 5%. The 15% level allows a reduction in the number of parameters so that the model does not contain a large number of variables of questionable value. Yet, this level is large enough such that a perspective of which variables perform the strongest can be gained.

3.3 Modeling Changes in Futures Prices

Following the general specification given in equation (2.4), and the lead/lag variables defined and discussed in Chapter 2, the information flows from the feeding sector to the live cattle futures market will be examined with the following model:

$$CLOSEL2(t) = \alpha + \sum_{j=1}^{p} \gamma_j \, CLOSEL2(t-j) + \sum_{i=0}^{q} \phi_i \, DPL(t-i) + \varepsilon(t) \quad (3.2)$$

where:

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

DPL (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 DPL variables, where i=0,1,...,q, and;

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

In the above 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.

The FPE criterion has two appealing qualities. First, the entire notion of causality revolves around whether prediction of a particular variable is improved with the use of a second variable. FPE is based on a prediction criterion. Second, work by Bessler and Binkley (1980) examined the autoregressive filtering of agricultural time series data and the authors suggest the use of FPE to guard against residual autocorrelation in autoregressive modeling. The behavior of residuals is of particular importance to this modeling procedure because positive serial correlation will bias upwards the joint tests of coefficients used to identify the information flows. The result will be that relationships which do not exist may be identified statistically. The use of FPE provides a safe guard against this.

Hsiao suggests the following three step procedure for a bivariate process (using the notation from equation 2.4 and 3.2):

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 estimate 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, will be 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.

3.4 Statistical Problems

The actual estimation can only be carried out after two final problems with this specification are recognized and corrective procedures considered. The two models specified in equations (3.1) and (3.2) have a statistical problem. The differenced placement series and the futures price series are dependent variable and independent variable in the model represented by equation (3.1), and independent variable and a portion of the dependent variable in the model represented by (3.2). 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). 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. This 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 in absolute value than five percent.

Interestingly, if iterations in the estimation of the input demand function result in deletion of the contemporaneous futures price variable from the independent variable set, then this model can be estimated with OLS. With the contemporaneous futures price variable absent, the estimators are no longer biased or inconsistent. Similarly, the first step in the FPE procedure can be estimated via OLS, but the second and third step must use 2SLS or 3SLS because of the the self-imposed restriction of requiring the contemporaneous and the one period lag placement variables in the model.

The two models of interest are now of such form that, with their estimation, the coefficient(s) on the futures price variable(s) in the input demand function will test hypothesis one, and the coefficients on the placement variables in the lead/lag model will test the information flows involved in hypothesis two.

3.5 Construction of the Disaggregate Data Sets

Although the procedure to create the necessary disaggregate data sets is not difficult it must be done correctly or all statistical results will be meaningless. The procedure is give in the following list and supported by an example in Table 1.

1. Data is arranged such that each line in the set contains observations from a individual week. The data is then appropriately differenced.
2. Each variable is lagged the necessary time periods.
3. The sign of the first differenced placement variable is examined. If it is positive the entire line is placed in the "increasing levels" data set. If it is negative the entire line is placed in the "decreasing levels" data set.
4. The previous step is carried out until each line of the original data set is classified.

3.6 Format for Interpretation of Estimation Results

Using the procedures discussed above, the input demand function and the lead/lag model can be estimated, yet slight manipulation of the estimates must be carried out in order to examine the stability of the system and interpret the model coefficients. The following subsections present these analytical procedures.

Table 1. AN EXAMPLE OF HOW DISAGGREGATE DATA SETS ARE CREATED FROM THE AGGREGATE DATA SET.

Aggregate Data Set

Placement Series (t)	Differenced Placement Series (t)	Futures Series (t)	Differenced Futures Series (t)	Differenced Futures Series (t-1)	Differenced Futures Series (t-2)
111000	-1500	60.00	+1.35	+0.50	-1.10
112000	+1000	59.50	-0.50	+1.35	+0.50
113000	+1000	60.00	+0.50	-0.50	+1.35
111000	-2000	61.00	+1.00	+0.50	-0.50
110000	-1000	61.75	+0.75	+1.00	+0.50
115000	+5000	60.75	-1.00	+0.75	+1.00
112500	-2500	59.00	-1.75	-1.00	+0.75

Increasing Levels Data Set

Placement Series (t)	Differenced Placement Series (t)	Futures Series (t)	Differenced Futures Series (t)	Differenced Futures Series (t-1)	Differenced Futures Series (t-2)
112000	+1000	59.50	-0.50	+1.35	+0.50
113000	+1000	60.00	+0.50	-0.50	+1.35
115000	+5000	60.75	-1.00	+0.75	+1.00

Decreasing Levels Data Set

Placement Series (t)	Differenced Placement Series (t)	Futures Series (t)	Differenced Futures Series (t)	Differenced Futures Series (t-1)	Differenced Futures Series (t-2)
111000	-1500	60.00	+1.35	+0.50	-1.10
111000	-2000	61.00	+1.00	+0.50	-0.50
110000	-1000	61.75	+0.75	+1.00	+0.50
112500	-2500	59.00	-1.75	-1.00	+0.75

3.6.1 Procedures to Examine System Stability

Tests for stability were developed by Theil and Boot (1962). The input demand function model and the lead/lag model can be represented in algebraic form as:

$$DPL(t) = \beta_{10}\ DCLOSE(t) + \ldots + \beta_{13}\ DCLOSE(t\text{-}3), \text{ and} \tag{3.3}$$

$$\begin{aligned} CLOSEL2(t) = {} & \phi_0\ DPL(t) + \ldots + \phi_q\ DPL(t\text{-}q) \\ & + \gamma_1\ CLOSEL2(t\text{-}1) + \ldots + \gamma_p\ CLOSEL2(t\text{-}p) \end{aligned} \tag{3.4}$$

It is important to note that the intercept terms and the exogenous variables are unimportant in the analysis of stability -- only the interaction 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 equation (3.4) can be expanded into their basic components using the identity:

$$CLOSEL2(t) = DCLOSE(t) + DCLOSE(t\text{-}1) \tag{3.5}$$

The system in equations (3.3) and (3.4) becomes (see Appendix A for the exact derivation):

$$DPL(t) = \beta_{10}\ DCLOSE(t) + \ldots + \beta_{13}\ DCLOSE(t-3), \text{ and} \tag{3.6}$$

$$\begin{aligned} DCLOSE(t) = {} & \phi_0\ DPL(t) + \ldots + \phi_q\ DPL(t-q) \\ & + \psi_1\ DCLOSE(t-1) + \ldots + \psi_{p+1}\ DCLOSE(t-p-1). \end{aligned} \tag{3.7}$$

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

$$DPL(t) - \beta_{10}\ DCLOSE(t) = \beta_{11}\ DCLOSE(t-1) + \ldots + \beta_{13}\ DCLOSE(t-3) \tag{3.8}$$

$$\begin{aligned} -\phi_0\ DPL(t) + DCLOSE(t) = {} & \phi_1\ DPL(t-1) + \ldots + \phi_q\ DPL(t-q) \\ & + \psi_1\ DCLOSE(t-1) + \ldots + \psi_{p+1}\ DCLOSE(t-p-1). \end{aligned} \tag{3.9}$$

Using the following column vectors and matrices:

$$y(t) = \begin{bmatrix} DPL(t) \\ DCLOSE(t) \end{bmatrix} \qquad y(t-s) = \begin{bmatrix} DPL(t-s) \\ DCLOSE(t-s) \end{bmatrix}$$

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

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

equations (3.8) and (3.9) can simplified to a single equation:

$$\Pi\ y(t) = \Gamma_1\ y(t-1) + \ldots + \Gamma_s\ y(t-s), \text{ or} \tag{3.10}$$

$$y(t) = \Pi^{-1}\Gamma_1\ y(t-1) + \ .\ .\ .\ + \Pi^{-1}\Gamma_s\ y(t-s). \tag{3.11}$$

Equation (3.11) represents the analytically derived reduced form equation of the system. Using the following:

$$A(1) = \Pi^{-1}\Gamma_1 \qquad A(s) = \Pi^{-1}\Gamma_s$$

the reduced form equation (3.11) can be simplified to:

$$y(t) = A(1)\ y(t-1) + \ .\ .\ .\ + A(s)\ y(t-s). \tag{3.12}$$

The system in (3.12) can be enlarged by **s** vector identities:

$$\begin{aligned} y(t) &= A(1)\ y(t-1) + \ .\ .\ .\ + A(s)\ y(t-s) \\ y(t-1) &= y(t-1) \\ &\bullet \\ &\bullet \\ &\bullet \\ y(t-s+1) &= y(t-s+1) \end{aligned} \tag{3.13}$$

which can be written in condensed form as:

$$Y(t) = A^{*}\ Y(t-1) \tag{3.14}$$

where:

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

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

Within the A^{*} matrix an "I" represents a 2×2 identity matrix, and "0" represents a 2×2 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 roots are complex, then this condition requires that all modulus must be less than one.

3.6.2 Interpretation of Coefficient Estimates

The parameter estimates represented in equations (3.3) and (3.4) or in equations (3.6) and (3.7) may not be interpreted directly if contemporaneous values of the endogenous variables are present in the set of regressor variables. The reason is that there is a possibility that the ceteris paribus conditions have been violated. Notice, for example, in equation (3.6) that β_{10} represents the change in placements in time (t) given a one dollar change in futures prices in time (t), holding all other factors constant. But a change in placements in time (t) will simultaneously cause a change in futures prices in time (t) as seen by the coefficient ϕ_0 of equation (3.7). Thus, the interpretation of parameters in this form is unclear if contemporaneous values of the endogenous variables are present in both models. The remainder of this subsection explains a procedure to circumvent this problem and present the findings. The method is general, therefore it reduces to the case where contemporaneous values of the endogenous variables are not present.

To solve the problem, the system is simplified to a form such that the contemporaneous endogenous variables are expressed as a function of lagged values of the endogenous variables and the exogenous variables. This method again follow from Theil and Boot. The result of this procedure is an analytically derived reduced form equation similar to equation (3.12). Whereas the exogenous variables are unimportant for the analysis of stability, these variables must be incorporated into this reduced form equation if the estimated coefficients are to be interpreted. To produce the necessary reduced form equation, (3.10) is modified to contain (v+1) additional components. The system now becomes:

$$\begin{aligned} \Pi\, y(t) &= \Gamma_1\, y(t-1) + \ldots + \Gamma_s\, y(t-s) \\ &\quad + \Theta_0\, x(t) + \ldots + \Theta_v\, x(t-v) \end{aligned} \tag{3.15}$$

where:

$$\Theta_0 = \begin{bmatrix} \beta_{20} & \beta_{30} & \ldots & \beta_{80} \\ 0 & 0 & \ldots & 0 \end{bmatrix}$$

$$\Theta_v = \begin{bmatrix} \beta_{2v} & \beta_{3v} & \ldots & \beta_{8v} \\ 0 & 0 & \ldots & 0 \end{bmatrix}$$

$$x(t) = \begin{bmatrix} DEXMAR(t) \\ DSSP(t) \\ DCRMAR(t) \\ DF600(t) \\ DCORN(t) \\ DSYIELD(t) \\ DSH(t) \end{bmatrix} \qquad x(t\text{-}v) = \begin{bmatrix} DEXMAR(t\text{-}v) \\ DSSP(t\text{-}v) \\ DCRMAR(t\text{-}v) \\ DF600(t\text{-}v) \\ DCORN(t\text{-}v) \\ DSYIELD(t\text{-}v) \\ DSH(t\text{-}v) \end{bmatrix}$$

All elements within the **x** vectors of exogenous variables have been defined in Section 3.2.

Simplification of equation (3.15) gives the following:

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

$$+ B(0)\ x(t) + \ldots + B(v)\ x(t\text{-}v) \tag{3.16}$$

Expanding the system by **s** vector identities gives:

$$Y(t) = A^{*}\ Y(t\text{-}1) \quad + \quad B^{*}\ X(t) \tag{3.17}$$

where: Y(t), A^{*}, and Y(t-1) are as defined earlier and

$$B^{*} = \begin{bmatrix} B(1) & B(2) & B(3) & \ldots & B(v) \\ 0 & 0 & 0 & \ldots & 0 \\ 0 & 0 & 0 & \ldots & 0 \\ 0 & 0 & 0 & \ldots & 0 \\ . & . & . & & . \\ . & . & . & & . \\ . & . & . & & . \\ 0 & 0 & 0 & \ldots & 0 \end{bmatrix} \qquad X(t) = \begin{bmatrix} x(t) \\ . \\ . \\ . \\ . \\ . \\ . \\ x(t\text{-}v) \end{bmatrix}$$

The behavior of the system is analyzed by examining the cumulative effects of shocks to the exogenous variables. There are three types of multipliers which will facilitate the analysis. These multiplier formulas calculate the impacts of changes in the exogenous variables as the effects are passed back-and-forth between the endogenous variables of the two models during the passage of time (Theil and Boot).

Impact Multiplier This type of multiplier measures the immediate impact of a one unit change in the exogenous variables on the endogenous variables in time (t). Impact multipliers are given in the matrix B^*.

Interm Multiplier These multipliers measure the effects of a one unit change in the exogenous variables on the endogenous variables after a specified number of time periods has elapsed. The formula $A^{*\,m-1}\ B^*$ produces multipliers measuring impacts after m time periods.

Total Multiplier Total multipliers represent the effects of a one unit change in the exogenous variables on the endogenous variables as the amount of time lapsed approaches infinity. The formula $(I-A^*)^{-1}\ B^*$ produces total multipliers.

The calculation of significance levels of these multipliers is not possible because the coefficients in the analytically derived reduced form equation are not linear combinations of normally distributed variables. These variables are linear combinations and nested ratios of normally distributed variables. It is possible to calculate the confidence interval of a simple ratio of two normally distributed variables using Fieller's theorem, but these multipliers are not simple ratios; therefore, confidence intervals cannot be derived. <u>However</u>, in the special case were the Π^{-1} matrix of this particular system is lower triangular, the coefficients and related significance levels of the <u>initial</u> shocks to the function will not be altered during the calculation of a reduced form equation.[7] Otherwise, it is assumed that the significance levels associated with the coefficients estimated in the original models will be adequate to test necessary hypotheses.

The pure interaction between the futures market and the cattle feeding sector model can also be measured. Slight adjustments are made to the reduced form equation (3.15) to give:

$$\Pi\, y(t,i) = \Gamma_1\, y(t-1) + \ldots + \Gamma_s\, y(t-s) + \Theta_0(i)\, x(t) \qquad (3.18)$$

where: $i=1,2$

$$\Theta_0(1) = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \qquad \Theta_0(2) = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$x(t) = \begin{bmatrix} \text{random shock in time } (t) \end{bmatrix}$$

[7] Examination of equations (3.8), (3.9), and the matrix notation following these equations reveals that Π^{-1} will be lower triangular if the contemporaneous value of the futures price variable is not in the final form of the input demand function.

The equation (3.18) represents two systems. The first system, when i=1, will shock the error term of the input demand function by one unit (1000 head of cattle), and the second system, when i=2, will shock the error term of the lead/lag model by one unit ($1.00 per cwt.). These shocks are not the result of a change in one of the specified exogenous variables, but are from a random source and will allow ceteris paribus examination of pure interaction between the live cattle futures market and the cattle feeding sector.

CHAPTER 4: EMPIRICAL RESULTS

4.1 Introduction

Using the detailed format presented in Chapter 3, estimation procedures were undertaken. The results from these efforts are presented in this chapter. Section 4.2 discusses some of the pertinent findings upon initial estimation of the two-equation system. Section 4.3 presents the specific results from estimation of the input demand function. Section 4.4 summarizes the findings of the lead/lag analysis. Section 4.5 provides an analysis of the multipliers and evidence with respect to the stability of this cattle feeding sector/live cattle futures market system. Section 4.6 will present the results from the disaggregate analysis of input demand and the lead/lag relationships. Finally, Section 4.7 summarizes the empirical results.

4.2 Initial System Findings

The first process undertaken was the specification of the lag lengths for the two series of regressor variables for the lead/lag analysis. Using the procedure suggested by Hsiao (outlined in Chapter 3) the FPE criterion was minimized with eight lagged values of the dependent variable and two values of the independent variable, contemporaneous and lagged one period. This model was then used in conjunction with the input demand function specified in equation (3.1) to create the initial system.

Estimation of the two-equation system and the immediate following iterations revealed that the longest of the lagged parameters in the input demand function performed poorly, thus they were removed from the model. Subsequent iterations revealed that the contemporaneous futures price variable in the input demand function was of incorrect sign and statistically insignificiant. Once this variable was removed from the model, the input demand function could be estimated via OLS. The lead/lag model must remain in a 2SLS framework, however, because the contemporaneous placement variable remains in the model at all times. A 2SLS framework for the lead/lag models is simple to produce once the final specification of the input demand function is found. The predicted values from the final input demand function model are used as data for the contemporaneous placement variable in the lead/lag model. This will remove the bias and inconsistency properties from the lead/lag model estimates. Lastly, the estimate of cross equation correlation between the two models was found to be slightly less than 3% in the initial system. A 3SLS procedure would improve the efficiency of the estimates only slightly, so the procedure was not used.

4.3 Results from Input Demand Function Modeling

The final results for the input demand function model are presented in Table 2. Collinearity is present but at levels which are not detrimental to model quality. Monte Carlo studies have shown that if variance inflation factors and condition indicies, calculated from any OLS data set, exceed levels of ten and thirty respectively, then collinearity is

Table 2. 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.

severe and the accuracy of all parameter estimates are eroded (Belsley, Kuh, and Welsh). 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 referenced in Chapter 3.

The F statistic for the entire regression is highly significant. Those variables which are present in the final model maintained significance, and stability in terms of parameter magnitude, across the iterations necessary to arrive at this model. Reported in Appendix B in Tables B1, B2, and B3 are the results of the three model iterations prior to the final model. The parameter estimates across these models illustrate this characteristic of stability. 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, i.e. observations within the series move from large positive to large negative values. Of greater interest is the fact that the R-square from the initial estimation of the input demand function in the 2SLS framework was 54.5%. Thus, the deletion of a major portion of the possible variables reduces the explanatory power of the model by a minor amount, 5.28%. The behavior of the final model's parameters and the behavior of the R-square suggests the final model is robust.

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 Thanksgiving and Christmas holidays.

During the estimation procedure, experimentation was carried out with slope shifting interest rate variables where the value which causes the shifts was varied. Prior to the late 1970's, 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 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. Cattle feeders respond consistently to changes in interest rates when making placement decisions in March, 1979, and from October, 1979 to the end of the data set in December, 1983.

The estimates presented in Table 2 can be directly interpreted because the contemporaneous futures price variable is not in the model. The Π^{-1} matrix of the analytically derived reduced form equation was lower triangular, thus the parameter estimates of the input demand function are unaffected by the derivation of this reduced form. Discussion of the estimates from the general input demand function will be presented later in this chapter in Section 4.5 entitled "Multipliers and Stability Results", for the purpose of continuity.

Table 3 presents an interesting deviation from the final model of Table 2. During the iteration process, the variables representing the differenced corn price series and the 650 pound feeder steer price series were eliminated because of their poor performance. The model in Table 3 has all variables which are in the final input demand model but the expected margin variables have been replaced with the two cost components in the margin, i.e. corn and 650 pound steer price series, at identical lags.

The results show that the coefficients on the feeder steer price variables and on the corn price variables are statistically insignificant even at the lenient critical level of 15%. The results suggest that cattle feeders, in the short-run, respond to changes in the expected margin, but not to changes in specific cost components of the margin in the making of placement decisions.

4.4 Results from the Lead/Lag Analysis

As stated in section 4.2, the Geweke type model suggested by the minimization of an FPE criterion contains eight lagged values of the dependent (futures price) variable and two values of the independent (placement) variable, contemporaneous and lagged one period. 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

Table 3. COEFFICIENT ESTIMATES FROM THE INPUT DEMAND FUNCTION FOR FEEDER CATTLE WHERE MARGIN VARIABLES HAVE BEEN REPLACED WITH THE MARGIN COST COMPONENTS

DEPENDENT VARIABLE: Differenced Placements (1000 Head)

F VALUE 9.8839 PROB > F 0.0001
R-SQUARE 0.4806 ADJUSTED R-SQUARE 0.4320
DEGREES OF FREEDOM 235

	PARAMETER ESTIMATE	t RATIO	P VALUE*
INTERCEPT	1.5300	0.383	0.7018
FUTURES PRICE (t-2)	2.1935	2.571	0.0108
CORN PRICE (t)	-4.9263	-0.515	0.6070
CORN PRICE (t-1)	-8.5951	-0.876	0.3819
FEEDER PRICE (t)	0.0309	0.030	0.9760
FEEDER PRICE (t-1)	1.3626	0.901	0.3684
CASH STEER PRICE (t-1)	2.7745	1.912	0.0572
T-BOND YIELD (t)	-0.0119	-3.088	0.0023
SHIPMENTS (t)	0.7381	9.986	0.0001
SHIPMENTS (t-1)	0.1983	2.834	0.0050
FEBRUARY	-3.54	-0.636	0.5254
MARCH	7.16	1.280	0.2018
APRIL	-5.43	-0.961	0.3377
MAY	5.29	0.966	0.3348
JUNE	-7.73	-1.410	0.1600
JULY	-0.21	-0.040	0.9682
AUGUST	1.32	0.244	0.8071
SEPTEMBER	8.51	1.552	0.1220
OCTOBER	4.00	0.734	0.4634
NOVEMBER (first 20 days)	-12.66	-2.024	0.0441
NOVEMBER (last 11 days)	-20.71	-2.557	0.0112
DECEMBER (first 20 days)	-4.23	-0.700	0.4848
DECEMBER (last 11 days)	-16.70	-2.027	0.0438

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

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. This can be achieved through a comparison of the relative significance levels of coefficients attached to the placement series variables.

The results from these two models are presented in Tables 4 and 5. In the first model, which contains two placement variables, an instantaneous information flow was identified with a 31.1% chance of error. A lagged information flow of one period was also identified, with a 5.4% chance of error. 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. Table 5 contains the results of the second model. An instantaneous information flow was identified with a 29.6% chance of error, a lagged information flow of one period was identified with a 13.6% chance of error, and a lagged information flow of two periods was identified with a 58.4% chance of error. 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, within the Cattle Fax member feedlots, significantly 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

Table 4. ESTIMATES FROM THE FIRST GEWEKE MODEL WHICH INCORPORATES TWO PLACEMENT VARIABLES

DEPENDENT VARIABLE: Corrected Futures Price Series

F VALUE 14.949 PROB > F 0.0001
R-SQUARE 0.3838 ADJUSTED R-SQUARE 0.3581
DEGREES OF FREEDOM 247

	PARAMETER ESTIMATE	t RATIO	P VALUE
INTERCEPT	-0.0071	-0.067	0.9469
PLACEMENTS (t-1) - (t)	-0.0064	-1.013	0.3121
PLACEMENTS (t-2) - (t-1)	-0.0085	-1.934	0.0543
FUTURES VARIABLE (t-3) - (t-1)	0.7320	11.339	0.0001
FUTURES VARIABLE (t-4) - (t-2)	-0.6964	-8.880	0.0001
FUTURES VARIABLE (t-5) - (t-3)	0.5922	6.692	0.0001
FUTURES VARIABLE (t-6) - (t-4)	-0.4954	-5.311	0.0001
FUTURES VARIABLE (t-7) - (t-5)	0.3241	3.455	0.0007
FUTURES VARIABLE (t-8) - (t-6)	-0.2884	-3.284	0.0012
FUTURES VARIABLE (t-9) - (t-7)	0.2236	2.905	0.0040
FUTURES VARIABLE (t-10) - (t-8)	-0.0872	-1.371	0.1716

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

Table 5. ESTIMATES FROM THE FIRST GEWEKE MODEL WHICH INCORPORATES THREE PLACEMENT VARIABLES

DEPENDENT VARIABLE: Corrected Futures Price Series

F VALUE 13.578 PROB > F 0.0001
R-SQUARE 0.3846 ADJUSTED R-SQUARE 0.3563
DEGREES OF FREEDOM 246

	PARAMETER ESTIMATE	t RATIO	P VALUE
INTERCEPT	-0.0066	-0.062	0.9507
PLACEMENTS (t-1) - (t)	-0.0067	-1.048	0.2959
PLACEMENTS (t-2) - (t-1)	-0.0089	-1.987	0.0480
PLACEMENTS (t-3) - (t-2)	-0.0024	-0.549	0.5838
FUTURES VARIABLE (t-3) - (t-1)	0.7285	11.213	0.0001
FUTURES VARIABLE (t-4) - (t-2)	-0.6931	-8.799	0.0001
FUTURES VARIABLE (t-5) - (t-3)	0.5950	6.703	0.0001
FUTURES VARIABLE (t-6) - (t-4)	-0.4916	-5.248	0.0001
FUTURES VARIABLE (t-7) - (t-5)	0.3262	3.469	0.0006
FUTURES VARIABLE (t-8) - (t-6)	-0.2933	-3.317	0.0011
FUTURES VARIABLE (t-9) - (t-7)	0.2259	2.927	0.0038
FUTURES VARIABLE (t-10) - (t-8)	-0.0871	-1.369	0.1724

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

the majority of this information is incorporated after the passage of one week, as seen by a comparison of significance levels of the placement variables (see Figure 3).

Figure 3 presents two time lines; the weeks within these lines are denoted by symbols (t+i), where i = 0, 1, . . . q. The first lead/lag model is presented on line A, and the second lead/lag model is presented on line B. The large horizontal brackets above the time lines denote the periods covered by the placement variables within the two lead/lag models. The numbers presented above these brackets denote the p-values of the particular placement variables. The large horizontal bracket below the time line represents the period when a given block of information, Φ, physically emerges.

The results of the first Geweke model shows that the majority of information which emerges between weeks (t) and (t+1) is incorporated into futures prices during weeks (t+1) and (t+2). The results of the second Geweke model again reveals this identical information flow. A comparison of significance levels of the placement variables preceding and following the variable examining weeks (t+1) and (t+2), (0.30 < 0.58), suggests that the bulk of information absorbed during this time period may take place in week (t+1). The arrow from Φ to week (t+2) identifies when information Φ becomes obviously public, due to the dissemination of the Cattle Fax newsletter. These diagrams show that information on placements of cattle on feed is registered in the live cattle futures market no later than the week the information becomes available via the newsletter, with the distinct possibility this incorporation occurs prior to the release.

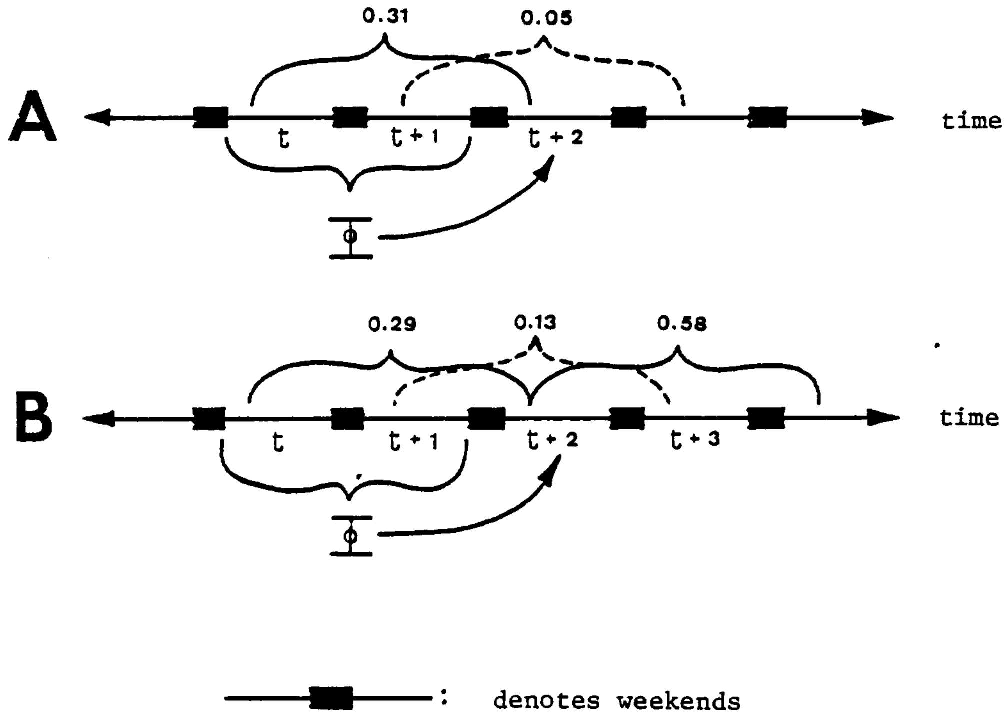

Figure 3. Illustration Of The Temporal Dimensions Associated With The Lead/Lag Modeling Results.

These modeling efforts show that there is a time lag of one week between the placement of cattle on feed and the incorporation of this information into the price discovery process for live cattle futures. The time lag should not, however, be construed as market inefficiency. The cattle Fax newsletter is received by subscribers 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 information is technically available as soon as the actual placements occur, but the gathering process is expensive. The Cattle Fax newsletter is a relatively inexpensive and compact source of one week old placement information. An efficiency criterion demanding instantaneous adjustment by the live cattle futures market to changes in placements, without considering the costs of gathering versus their potential returns, is not rational. But the futures market should, and does, adjust rapidly to new information revealed through an inexpensive report.

The findings suggest that the live cattle futures market is semi-strong form efficient because the market absorbs new information during and possibly prior to the time period 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.

4.5 Multipliers and Stability Results

Using the results of the previous two sections of this chapter and the format on interpreting results presented in Chapter 3, the analytically derived reduced form equation of this system was calculated using the final form of the input demand function and the first lead/lag model. Several of the parameter estimates in this equation were relatively large in magnitude and possessed variances which questioned their significance. This was especially true with the autoregressive parameters of the lead/lag model. Coefficients were set equal to zero if the estimate was not significantly different from zero at the $\alpha = 0.10$ level.

Table 6 presents the impact, eight interm, and the total multipliers resulting from shocks to the exogenous variables specified in the final models of changes in placements and changes in live cattle futures prices. Theil and Boot provides a complete discussion of these multipliers. A \$1.00 increase (decrease) in the expected margin between the weeks (t-1) and (t) will cause placements in Cattle Fax member feedlots to increase (decrease) by 219 head between the weeks (t-1) and (t), increase (decrease) by 157 head between the weeks (t) and (t+1), and increase (decrease) by zero head between weeks (t+1) and (t+2). The total effect as an infinite amount of time passes approaches 369 head.

A \$1.00 per cwt. increase (decrease) in slaughter steer prices between the weeks (t-1) and (t) will cause placements to increase (decrease) by 3303 head between weeks (t) and (t+1), a 2.96% change from average levels, with the net effect in the limit being 3244 head. A 1% increase (decrease) in interest rates as proxied by T-bond yields between the weeks

Table 6. MULTIPLIERS MEASURING THE IMPACTS ON PLACEMENTS GIVEN ONE UNIT SHOCKS TO THE SPECIFIED EXOGENOUS VARIABLES

	SPECIFIED EXOGENOUS VARIABLES (Units of Measure)			
MULTIPLIERS	EXPECTED MARGIN ($)	STEER PRICE ($/cwt)	T-BOND YIELD (%)	SHIP-MENTS (K Head)
IMPACT (t=0)**	0.2191* (0.0220)***	0.0	-0.0119	0.7290 (0.0001)
INTERM 1 (t=1)	0.1567 (0.1134)	3.3034 (0.0007)	0.0	0.2216 (0.0022)
INTERM 2 (t=2)	0.0	0.0	0.0	0.0
INTERM 3 (t=3)	-0.0052	0.0	0.0003	-0.0173
INTERM 4 (t=4)	0.0002	-0.0783	-0.0001	0.0004
INTERM 5 (t=5)	0.0006	0.0210	0.0000	0.0001
INTERM 6 (t=6)	0.0000	-0.0056	0.0000	0.0004
INTERM 7 (t=7)	0.0000	0.0034	0.0000	-0.0001
INTERM 8 (t=8)	0.0009	-0.0014	0.0001	0.0030
TOTAL ($t=\infty$)	0.3692	3.2444	-0.0117	0.9238

* Figures are measured in thousands of head of cattle placed.
** Weeks elapsed after the initial shock to the exogenous variable.
*** P-values, if available.

(t-1) and (t) will increase (decrease) placements by less than 12 head between the same two weeks, and by less than 12 head in the infinite horizon.

A 1000 head increase (decrease) in shipments from Cattle Fax member feedlots between the weeks (t-1) and (t) will result in an increase (decrease) in the number of cattle placed by 729 head between the same two weeks and by 212 head between week (t) and (t+1), with a net effect of 924 head in the infinite horizon. The coefficients on the two shipment variables indicate that, if all other economically important variables such as prices, margins, and seasons, are held constant, then cattle feeders will place 941 head of cattle within one week after shipping 1000 head of finished cattle. This 941 value is not significantly different from 1000, thus the shipment variable coefficients show that when all other variables are held constant, cattle feeders fill empty pens within one week after shipping finished cattle. This result further helps to solidify confidence that the model is specified correctly, and is robust.

Table 7 presents multipliers which reveal the pure interaction between the input demand function model and the lead/lag model. The top half of Table 7 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 7 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).

Table 7. MULTIPLIERS MEASURING INTERACTION OF THE INPUT DEMAND FUNCTION AND THE LEAD/LAG MODEL WHEN SHOCKED FROM A RANDOM SOURCE

	RANDOM SHOCK TO THE INPUT DEMAND FUNCTION		
MULTIPLIERS	DPL (1000 Head)	DCLOSE ($/cwt.)	
IMPACT	1.0	0.0	
INTERM 1	0.0	-0.0086	(0.0543)*
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 LEAD/LAG MODEL		
MULTIPLIERS	DPL (1000 Head)		DCLOSE ($/cwt.)
IMPACT	0.0		1.0
INTERM 1	0.0		-0.2680
INTERM 2	2.7794	(0.0015)*	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

* P-values, if available.

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 both types of random shocks. The interaction within this system given a random shock to the input demand function reveals a highly stable set of multipliers. A 1000 head increase (decrease) in placements causes the futures market to make adjustments in distant contract prices initially which are followed by shrinking oscillatory adjustments. Likewise, all subsequent adjustments of placements in the input demand function after the initial random shock are less than 25 animals. 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 input demand function 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 the response or curtailment of 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 equal to -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.

4.6 Results from the Disaggregate Analysis

In this section, two sets of results for the input demand function and the lead/lag models will be presented. The first group was estimated using a subset of the original data where placement figures were positive, and the second uses a subset where placements were declining. Using the dummy variable estimates from the general input demand function, which were statistically significant at $\alpha = 0.15$ level, the differenced placement series was deseasonalized for this analysis. Seasons play an important role in determining levels of placements; therefore, seasonal variables should be present in an input demand function for feeder cattle, but free-form estimation of seasonal fluctuations from disaggregate data may fit an obscure pattern. The use of the above procedure should remove an seasonal pattern consistent with a more general environment. Other than the absence of the dummy variables from the input demand function, the procedures to be followed in the estimation of the input demand function and the lead/lag models for the disaggregate analysis are identical to those followed for the more general forms outlined in Chapters 2 and 3, unless otherwise specified.

4.6.1 Disaggregate Input Demand Functions

The input demand functions for increasing and decreasing placements do not perform as well as the general model, but this should not serve as a dominant factor in establishing a preference for the aggregate or disaggregate models. These two types of models examine producer behavior in two different environments where the disaggregate environment is a subset of the aggregate environment, and therefore can be thought of as more constricted. It would not be surprising if models of a constricted environment performed poorly when compared to a more general environment.

F statistics for both models are significant at the 0.01% level. Collinearity is present in both models but the diagnostics are well below threshold levels. Serial correlation is present in both models; thus, the results to be presented are from the two step full transformation corrective procedure.

The results to the two input demand functions are presented in Tables 8 and 9. 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 iterative procedure used to reduce the number of parameters was stopped when there were no variables of incorrect sign, and when all p-values were greater than 0.50. The differenced live cattle futures price variable and the cash slaughter price variables were maintained in the model as long as they were of correct sign. These two criterion will produce a model which allows a more general comparison of what variables cattle feeders are responding to when increasing or decreasing rates of placement than would models produced from the more strict procedure employed earlier. This model also permits the direct comparison of the role of live cattle futures market prices and cash slaughter steer prices in the supply response.

The contemporaneous value of the futures price variable in both disaggregate models was found to be insignificant and of inconsistent sign during the iterative process. The removal of this variable enables the

Table 8. 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.

Table 9. 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.

subsequent coefficients and significance levels to be interpreted directly, without transformation through the analytically derived reduced form equation. These coefficients measure the initial impacts of a change in the underlying variable on the placement series. The initial impacts will be sufficient for the analysis; thus, longer term multipliers and total multipliers will not be reported.

During weeks when placements are increasing, the model presented in Table 8 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, in that order of importance. A \$1.00 increase (decrease) in futures prices will result in increases (curtailed increases) in average placements across two weeks for a total change of 4129 head. A \$1.00 per cwt. increase (decrease) in slaughter steer prices will cause increases (curtailed increases) in placements across three weeks for a total effect of 1723 head or an 1.54% change from average levels. A \$1.00 per cwt. decrease (increase) in the price of feeder cattle will cause a 3172 head, or 2.84%, increase (curtailed increases) in average placements during the same time period. The shipments and expected margin variables indicate that during periods of increased placements, part of the increase is due to increased shipments and increases in the expected margin.

An important feature revealed by this table 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 very high degree of inconsistency to changes in cash prices for finished animals.

For periods when placements are decreasing, the model presented in Table 9 indicates that cattle feeders respond to changing futures prices, shipments, cash steer price, and the expected margin, in that order of magnitude. A $1.00 decrease (increase) in the distant live cattle futures contract will result in decreases (slowed decreases) in the placement of cattle on feed with the total effect measuring 4883 animals, or a 4.38% change from average levels. For every 1000 head reduction in the number of finished cattle shipped from Cattle Fax member feedlots, 458 less cattle are placed in response. 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 symmetric between periods of increasing and decreasing placements.[8] Cattle feeders weight

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[8] The negative response attributed to changes in futures prices is 755

decreases in futures prices equally important as increases in futures prices. The live cattle futures market therefore not only motivates placements in anticipation of reduced supplies of fed cattle, a desirable performance, but also works to curtail placements, discouraging over reactions, 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 explicitly increase or decrease placement rates. This should not be a surprising because of the following factors. The membership to 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 production decisions based on expectations of future conditions. Second, when cattle feeders are evaluating a specific decision, where 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

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head greater than the positive response attributed to changes in futures prices, but this level is statistically insignificant from zero.

(i.e. increasing or decreasing placements), current cash prices play a small and indirect role.

4.6.2 Disaggregate Lead/Lag Analysis

As with the disaggregate analysis of the input demand function, this subsection presents the estimates of lead/lag models from two subsets of the original data, and similar to the general lead/lag modeling efforts, two models will be estimated (within each subset). The first model contains the number of placement parameters necessary to minimize the FPE criterion (q) and the second contains (q+1) placement parameters in order to establish additional perspective on the temporal dimensions of these information flows. Also similar to the general lead/lag analysis is that the data for the contemporaneous placement variables in these lead/lag models comes from the predicted values of the appropriate disaggregate input demand function. The placement variable in these disaggregate input demand functions was deseasonalized; therefore, the lead/lag analysis makes use of lagged values of this variable for consistency.

The lead/lag models 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 lead/lag models estimated under general conditions. The two separate models were estimated with the same specifications as the general lead/lag models. In the first model the contemporaneous placement variable was significant at the 53.1% level, and the placement variable lagged one period was significant at the 13.9% level. In the second model the contemporaneous placement variable was significant at the 45.5% level, the placement variable lagged one period was significant at the 11.8% level, and the placement variable lagged two periods was significant at the 34.7% level.

The individual coefficients on the placement variables are 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 approximately reduced by 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 from periods when placements were decreasing did reveal surprising results. The temporal dimensions associated with information flows containing news of decreasing placements were different than those of the lead/lag models estimated under general conditions and under conditions of increasing placements. In the first model the contemporaneous placement variable was significant at the 28.1% level, and the placement variable lagged one period was significant at the 50.7% level. In the second model the contemporaneous placement variable was significant at the 26.5% level, the placement variable lagged one period was significant at the 49.5% level, and the placement variable lagged two periods was significant at the 68.8% level.

These two models 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 suggest that, most likely, the live cattle futures market has trouble registering specific information on decreasing rates of placements of cattle on feed.

4.7 Summary

The empirical results reported in this chapter have confirmed all three of the hypotheses presented in Chapter 1. Cattle feeders respond to changing prices of distant live cattle futures contracts in making decisions on the number of cattle to be placed on feed. The live cattle futures market appears to be semi-strong form efficient in the gathering and incorporation of information on future supply conditions. Information contained in the Cattle Fax newsletter is reflected in live cattle futures prices during the week the newsletter is released. And lastly, the recursive system created by the interaction of these two economic entities is stable.

CHAPTER 5 SUMMARY AND CONCLUSIONS

5.1 Introduction

The previous chapters have presented the conceptual framework, methods, and empirical results from research which has examined the interaction between the cattle feeding sector and the live cattle futures market. Section 5.2 summarizes the findings from the analysis of the response by Cattle Fax member feedlots to changes in live cattle futures prices. Section 5.3 summarizes the tests of efficiency of the live cattle futures market. Section 5.4 comments on the stability of this recursive economic system and Section 5.5 presents concluding remarks.

5.2 Supply Response by Cattle Feeders

The general analysis of behavior in the cattle feeding sector, as modeled by the input demand function for feeder weight animals, confirms hypothesis one. 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. Increasing futures prices suggest a relatively small supply of cattle will be arriving in slaughter markets in distant time periods. The positive response by cattle feeders to these increases serves to increase future supplies of fed cattle, thus preventing any shortage from occurring. The converse also appears to be true. Decreasing distant futures prices, in response to prospects of abundant future beef supplies, will curtail placements. This will prevent prolonged periods of over supplies of beef and the low prices which accompany them.

When the data under examination was disaggregated into one subset where placement levels are increasing, and a second subset where placement levels are decreasing, the results of the input demand functions for feeder cattle show that placements increase 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. Thus, the live cattle futures market cannot be blamed for eliciting increased placements but failing to constrain placements.

5.3 Efficiency of the Live Cattle Futures Market

The lead/lag analysis of 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 the price discovery process for distant contracts. This information is incorporated into prices the same week the information becomes obviously available to the public through the release of the Cattle Fax newsletter, suggesting the market is semi-strong form efficient.

Additional lead/lag models of futures price changes reveal that the live cattle futures market performs the process of gathering and incorporating placement information when levels are increasing at approximately the same speeds at which it preforms these processes in the general environment. But the lead/lag results on decreasing placements suggests that this market has trouble gathering and incorporating this type of information. Increasing placements are quickly registered in the live cattle futures market, depressing the price of the distant contracts, thus avoiding continued increases in placements of cattle and depressed cash cattle prices in the future. Decreasing placements are not registered as quickly or as consistently in the futures market. Prices of distant futures contracts consequently do not reflect the potential shortages without some time lag. Supply responses are therefore not as strong and the general level of cash cattle prices may be slightly inflated because of this less efficient response in the futures market.

5.4 Stability of the System

The recursive economic system described mathematically by the input demand model and the model of futures price behavior is stable. A shock to this system works its effects back-and-forth between the two models as time passes and eventually becomes negligible. Changes in information pertinent to the feeding sector and the live cattle futures market will cause orderly shifts to new equilibrium levels of live cattle futures prices and placements of cattle on feed.

5.5 Final Remarks

Cattle feeders respond to changes in the prices of distant live cattle futures contracts when making placement decisions. A disaggregate analysis of supply response suggests that the live cattle futures market carries the burden of directing placement behavior. Time-related models reveal that the live cattle futures market is effective in registering information on future supply conditions coming out of the feedlot complex.

If the time lags were longer or if the futures market was less efficient in absorbing the information, the possibility of more pronounced swings in fed cattle supplies would increase. The stability results provide empirical evidence that "shocks" to either futures prices or placements sets in motion interactions and a recursive system that moves to restore an equilibrium situation.

Theoretically, the futures market is charged with the task of making a significant contribution to the price discovery process. The nature of supply response and the effectiveness in incorporating new information are of integral importance to the effectiveness of price discovery. This analysis suggests these functions are performed quite well.

In conclusion, this research 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.

LITERATURE CITED

Akaike, H. (1969): "Fitting Autoregressive Models for Prediction," Annals of the Institute of Statistical Mathematics, 21: 243-247.

Belsley, D. A., Kuh, E., and Welsh, R. E. (1980): Regression Diagnostics: Identifying Influential Data and Sources of Collinearity, John Wiley and Sons, Inc., New York.

Bessler, D. A., and Binkley, J. (1980): "Autoregressive Filtering of Some Economic Data Using PRESS and FPE," Proceedings, American Statistical Association, Business and Economic Statistics Section, pp. 261-265.

Black, F. (1976): "The Pricing of Commodity Contracts," as reprinted in Peck (1984), pp. 181-192.

Bressler, R. G., and King, R. A. (1978): Markets, Prices, and Interregional Trade, John Wiley and Sons, Inc., New York.

Cargill, T. F., and Rausser, G. C. (1975): "Temporal Price Behavior in Commodity Futures Markets," as reprinted in Peck (1984), pp. 225-235.

Cox, J. C. (1976): "Futures Trading and Market Information," Journal of Political Economy, 84: 1215-1237.

Chicago Board of Trade Interest Rate Futures Statistical Annual, Chicago Board of Trade, Chicago, various issues.

Chicago Mercantile Exchange Year Book, Chicago Mercantile Exchange, Chicago, various issues.

Danthine, J. (1978): "Information, Futures Prices, and Stabilizing Speculation," Journal of Economic Theory, 17: 79-98.

Dewbre, J. H. (1981): "Interrelationships Between Spot and Futures Markets: Some Implications of Rational Expectations," American Journal of Agricultural Economics, 63: 926-933.

Fama, E. F. (1970): "Efficient Capital Markets: A Review of Theory and Empirical Work," Journal of Finance, 65: 383-421.

Feder, G., Just, R. E., and Schmitz, A. (1980): "Futures Markets and the Theory of the Firm Under Price Uncertainty," Quarterly Journal of Economics, 19: 317-328.

Forker, O. D. (1975): "Price Determination Processes: Issues and Evaluation," FCS Information 102, Farmer Cooperative Service, United States Department of Agriculture, September, 27 pp.

Geweke, J. (1982): "Inference and Causality in Economic Time Series Models," Handbook of Econometrics Eds. Z. Griliches and M. Intrilligator, Amsterdam-North Holland.

Geweke, J., Meese, R., and Dent, W. T. (1982): "Comparing Alternative Tests of Causality in Temporal Systems: Analytic Results and Experimental Evidence," SSRI Workshop Series, No.8212, University of Wisconsin, Madison.

Grain Market News, USDA, AMS, various issues.

Granger, C. W. J. (1969): "Investigating Causal Relationships by Econometric Models and Cross-Spectral Methods," Econometrica, 37: 424-438.

Gray, R. W. (1972): "The Futures Market for Maine Potatoes: An Appraisal," as reprinted in Peck (1977), pp. 337-366.

Gray, R. W. (1963): "Onions Revisited," as reprinted in Peck (1977), pp. 325-336.

Grossman, S. J. (1977): "The Existence of Futures Markets, Noisy Rational Expectations and Information Externalities," Review of Economic Studies, 44: 431-449.

Harvey, A. C. (1981): The Econometric Analysis of Time Series, John Wiley and Sons, Inc., New York.

Helmuth, J. W. (1983): "Cattle Futures," Speech before a group of cattle industry representatives.

Helmuth, J. W. (1981): "A Report on the Downward Bias in Live Cattle Futures Market," Journal of Futures Markets, 3: 347-358.

Henderson, J. M., and Quandt, R. E. (1980): Microeconomic Theory: A Mathematical Approach, 3rd. ed., McGraw-Hill, New York.

Hoffman, G. (1979): "The Effects of Futures Prices on the Short-Run Supply of Fed Cattle and Hogs," Livestock Futures Research Symposium, R. M. Leuthold and P. M. Dixon, Eds, Chicago Mercantile Exchange, Chicago, pp. 163-180.

Hsiao, C. (1979): " Autoregressive Modeling of Canadian Money and Income Data," Journal of the American Statistical Association, 74: 553-560.

Hudson, M. A. (1984): "Price Discovery and Lead/Lag Relationships Between Cash and Futures Prices for Agricultural Commodities: Theory and Applications," unpublished Ph. D. dissertation, Virginia Polytechnic Institute and State University.

Hudson, M. A., and Purcell, W. D. (1984): "Price Discovery Processes in the Slaughter Cattle, Carcass Beef, and Live Cattle Futures Markets," Summary Report for Cooperative Agreement (12-28-A-1000) between the Packers and Stockyards Administration of the USDA and the Agricultural Economics Department of Virginia Polytechnic Institute and State University, July.

Johnston, J. (1984): Econometric Methods, 3rd. ed., McGraw-Hill, New York.

Judge, G. G., Griffiths, W. E., Hill, R. E., and Lee, T. C. (1980): The Theory and Practice of Econometrics, John Wiley and Sons, Inc., New York.

Just, R. E., and Rausser, G. C. (1981): "Commodity Price Forecasting with Large-Scale Econometric Models and the Futures Markets," as reprinted in Peck (1984), pp. 61-75.

Kaldor, N., Dow, and Hawtrey (1939): "A Symposium on the Theory of Forward Markets," Review of Economic Studies, 7: 195-205.

Kofi, T. A. (1973): "A Framework for Comparing Efficiency of Futures Markets," American Journal of Agricultural Economics, 55: 584-594.

Kolb, R. W., and Gay, G. D. (1983): "The Performance of Live Cattle Futures as Predictors of Subsequent Spot Prices," Journal of Futures Markets, 3: 55-63.

Koppenhaver, G. D. (1983): "The Forward Pricing Efficiency of the Live Cattle Futures Market," Journal of Futures Markets, 3: 307-319.

Larson, A. B. (1960): "Measurement of a Random Process in Futures Prices," Food Research Institute Studies, 1: 313-324.

Leuthold, R. M. (1979): "An Analysis of the Futures-Cash Price Basis for Live Beef Cattle," North Central Journal of Agricultural Economics, 1: 47-52.

Leuthold, R. M. (1974): "The Price Performance on the Futures Market of a Nonstorable Commodity: Live Beef Cattle," as reprinted in Peck (1977), pp. 55-65.

Leuthold, R. M., and Dixon, P. M., Eds. (1980): Livestock Futures Research Symposium, Chicago Mercantile Exchange, Chicago.

Leuthold, R. M., and Hartman, P. A. (1979): "A Semi-Strong Form Evaluation of the Efficiency of the Hog Futures Market," American Journal of Agricultural Economics, 61: 482-489.

Martin, L., and Garcia, P. (1981): "The Price-Forecasting Performance of Futures Markets for Live Cattle and Hogs: A Disaggregate Analysis," as reprinted in Peck (1984), pp. 51-60.

Miller, S. E., and Kenyon, D. E. (1979): "Empirical Analysis of Live Hog Futures Price Use by Producers and Packers," Livestock Futures Research Symposium, R. M. Leuthold and P. M. Dixon, Eds, Chicago Mercantile Exchange, Chicago, pp. 109-133.

Nelson, C. R., and Schwert, G. W. (1982): "Tests for Predictive Relationships Between Time Series Variables: A Monte Carlo Investigation," Journal of the American Statistical Association, 377(March): 11-18.

Peck, A. E., Ed. (1984): Selected Writings on Futures Markets: Research Directions in Commodity Markets, 1970-1980, Chicago Board of Trade, Chicago.

Peck, A. E., Ed. (1977): Selected Writings on Futures Markets, Vol. 2, Chicago Board of Trade, Chicago.

Peck, A. E. (1976): "Futures Markets, Supply Response, and Price Stability," Quarterly Journal of Economics, 90: 407-423.

Peck, A. E. (1973): "Futures Markets, Supply Response, and Price Stability," unpublished Ph. D. dissertation, Stanford University.

Powers, M. J. (1970): "Does Futures Trading Reduce Price Fluctuations in Cash Markets ?," American Economic Review, 60: 460-464.

Purcell, W. D., Flood, D., and Plaxico, J. (1979): "Cash-Futures Interrelationships in Live Cattle: Causality, Variability, and Pricing Processes," Livestock Futures Research Symposium, R. M. Leuthold and P. M. Dixon, Eds, Chicago Mercantile Exchange, Chicago, pp. 135-161.

Samuelson, P. (1965): "Proof that Properly Anticipated Prices Fluctuate Randomly," Industrial Management Review, 6: 41-50.

Sargent, T. J. (1976): "A Classical Macroeconomics Model for the United States," Journal of Political Economy, 84: 207-238.

Schmit, S. (1965): "A Test of the Serial Independence of Price Changes in Soybean Futures," as reprinted in Peck (1977), pp. 253-273.

Sims C. A. (1972): "Money, Income, and Causality," American Economic Review, 62: 540-552.

Stevenson, R. A., and Bear, R. M. (1970): "Commodity Futures: Trends or Random Walks ?," as reprinted in Peck (1977), pp. 275-290.

Taylor, G. S., and Leuthold, R. M. (1974): "The Influences of Futures Trading on Cash Cattle Price Variations," as reprinted in Peck (1977), pp. 367-373.

Telser, L. G. (1979): "Reasons for Having an Organized Futures Market," Livestock Futures Research Symposium, R. M. Leuthold and P. M. Dixon, Eds, Chicago Mercantile Exchange, Chicago, pp. 11-31.

Theil, G. S., and Boot J. C. G. (1962): "The Final Form of Econometric Equation Systems," The Review of the International Statistical Institute, 30: 136-152.

Tomek, W. G. (1979): "Futures Trading and Market Information: Some New Evidence," Food Research Institute Studies, 17: 351-359.

Walton, H. (1983): "Merc advisor quits, contending futures 'detrimental' to industry," The Record Stockman, Article by T. J. Gilles.

Weaver, R. D. and Banerjee, A. (1982): "Cash Price Variation in the Live Beef Cattle Market: The Role of Futures Trade," Journal of Futures Markets, 2: 367-389.

Working, H. (1977): Selected Writings of Holbrook Working, Chicago Board of Trade, Chicago.

Working, H. (1970): "Economic Functions of Futures Markets," as reprinted in Working (1977), pp. 267-297.

Working, H. (1962): "New Concepts Concerning Futures Markets and Prices," as reprinted in Working (1977), pp. 243-266.

Working, H. (1958): "A Theory of Anticipatory Prices," as reprinted in Working (1977), pp. 33-44.

APPENDIX A

This appendix presents the steps where equation (3.7) is derived from equation (3.4) in Chapter 3. First, equation (3.4) is reproduced:

$$\begin{aligned} CLOSEL2(t) = {} & \phi_0 \, DPL(t) + \ldots + \phi_q \, DPL(t-q) \\ & + \gamma_1 \, CLOSEL2(t-1) + \ldots + \gamma_p \, CLOSEL2(t-p) \end{aligned} \qquad (A1)$$

Using the following identity:

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

equation (A1) can be transformed into:

$$\begin{aligned} DCLOSE\ (t) + DCLOSE(t-1) = {} & \phi_1 \, DPL(t-1) + \ldots + \phi_q \, DPL(t-q) \\ & + \gamma_1 \, \{DCLOSE(t-1) + DCLOSE(t-2)\} \\ & + \gamma_2 \, \{DCLOSE(t-2) + DCLOSE(t-3)\} + \ldots \\ & + \gamma_p \, \{DCLOSE(t-p) + DCLOSE(t-p-1)\} \end{aligned} \qquad (A3$$

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

$$
\begin{aligned}
DCLOSE(t) = {} & \phi_1 \, DPL(t-1) + \ldots + \phi_q \, DPL(t-q) \\
& + (\gamma_1 - 1) \, DCLOSE(t-1) \\
& + (\gamma_1 + \gamma_2) \, DCLOSE(t-2) + \ldots \\
& + (\gamma_{p-1} + \gamma_p) \, DCLOSE(t-p) \\
& + (\gamma_p) \, DCLOSE(t-p-1) \qquad \text{(A4)}
\end{aligned}
$$

Now simplifying terms gives:

$$
\begin{aligned}
DCLOSE(t) = {} & \phi_1 \, DPL(t-1) + \ldots + \phi_q \, DPL(t-q) \\
& + \psi_1 \, DCLOSE(t-1) + \psi_2 \, DCLOSE(t-2) + \ldots \\
& + \psi_p \, DCLOSE(t-p) + \psi_{p+1} \, DCLOSE(t-p-1) \qquad \text{(A5)}
\end{aligned}
$$

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 equation (3.7) of Chapter 3.

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.

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