DYNAMIC PRICE ADJUSTMENT, PRICE DISCOVERY, AND VERTICAL COORDINATION IN CATTLE MARKETS

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Chapter I

Introduction

The past fifteen years have been a difficult period for the beef industry. Industry participants have witnessed the gradual erosion of their market share due to increased competitive pressure from poultry and pork. In 1980, per capita beef consumption was just over 75 pounds. By 1994, that figure had dropped to only 63 pounds (United States Department of Agriculture). The inability of the beef industry to respond effectively to these competitive pressures may be attributed to a number of different problems. A brief list of these problems might include product inconsistency, imprecise or inadequate quality standards, the public's perception of red meat as unhealthy, poor coordination of the efforts of producers at different market levels, and the often-hostile relationship between cattle feeders and meatpackers (Schroeder et al.). Solutions to problems such as product inconsistency and a poor grading system must rely primarily on technical advances to aid in the production and evaluation of meat products; however, some of the critical issues facing the beef industry are primarily economic in nature. Economic research thus provides the most appropriate means of understanding and resolving these problems. This dissertation deals with three important issues faced by the beef industry:

- the proper application of information about corn and feeder cattle prices when making production/marketing decisions,
- the role and importance of market information in price discovery, and
- the potential economic benefits of non-price vertical coordination.

In terms of relevant economic theory, these problems may be broadly considered as management, policy, and marketing issues. However, in a more applied context, these problems relate primarily to the efficiency (or lack thereof) of both production and exchange in the cattle industry. The following three articles present the results of research on each of these issues. A brief outline of each article follows.

The Feeder Cattle/Corn Price Relationship

The first article, "The Dynamics of Feeder Cattle Market Response to Corn Price Change," studies the relationship between prices of the two most important inputs to cattle feeding: corn and feeder calves. The objective of this study is to provide a more complete understanding of the corn/feeder cattle price relationship than is currently embodied in common rules-of-thumb derived from linear econometric models or break-even budgets. To accomplish this objective, a recursive system of equations is developed which describes how cattle placement weights and slaughter weights as well as feeder cattle prices respond to a change in corn prices. This research will thus allow cattle producers to respond more appropriately to corn price changes, resulting in more efficient allocation of the resources used in beef production. Dynamic simulation of the system reveals how these adjustments take place over time.

The unique feature of this research is that it presents a feeder calf pricing model based directly upon a break-even budget calculation of feeder price. Consequently, the model includes technical parameters related to the feeding process (i.e., placement weight, slaughter weight, and feed conversion rate) which must be considered in budgeting. Previous econometric studies have not included this type of information

(Buccola; Rucker, Burt, and LaFrance). They have thus not been able to provide a complete explanation of how production practices, as well as feeder cattle prices, adjust in response to corn price changes.

Public Information and Price Discovery

The second article, "Experimental Simulation of Public Information Impacts on Price Discovery and Marketing Efficiency in the Fed Cattle Market," examines an important public policy issue related to the cattle feeding industry. The objective of this study is to provide important information to policymakers who must decide the fate of government price reporting programs in the face of shrinking budgets for such programs. This study uses data from the Fed Cattle Market Simulator (FCMS) to determine the economic effects of a reduction in the amount of publicly provided price and quantity information available to fed cattle market participants. This study examines the effects of information reductions on the level and variability of prices as well as on the ability of FCMS participants to efficiently produce and market fed cattle.

This study is unique in two respects. First, the data used in this study were obtained from a controlled experiment with the FCMS. Such experiments are rare in the economics literature. Moreover, the study specifically examines the effects of public price and quantity information on a cash market. Most previous studies on the value of public information have focused instead upon the impact of government production or inventory reports on commodity futures markets. (For examples of these studies, see Colling and Irwin and Grunewald, McNulty, and Biere.) Results of this study indicate that reducing the amount of publicly provided information in the fed cattle market will increase price variability and decrease the efficiency of production and marketing.

Vertical Coordination in the Fed Cattle Market

The third article, "Estimated Value of Non-Price Vertical Coordination in the Fed Cattle Market," examines the issue of cooperation in marketing between feedlots and meatpackers. The study's objective is to determine the value—in terms of increased industry-level profits—of coordinated marketing/purchasing of fed cattle by feedlots and packing plants. Like the information impact study just described, this study also uses data obtained from the FCMS. In this study, the industry-level profits achieved by FCMS participants whose marketings were coordinated only by the price system are compared with the profits which could have been achieved by employing various non-price coordination strategies. Analysis of these industry-level profits reveals whether gains to vertical coordination result from increased revenue or from cost reductions for either feeders or packers. The comparisons made in the study are accomplished using simulation techniques. This study is unique in that it quantifies the gains from vertical coordination. Much literature exits on the subject of vertical coordination; however, this extensive literature deals almost exclusively with the theoretical incentives for vertical coordination (Den Ouden, et al). As a quantitative study of vertical coordination's effects, this study represents an important addition to the literature. Results of this study indicate that the potential gains in industry-level profit due to the adoption of non-price coordination strategies are significant in the fed cattle market.

Chapter Structure

The following three chapters present each of the above summarized articles in their entirety. Each of these chapters is written in the style of a journal article (with the exception that all references have been combined into a single reference list). Consistent with the format for journal article submissions, all tables and figures are placed at the end of each chapter. The format of a journal article does not allow for a great deal of elaboration on issues not directly addressed in the article's stated objectives, even if these issues are related to the main topic of the article. For this reason, a number of appendices have been attached to this dissertation. These appendices provide additional detail and further research results related to the findings presented in Chapters II through IV. The final chapter briefly summarizes the major conclusions of each article and offers selected suggestions for future research.

Chapter II

The Dynamics of Feeder Cattle Market Response to Corn Price Change

One of the more useful firm-level management tools available to cattle feeders is break-even budgeting. Simple budgeting exercises allow feeders to estimate the profit potential of a pen of cattle, to determine the price which they can afford to pay for feeder cattle, or to evaluate the effect on their bottom line of a change in cattle and/or feed prices.

The use of break-even budgeting analysis has frequently been extended by agricultural economists and others to describe and forecast feeder cattle market reactions to various exogenous shocks. There would appear to be inherent potential dangers in using what is essentially a comparative static micro-level tool as a macro/market-level analysis tool. One potential danger or weakness is that break-even budgeting analysis appears to ignore the dynamics of the cattle industry. A second danger is that break-even analysis assumes perfectly competitive market responses to all exogenous shocks.

This study will first describe the general methodology used in making market-level forecasts using break-even budgeting analysis. It will then summarize the general conclusions reported from such analyses about the nature of the feeder cattle market. Specific emphasis will be given to summarizing the implications economists have made and published in the last few years about the impact of corn price changes on feeder cattle prices. The number of popular press and professional articles on this subject is quite large over the past few years given recent record high corn prices. Following this review, a dynamic framework for modeling feeder cattle price will draw upon the sound theoretical postulates of break-even analysis as well as other previous econometric studies of the feeder cattle market. In so doing it will attempt to correct the aforementioned perceived weaknesses of break-even analysis with regard to market dynamics and the assumption of perfectly competitive market behavior. Results of this study suggest that estimates of the impact of corn price changes on feeder cattle price made with break-even analysis significantly underestimate the impact of corn price changes on feeder cattle prices. The cause(s) of this underestimation are explored and the considerations needed to alleviate it are postulated.

Review of Break-even Analysis Methods and Results

The use of break-even budgets by cattle feeders is justified by economic theory, which maintains that the price of an input will depend to a large degree upon output price and transformation costs. With respect to cattle markets, this suggests that feeder calf prices will be closely related to fed cattle and corn prices. The relationship among prices for these commodities can be illustrated with break-even budget calculations. Assume that the price of corn is $2.50/bu and that the price of 1,200 pound fed steers is $74/cwt. Given a feed conversion rate of 7 pounds of feed to one pound of beef gain, a cattle feeder can estimate a break-even price for 750 pound feeder steers by the method illustrated in table 2.1.

Particular attention is often focused on the impact of corn price on feeder calf prices. Given the importance of corn in the feeding process, this focus is warranted. Generally, in commercial feedlots well over two-thirds of the cost of feed can be attributed to grain costs (USDA). The vast majority of this grain is corn. Corn accounts for over 80% of all feed grains consumed by U. S. livestock (Ash). Albright, Schroeder, and Langemeier examined cost of gain in two Kansas feedlots and determined that over 60% of the variability in cost of gain could be attributed to corn price variability. More recently, Langemeier, Schroeder, and Mintert found that changes in corn price account for 22% of the variability in the profits to cattle feeding. Clearly, there is great incentive to investigate the relationship between corn and feeder calf prices.

Various guidelines which attempt to describe the relationship between corn and feeder calf prices can be found in the popular press. In discussing this relationship, the popular press typically uses the term "corn price multiplier" which is defined as the ratio of the long-term change in feeder calf prices to a change in the price of corn. Fox reports that a $1/bu increase in the price of corn results in a $7 - $10 decrease in the value of calves and feeder cattle. Similarly, Maday writes that a $0.10/bu increase in corn price will result in a $0.75/cwt drop in feeder prices. Results such as these can be obtained from the break-even budget of table 2.1. Given the budget parameters in table 2.1, a one dollar increase in the corn price drops the break-even feeder price by $7.50/cwt.

The fundamental problem with deriving estimates of a corn price multiplier from break-even budgets is that the budgets assume independence of corn prices and the technical feeding parameters: placement weight, slaughter weight, and feed conversion rate. In other words, to derive a multiplier value, these factors are held constant regardless of the corn price. There are two important reasons to believe that this is not a valid assumption. First, at high corn prices other grains (e.g., wheat) may be used in rations. This, in turn, may affect feed conversion. Second, placement and slaughter weights will be adjusted in response to corn price changes. As corn prices increase, more weight will be put on calves with forages, leading to higher placement weights (Parsons). Cattle may also be sold earlier than usual, leading to lower slaughter weights. These weight changes also affect feed conversion rates. Examination of the break-even budget in table 2.1 shows that variability in these technical feeding factors will have an impact on the relationship between corn and break-even feeder prices. In general, we would anticipate a high degree of correlation between observed feeder cattle prices and these break-even estimates.

The objective of this research is to provide a more complete understanding of the relationship between corn and feeder calf prices than is currently reflected in popular corn price multipliers based on *ceteris paribus* break-even budgets. This understanding should allow cattle producers and feeders to respond more appropriately to corn price changes with respect to both production and pricing decisions. Furthermore, a better understanding of how technical feeding parameters (placement weight, slaughter weight, and feed conversion) are affected by corn price changes will allow producers to use budgeting more effectively as a management/decision making tool.

Theory and Background

The basic budget calculation giving profit per head (Π) from feeding cattle can be written as follows:

(1) $$\Pi = [(FED \bullet SW)(1 - DL)] - [(FC \bullet PW) + (SW - PW)COG],$$

where *FED* is the price received for fed cattle; *SW* is the slaughter weight of fed cattle; *DL* is death loss as a percentage of the number of cattle fed; *FC* is the price paid for feeder cattle at placement; *PW* is the placement weight of feeder cattle; and *COG* is cost of gain per pound. The break-even feeder calf price can be determined from (1) by assuming that $\Pi = 0$ and then solving for *FC*. The result is equation (2) below:

(2) $$FC = [((FED \bullet SW) / PW)(1 - DL)] - [((SW - PW)COG) / PW].$$

Corn price does not explicitly appear in either of the above equations; however, corn price is an important element in cost of gain (*COG*). To see how corn price multipliers are derived from break-even budgets, note that

(3) $$COG = RC \bullet CONV,$$

where *RC* is ration cost/pound; and *CONV* is the feed conversion rate (lbs feed/lb beef gain).

Because corn is such an important ingredient in feedlot rations, the price of corn is often used as a proxy for ration cost. By replacing ration cost with corn price in the cost of gain relationship (3) and substituting that new equation into the break-even calculation of (2), the relationship between corn price and the break-even feeder calf price is explicitly established:

(4) $$FC = [((FED \bullet SW) / PW)(1 - DL)] - [((SW - PW)CONV \bullet CORN) / PW],$$

where *CORN* is the price per bushel of corn, and all other variables are as previously defined.

In econometric estimation, as in budgeting, corn price has often been used as a proxy for ration cost. Brester and Marsh modeled the feeder sector as one component of the entire beef industry. Their model of the feeder sector consisted of equations to estimate feeder cattle inventories, feeder placement demand, and feeder placement supply. In that model, the quantity of feeder cattle placed on feed is given as a function of feeder calf prices and a slaughter steer/corn price ratio.

Rucker, Burt, and Lafrance also used the beef/corn price ratio in generating an econometric model of cattle inventory for the state of Montana and for the entire United States. As part of their research, the authors estimated an equation to model feeder cattle price as a function of the beef/corn price ratio. They concluded that the ratio provided information on feeder cattle prices that is not contained in current and lagged calf prices alone.

In his analysis of feeder cattle price differentials, Buccola also estimates a feeder calf price model. Rather than using a beef/corn price ratio, his model employs corn prices and live cattle futures prices. Buccola also included the annual change in all cattle inventory and the Palmer Drought Severity Index in his model.

Feeder Calf Price Model Specification

The plan of this research was to estimate an econometric model derived directly from the break-even equation and to compare the results of that model with those of the linear feeder calf price model specified by Buccola. The following equation provides a starting point for the break-even model:

$$(4') \quad FC_t = [((FED^e_{t+f} \bullet SW^e_{t+f}) / PW^e_t)(1 - DL^e_{t+f})] - [((SW^e_{t+f} - PW^e_t)CONV^e_{t+f} \bullet CORN_t) / PW^e_t],$$

where FC is the feeder cattle break-even price at time t; FED is the expected fed cattle price for t+f at time t, with f representing the length of the feeding period; SW is expected slaughter weight at t+f; PW is the expected weight of cattle placed at t; DL is the expected death loss for cattle slaughtered at t+f; $CONV$ is the expected dry matter feed conversion rate of cattle slaughtered at t+f; and $CORN$ is the per bushel corn price at t.

The multiplicative relationships that exist between the variables in (4') indicate that a model with strictly linear relationships between corn price, live cattle futures price, and feeder cattle price is not the most appropriate representation of the feeder cattle market. A more appropriate model would be one using the expected cost and revenue components of the break-even feeder cattle price equation as variables. The right-hand side of equation (4') can be broken into expected revenue (REV^e) and expected cost ($COST^e$) components as follows:

(5) $$REV^e_{t+f} = ((FED^e_{t+f} \bullet SW^e_{t+f}) / PW^e_t)(1 - DL^e_{t+f}), \text{ and}$$

(6) $$COST^e_{t+f} = ((SW^e_{t+f} - PW^e_t)CONV^e_{t+f} \bullet CORN_t) / PW^e_t.$$

From (5) and (6) it is clear that factors other than corn and expected fed cattle prices influence feeder calf prices. Changes in cattle weights, feed conversion, and death loss[1] will clearly have some impact on the break-even feeder price. The problem with including these factors in a price model is that data on them is not readily available. Technical information about cattle in feedlots is only available from individual feedlots. Obtaining enough of this private information to create a reliable data set would be difficult if not impossible for a researcher.

Professional Cattle Consultants (PCC) of Weatherford, Oklahoma is a consulting firm that compiles performance information from approximately one hundred major feedlots throughout the dominant cattle feeding areas of the United States. The feedlots reporting to PCC collectively produce over 25% of the fed cattle in the United States. While individual feedlot data is confidential, aggregate monthly data for placement weights[2], slaughter weights, feed conversion rates, and death loss were available for use in this research (PCC Newsletter). These data were used to develop models to obtain expected values for the technical parameters specified in equations (5) and (6).

Placement weight is treated as an endogenous variable in this model. At the time cattle are placed on feed, the buyer/owner has a choice of what weight of cattle to buy/place on feed, thus placement weight is subject to variation due to economic conditions. Using monthly PCC data, an econometric model for expected placement weight was developed. Of particular interest in this study is the effect of corn price upon placement weight. Thus placement weight was specified as a function of the corn/live cattle price ratio, a trend variable, and sin/cosine seasonality variables. The estimated equation is given below with standard errors in parentheses:

$$(7)\quad \underset{}{PW_t} = \underset{(51.07)}{270.34} + \underset{(0.071)}{0.613}\,PW_{t-1} + \underset{(187.0)}{316.82}(C/LC)_t + \underset{(0.029)}{0.078}\,TIME + \underset{(2.184)}{6.458}\,SIN12 +$$

$$\underset{(1.403)}{7.446}\,SIN6 - \underset{(2.210)}{17.430}\,COS12 - \underset{(1.403)}{6.728}\,COS6;$$

$R^2 = 0.8902$ and F statistic = 136.628,

where PW is placement weight at t; C/LC is corn price at t ÷ live cattle futures price at t; *TIME* is a trend variable; *SIN12* and *SIN6* are sine variables with 12 and 6 month cycles respectively; and *COS12* and *COS6* are cosine variables with 12 and 6 month cycles respectively. These sine and cosine variables are included to capture the seasonal behavior of placement weights. As expected, a positive relationship was found between placement weight and corn price.

Slaughter weight expectations are derived from a similar partial adjustment model. Slaughter weight is modeled as a function of placement weight, a time trend variable, and sine/cosine seasonality variables identical to those of the placement weight expectation model. The estimated equation is given below with standard errors in parentheses:

$$(8) \qquad \underset{}{SW_{t+f}} = \underset{(62.970)}{109.97} + \underset{(0.049)}{0.794 SW_{t+f-1}} + \underset{(0.064)}{0.165 PW_t} + \underset{(0.045)}{0.144 TIME} - \underset{(1.447)}{13.393 SIN12} +$$

$$\underset{(1.304)}{2.448 SIN6} - \underset{(2.507)}{11.363 COS12} + \underset{(1.163)}{6.165 COS6};$$

$R^2 = 0.9568$ and F statistic = 373.447,

where *SW* is the slaughter weight at t+f; and *PW* is the placement weight of those cattle at t. Joint conditional means and joint conditional variance tests of both of these models revealed no significant problems with either autocorrelation or heteroskedasticity (McGuirk, Driscoll, and Alwang). It should be noted in equation (8) that slaughter weight increases with placement weight. This is consistent with the biological nature of cattle feeding and with the habits of some cattle feeders. A certain amount of gain must come from grain feeding if cattle are to grade choice, and some cattle feeders will feed for the same number of days under almost any circumstances. For this reason, higher placement weights generally result in higher slaughter weights and vice versa; however, sufficient latitude exists within the placement weight/slaughter weight relationship to allow significant adjustment to be made and the majority of cattle still grade choice.

An attempt was made to estimate feed conversion as a function of placement and slaughter weights and seasonality; however, in a partial adjustment specification of the model, these explanatory variables were not significant. In a full adjustment model, severe autocorrelation was a problem. Since it was not possible to estimate an acceptable model of feed conversion rates, monthly average feed conversion figures were calculated for the entire 10-year period of the study. These monthly average values were used in computing the cost and revenue variables of the break-even equation.

An actual death loss series was not used in generating the revenue variable. The only death loss figure available for the entire period of the study was average death loss per month. A more appropriate figure would have been average death loss per pen of cattle over the feeding period of the pen. Since this was not available, an average death loss per pen of 0.87 percent was used rather than an actual death loss data series. This value corresponds to the average death loss per pen in 1994 and 1995, the two years for which these data are available.

Prices used in addition to the technical data obtained from PCC included corn prices, feeder cattle prices, and live cattle futures prices. The corn price used was Thursday's average of the price received by farmers for corn delivered in Omaha, NE. The futures prices used were CME live cattle closing prices. Thursday closes were used rather than a weekly average in order to maintain consistency with the cash market prices, which were each one day's price rather than a weekly average price. If a holiday fell on Thursday, Wednesday's close was substituted. Table 2.2 gives a description of the data used in this study.

For this study, calves are assumed to be on feed 140 days. Thus, the feeder calf price was estimated as a function of the same week's corn price and the live cattle futures price 140 days forward. Live cattle prices were the futures price that producers would most likely use to hedge their cattle. For example, if the expected finish date was in May, prices were taken from the June live cattle contract. If the expected finish date was in June, prices were taken from the August contract because hedgers would not be inclined to take a position that they would need to maintain into the contract expiration month.

Because the model specified here specifically allows for placement weights to change over time, this fact must be recognized in the collection and specification of an appropriate feeder cattle price series. Feeder cattle prices are reported as the average price received over specified weight ranges. To use a price series from just one weight range would reflect the general rise and fall of feeder cattle prices over time, but would not allow for price changes due to changes in the weight of feeder cattle being placed on feed. In general, a strong negative relationship exists between feeder cattle prices per hundredweight and the weight of feeder cattle; that is, as feeder cattle weights increase, the price per hundredweight declines. Over the time period considered in this study, the price for 700-800 pound feeder cattle averaged $3.24/cwt less than the price for 600-700 pound feeder cattle.

To address the problem of changing feeder cattle prices with weight, a "weight-continuous" series of feeder cattle prices was developed by linearly interpolating between the discrete weight point prices given by the reporting of average prices received over a given weight range. From 1985 to 1991, average prices for 600-700 pound feeder cattle and for 700-800 pound feeder cattle were reported. If it is assumed that the average price for 600-700 pound feeders most accurately represents the price for a 650 pound animal and that the average price for 700-800 pound feeders represents the price for a 750 pound animal, then the price for any weight between 650 and 750 pounds can be imputed by linear interpolation. For example, if the price of 600-700 pound steers was $82/cwt, and the price for 700-800 pound steers was $80/cwt, the following prices by weight would be deduced from linear interpolation: 650 pounds-$82.00; 675 pounds-$81.50; 700 pounds-$81.00; 725 pounds-$80.50; 750 pounds-$80.00. Equation (9) expresses this process algebraically:

$$AFC = FC67 - [((PW - 650)/100)(FC67 - FC78)], \tag{9}$$

where AFC is the derived weight-continuous "adjusted feeder price" value; PW is placement weight; $FC67$ is the reported average price for 600-700 pound feeder steers; and $FC78$ is the reported average price for 700-800 pound feeder steers. After 1991 feeder cattle prices began to be reported for 50 pound weight increments instead of 100 pound increments. The same basic procedure was used in adjusting these prices except one first had to determine which weight range was appropriate and then interpolate in the same manner as done in equation (9) but over a 50 pound weight range instead of a 100 pound weight range. Appendix A explores the possibility that the change in price reporting practices beginning in 1992 might bias the parameters of the model.

Having defined equations (5) through (9), we can return to equation (4') and complete the specification of the feeder cattle price model to be estimated (see equation (10) below). Equation (4') contains a revenue and cost component. A positive sign is expected on the revenue component, and a negative sign is expected on the cost component. The effect of corn prices enters directly into the cost component as is shown in (4') as well as (6). Corn price also affects the revenue component of (4'), but the effect is indirect through placement weight (*PW*) and slaughter weight (*SW*) variables. Equation (7) for placement weight includes corn price as a variable, and, in turn, equation (8) for slaughter weight contains placement weight as a variable. Figure 2.1 illustrates the relationship between variables and equations used in arriving at the break-even model specified in equation (10).

Following Buccola's arguments, a cattle on feed variable was included in the estimation to help explain the effect of changes in cattle inventory on feeder calf prices. The variable was calculated by subtracting the number of cattle on feed one year ago from the current number of cattle on feed. The objective of calculating the change variable in this manner was to isolate the longer-term annual effect of inventory changes rather than the short-term seasonal effect that a monthly change variable would have reflected. A positive sign was anticipated since higher numbers of cattle being placed on feed would signal a greater demand for feeder cattle. A pair of sine/cosine cyclical variables was also used to account for the long-term cattle cycle. These variables were specified assuming an eleven-year cycle. Thus, the feeder cattle price equation specified for estimation is as follows:

(10) $AFC_t = f(AFC_{t-1}, COST_t, REV_t, DCOF, D2, ..., D12, COS, SIN)$,

where *AFC* is the adjusted feeder cattle price; *COST* is feeding cost as defined in equation (6); *REV* is feeding revenue as defined in equation (5); *DCOF* is a variable measuring the change in the number of cattle on feed; *D2, ..., D12* is a set of monthly seasonal dummy variables; *COS* is a cosine variable for an eleven year cattle cycle; and *SIN* is a sine variable for an eleven year cattle cycle.

Break-even Feeder Calf Price Model Results

Results of the feeder calf price model are presented in table 2.3. Misspecification tests suggested by McGuirk, Driscoll, and Alwang indicated that the break-even model displayed no significant statistical problems. A joint conditional means test indicated no significant nonlinearity or autocorrelation. A joint conditional variance test indicated no significant heteroskedasticity. In addition, Chow tests at January 1991 and at January 1992 were not significant at the 1% level, indicating that model stability was acceptable. A Chow test was performed at January 1992 because, as noted, feeder calf price reporting practices were changed at that date. A test was also conducted at January 1991 to determine whether or not cyclical effects would lead to parameter instability. That date closely corresponds to the peak of the cattle cycle.

One problem with the model was noted, however. Non-normal distribution of the errors was indicated by the Jarque-Bera statistic and by an omnibus test. Using robust estimation it was determined that this non-normality had little impact on the parameter estimates so no further modifications were made. Reported results are from OLS estimation of the model.

Comparison with Linear Model

Properties of the break-even model were compared with those of a second feeder calf price model with a linear specification. The linear model was based on the Buccola model; however, weekly data were used here rather than the semi-annual data used by Buccola. Explanatory variables used in the model included corn prices and live cattle futures prices as well as a cattle inventory variable and the Palmer Drought Severity Index for central Oklahoma. Following Buccola, the inventory variable used in this model was the change in the January 1 all cattle inventory. The Palmer Index was included—also following Buccola's methodology—as a proxy for a pasture condition variable. Monthly dummy variables were included to account for seasonality of feeder prices, and a partial adjustment specification of the model was used to correct for autocorrelation. Coefficient estimates for the linear model are not reported here. Discussion will focus on the properties of the linear model.

Results of misspecification testing on the linear model indicate that this form of the model is inadequate to accurately and consistently estimate feeder cattle prices. First, the nonlinear component of a joint conditional means test was highly significant, indicating that the linear functional form was inappropriate. This test also revealed significant correlation between the lagged dependent variable and the error term, indicating that parameter estimates would not be efficient, unbiased, or consistent.

Parameter instability was a serious problem with the linear model. A Chow test comparing the periods 1985-1991 and 1992-1995 indicated large differences in the coefficients for those periods. The corn price coefficient was particularly unstable, changing from a long run value of -10.450 in the earlier period to only -4.827 in the later period. The live cattle futures price coefficient was considerably more stable, only changing from 1.707 to 1.546. It appears that cyclical/seasonal variation in the technical feeding parameters was being reflected in the corn price coefficient of the linear model, leading to that coefficient's instability. By including data on these technical parameters, the break-even model corrects the parameter instability and autocorrelation detected in the linear model.

Implications of the Break-even Model

The break-even model specification corrects the statistical problems of the linear model, which is significant in itself; however, the real economic significance of the break-even model is that it allows for a determination of how changes in placement weight, slaughter weight, and feed conversion affect the relationship between corn and feeder calf prices. Record grain prices throughout 1995 and into 1996 focused a great deal of attention on this relationship. Rule of thumb estimates are certainly consistent with break-even budgeting; however, they are not consistent with the break-even model presented in table 2.3. Due to the multiplicative relationships between corn price, feed conversion, placement weight, and slaughter weight, the effect of corn price on feeder cattle price will not be constant. A more precise estimate of the effect of corn price on cattle price can be found in the first derivative of the long-run break even equation in table 2.3 with respect to corn price:

(11) $$\partial FC/\partial CORN = -2.305\ ((SW - PW)CONV)\ /\ PW.$$

If equation (11) is evaluated at the mean values of the data for placement weight, slaughter weight, and conversion rate, the resulting corn price multiplier is found to be -8.74. Given the accuracy of the long-run parameters in the feeder cattle price equation, the standard error of this estimate of the corn price multiplier is 0.903. If the same mean values for placement weight, slaughter weight, and feed conversion, plus the mean values for fed cattle and corn price are used in the budget format presented in Table 2.1 to estimate a corn price multiplier, the resulting corn price multiplier is -7.69. Thus the feeder cattle price equation estimated here implies that feeder cattle prices in general respond more to a given corn price change than the budgeting analysis implies. More will be discussed on this issue presently.

It is of interest to note here that feed conversion, placement weight, and slaughter weight remain in the first derivative expressed in equation (11). Thus the effect of corn price on cattle price varies with these factors. These factors are themselves quite variable—seasonally as well as from year to year. The key point is that this corn price multiplier will change in response to—or is "conditioned" by—changes in placement weights, slaughter weights and feed conversion. Thus, it is inaccurate to consider the relationship between corn and feeder prices as constant, as the popular rules of thumb imply. Seasonality of the technical factors alone will result in noticeable changes in the multiplier. In addition, more permanent changes in the average levels of these factors due to technological and institutional changes in the feeding sector will also contribute to the dynamic character of the multiplier. Table 2.4 shows conditional values of the corn price multiplier under different placement weight, slaughter weight, and feed conversion conditions. Values in this table illustrate that even relatively small changes in the technical factors can significantly affect the relationship between corn and feeder prices. Figure 2.2 shows how the multiplier changes as a result of seasonal changes in the technical factors. This figure illustrates that seasonal placement weight and conversion rate values correspond as expected with the seasonal multiplier. That is, seasonally low placement weights and poor conversion rates correspond to seasonally high multiplier (absolute) values. Conversely, seasonally high placement weights and favorable conversion rates correspond to seasonally low multiplier values.

Conditional multiplier values in table 2.4 indicate that producer responses to higher corn prices can alter the relationship between corn and cattle prices. At high corn prices, producers have an incentive to economize on the use of corn to produce market-ready finished cattle. This may involve such strategies as putting more weight on calves with grass, leading to higher placement weights or, if possible, using relatively cheaper grains in feedlot rations. The net effect of these adjustments is to alter the impact that corn price changes have on cattle prices. The conditional multiplier derived from equation (11) reflects the dynamic nature of this relationship in a way that static multipliers cannot.

A Systems Interpretation of the Variable Multiplier

The foregoing discussion suggests that producer responses to corn price increases should mitigate the effects of these increases by changing placement weights, ration composition, slaughter weight, etc., thus leading to a smaller feeder cattle price reduction than the break-even budget predicts. However, the results from this study seem to contradict this line of reasoning. Specifically, the corn price multiplier generated at the mean value of the variables in the feeder cattle price equation is -8.75 while the budget derived multiplier at the same mean values is -7.69. This implies that in reality, feeder cattle prices change by about a dollar more per one dollar change in corn price than the traditional break-even budget analysis implies they should.

An important reason for this apparent discrepancy is that the econometrically-derived corn price multiplier found here does not describe just the movement of feeder prices in response to corn price. Rather, it describes the combined change in feeder cattle purchase weight and the feeder cattle price. As previously explained, the feeder cattle price series used is not the price for one specific weight of feeder animal, but it has been adjusted through a linear interpolation process to be consistent with the reported placement weight. Thus the variable corn price multiplier cannot be directly compared to the static budgeted corn price multiplier.

Table 2.5 shows a sample of the model's predictions for feeder cattle prices and purchase weights for different combinations of corn prices and finished cattle prices. As can be seen in the table, as corn price rises, the purchase weight of feeders rises. In a typical feeder cattle market, prices per hundredweight for feeder cattle decline as they become heavier. In the data sample used in this study (1985-1995), the average decline in feeder cattle price over the weight range of 650-750 pounds was $3.24/cwt. Because heavier feeder cattle generally sell at a discount to lighter cattle, the increase in placement weight associated with higher corn prices will reinforce the direct effect on feeder prices of a corn price increase. This compounding effect explains why the variable corn price multiplier, by definition, will be larger than the static budget corn price multiplier.

To derive a multiplier from the budget model in Table 2.1 that is more comparable to the variable multiplier estimated here, it is necessary not only to change the corn price in the budget, but also to change the placement weight and slaughter weight variables by the amounts which equations (7) and (8) indicate they should change in response to a corn price change. To illustrate this point, a $0.25 corn price rise from the mean corn price was considered. This results in a long-run increase in placement weight of 2.99 pounds and a long-run increase in slaughter weight of 2.38 pounds. If these weight changes are budgeted along with the $0.25 corn price increase, the resulting multiplier is -8.24. This multiplier, while much closer to the multiplier derived from the derivative of the feeder cattle price equation, i.e. -8.76, is still somewhat smaller. Thus the implication remains that the econometric model using actual data indicates that actual feeder cattle price responses to changes in the corn price are larger than those indicated by the break-even budgeting process.

Upon further reflection, the multiplier derived from the feeder cattle price equation derivative (equation (11)) is not the appropriate multiplier to compare to the budget multiplier found when placement weight, slaughter weight, and corn price are simultaneously changed. The derivative reported in equation (11) holds placement weight and slaughter weight constant at their means, despite the fact that it uses prices in the estimation process that assume the placement weight is changing. To derive a conceptually comparable multiplier, a five-equation dynamic simulation model was constructed consisting of equations (7) and (8) for placement weight and slaughter weight respectively, equations (5) and (6) which calculate revenue and cost to be used in the feeder cattle price equation, and the feeder cattle price equation (10). The short-run partial adjustment coefficients reported in table 2.3 were used to define equation (10).

The model was simulated in the recursive sequence depicted in figure 2.1; that is, placement weights and slaughter weights were calculated first and then used to derive revenues and costs as defined by equations (5) and (6). These revenues and costs were in turn used in equation (10) to calculate the feeder price. The dynamics of the model follow from the fact that the solution values found for placement weights, slaughter weights, and feeder cattle prices were then lagged one period and fed back into their respective equations and the system of equations solved again for the next period. This process was repeated until the feeder cattle price solution value stabilized. Specifically, all exogenous variables were set to their mean values and held constant throughout the simulation, except for corn price. In period 0, corn price was set at its mean, but in period 1, corn price increased by $0.25/bu. Following the increase in corn price, approximately 97 weeks of simulated recursive solutions were required for the model to stabilize.

Results of the simulation are presented in table 2.6. In viewing table 2.6, it should be noted that the simulated values for placement weight and slaughter weight change only every fourth week as opposed to feeder cattle prices which change weekly. This is because placement weight and slaughter weight models used monthly data, and the feeder cattle price equation used weekly data. Simulation of these two different time lengths was accomplished by only allowing the lagged values for placement weight and slaughter weight to be updated every fourth iteration, instead of every iteration as was the case for the lagged feeder cattle price variable.

Empirical validation of the simulation model was achieved by checking to ensure that the placement weight, slaughter weight, and feeder cattle price equations, when simulated independently with all variables held constant at their mean (except corn price) reached the same values at equilibrium as are found when each equation is solved using their respective long-run coefficients and mean values for all variables (except corn price, which was set at \$0.25 above its mean). For the purposes of this validation, placement weight and slaughter weight were held constant at their mean rather than being allowed to dynamically adjust to the simulated corn price change. The long-run coefficients used were derived by multiplying the parameters in each equation by $1/(1-\alpha)$, where α is the parameter on the lagged dependent variable in each respective equation.

The simulation results indicate that nearly three-fourths of the adjustment to the corn price change is achieved in four weeks, that is, in one month. As reported above, the change in the placement weight between the new equilibrium and the initial placement weight is 2.99 pounds and the change in the slaughter weight is 2.38 pounds. The simulated change in feeder cattle price is a \$2.27 decline. When divided by \$0.25, this results in a corn price multiplier of -9.08. This multiplier is once again higher than the comparable multiplier of -8.24 as derived from the budget model when placement weight, slaughter weight, and corn price are changed. This is due to the dynamic interaction of placement weight and slaughter weight changing and in turn impacting the dynamics of the feeder cattle price adjustment process. As placement weight rises in response to corn price, it increases cost which in turn depresses feeder prices. An increase in placement weight also causes slaughter weight to increase, which causes revenue to rise, increasing feeder prices. On balance, the increased cost impacts of a rise in corn prices dominate the increased revenue impacts, thus resulting in the dynamic corn price multiplier being larger than various break-even or statistically determined multipliers.

Viewing the weight and price equations as a system emphasizes that producer response to corn price changes are aimed not at maintaining the level of feeder prices, but at maintaining profitable feeding programs. By over-responding to a corn price increase--depressing feeder cattle prices more than is indicated to be necessary by break-even analysis--cattle feeders generate more feeding profits in the system sooner than would be the case if they responded according to budgeting-based price guides. Similarly, when corn prices fall, feeder cattle prices are bid up more than the break-even budget would imply is warranted, thus removing profits quicker than they would be removed following budgeting pricing guides. The combined implication is that the over-response in feeder cattle price adjustments to changes in corn price found in this study (evidenced by higher corn price multipliers than those derived from budgeting) leads to a market in which excess profits or losses due to exogenous shocks do not persist and are, in fact, over-compensated for.

Summary and Conclusions

Use of break-even budgeting indicates a corn price multiplier of about -7.5. That is, for every $1 rise in corn price/bu, the feeder cattle price will be depressed by $7.50/cwt. Multipliers close to these values have been widely cited in the popular press by professional economists.

In this study, a regression model was specified which was derived directly from the break-even feeder price budget. The model contained as explanatory variables a revenue variable (consisting of a slaughter weight times the appropriate futures price for live cattle) and a cost variable (incorporating estimates of placement weights, pounds of gain, feed conversion rates, and corn prices to proxy feeding costs). These two variables together with seasonal and cyclical variables and a cattle-on-feed inventory variable were regressed against feeder cattle prices.

Statistical properties of this model were far superior to a more traditional specification of a feeder cattle price model using corn and live cattle futures prices in a linear form. The most dramatic differences between the two model specifications were that the break-even model exhibited no autocorrelation and improved parameter stability. These results are not surprising given the fact that the break-even model incorporates important information about the physical characteristics of cattle (i.e., placement and slaughter weights) and about feeding efficiency (i.e., conversion rates) which is omitted from the simpler linear model.

This study found that the corn price multiplier of -7.5 commonly reported in the literature based on break-even cattle feeding budgets underestimated the response of feeder cattle prices to corn price changes. Traditional break-even budget analyses of the impact of a corn price change on the feeder cattle market typically do not consider the total feeding system adjustments caused by corn price changes. This study finds the corn price multiplier to be nearly 1 unit higher than the break-even budget derived multiplier. This implies that a one dollar increase (or decrease) in corn price will result in around an $8.50 change in feeder cattle prices versus the $7.50 change predicted from a break-even model analysis, on the average. In addition, it was found that placement weights respond to corn price changes. Placement weights were found to rise by approximately 12 pounds per dollar of increase in the corn price. The placement weight changes associated with corn price changes reinforce the direct price impact of the corn price change on feeder cattle prices paid. To elaborate, higher corn prices cause feeder cattle purchasers to bid down prices for a given weight of animal as well as move to heavier weight cattle which are typically priced lower. Thus the combined impact is to change the actual price paid for the cattle purchased by more than the static break-even budget analysis would imply when only corn price is changed in the budget. However, the results further show that even when placement weight changes are incorporated in to the break-even budget analysis, the implied change in feeder cattle prices needed to reestablish a break-even situation is typically exceeded by the market's response by about one dollar per one dollar change in the corn price. In other words, feeder cattle prices were estimated to over-respond by about 10% - 15% to a given change in corn prices in comparison to the changes needed to return the market to break-even price levels.

Endnotes

1. This method of incorporating death loss into the equations assumes that all feeding costs are incurred by the cattle that die—in other words, that they die on the last day of feeding. This is obviously an unlikely assumption; however, death loss is included in this model only for conceptual completeness. In addition, it was found in estimating the break-even model that eliminating death loss completely results in only very small changes in the magnitude of the revenue variable.
2. PCC does not report the weight of cattle placed each month. Rather, they report from the closeout sheet of pens slaughtered the average placement weight of cattle slaughtered each month. They also report average number of days on feed for cattle slaughtered. Thus, placement weights for a given month can be deduced retroactively.

Table 2.1. Break-even Feeder Calf Price Estimate

Fed Cattle Value: .... 1,200 lbs x $0.74/lb = $888

Cost of Gain: .... = $140.63

Pounds of Gain = 1,200 lbs – 750 lbs = 450 lbs

Bushels of Grain = (450 lbs x 7lbs grain/lb gain)/56 lbs/bu = 56.25 bu

Cost of Gain = 56.25 bu x $2.50/bu = $140.63

Net Revenue: .... $888 – $140.63 = $747.37/head

Break-even Feeder Price: .... $747.37 ÷ 750 lbs = $0.9965/lb

Note: A bushel of corn is assumed to weigh 56 lbs.

Table 2.2. Description of Variables Used in Weekly Feeder Calf Price Model

Variable	Description	Mean	SD
Dependent:			
FC	OKC cash feeder calf price ($/cwt)[a]	78.08	10.09
Independent:			
CORN	Omaha cash corn price ($/bu)[b]	2.25	0.36
LC	live cattle futures price 140 days forward ($/cwt)[c]	68.42	6.26
DCOF	change in cattle on feed[d] (000s)	72.74	467.70
PW	placement weight[e]	736.40	29.52
SW	slaughter weight[e]	1,162.70	40.21
CONV	feed conversion[e] (lbs dry matter/lb gain)	6.55	0.35
REV	break-even revenue	108.01	11.12
COST	break-even cost	8.51	1.60

[a] Source: Oklahoma Dept. of Agriculture

[b] Source: Livestock Marketing Info. Center

[c] Source: CME daily closing price

[d] Source: USDA monthly 7 states cattle on feed report

[e] Source: Professional Cattle Consultants Weatherford, OK

Table 2.3. Estimated Parameters For the Break-even Feeder Calf Price Model

Independent variables	Partial Adjustment estimated coefficients	S.E.	Long-Run estimated coefficients	S.E.
FC_{t-1}	0.705**	0.025		
COST	-0.680**	0.070	-2.309**	0.238
REV	0.275**	0.023	0.934**	0.078
DCOF	0.265 E -3	0.157 E -3	0.898 E -3	0.532 E -3
D2	0.039	0.280	0.134	0.949
D3	-0.002	0.273	-0.007	0.926
D4	0.838**	0.281	2.845**	0.954
D5	0.693*	0.281	2.353*	0.953
D6	1.120**	0.282	3.802**	0.957
D7	1.031**	0.284	3.501**	0.964
D8	0.789**	0.296	2.680**	0.785
D9	-0.136	0.277	-0.461	0.940
D10	-0.451	0.274	-1.531	0.931
D11	0.370	0.273	1.258	0.928
D12	0.157	0.274	0.535	0.930
COS	-0.812**	0.163	-2.759**	0.554
SIN	0.054	0.122	0.184	0.413
constant	-0.958	1.176	-3.253	3.992
F statistic	1,791.791**			
R^2	0.984			

F statistic on monthly dummy variables	5.416**
F statistic on cosine and sine cycle variables	19.317**

Note: The number of observations was 517. Single asterisks denote significance at the 5% level; Double asterisks denote significance at the 1% level.

Table 2.4. Corn/Feeder Cattle Price Multiplier at Different Placement Weight, Slaughter Weight, and Feed Conversion Levels

		Placement Weight = 675		
		Slaughter Weight		
Feed Conversion	1100	1150	1200	1250
6.25	-9.086	-10.155	-11.224	-12.293
6.50	-9.450	-10.562	-11.673	-12.785
6.75	-9.813	-10.968	-12.122	-13.277
7.00	-10.177	-11.374	-12.571	-13.769
		Placement Weight = 700		
6.25	-8.246	-9.277	-10.308	-11.339
6.50	-8.576	-9.648	-10.720	-11.792
6.75	-8.906	-10.019	-11.133	-12.246
7.00	-9.236	-10.391	-11.545	-12.700
		Placement Weight = 725		
6.25	-7.464	-8.460	-9.455	-10.450
6.50	-7.763	-8.798	-9.833	-10.868
6.75	-8.062	-9.136	-10.211	-11.286
7.00	-8.360	-9.475	-10.590	-11.704
		Placement Weight = 750		
6.25	-6.735	-7.697	-8.659	-9.621
6.50	-7.003	-8.005	-9.005	-10.006
6.75	-7.273	-8.312	-9.351	-10.391
7.00	-7.543	-8.620	-9.698	-10.775
		Placement Weight = 775		
6.25	-6.052	-6.983	-7.914	-8.845
6.50	-6.294	-7.262	-8.230	-9.199
6.75	-6.536	-7.541	-8.547	-9.553
7.00	-6.778	-7.821	-8.864	-9.906

Table 2.5. Estimated Feeder Cattle Prices and Average Purchase Weights Associated With Alternative Corn and Slaughter Cattle Prices

	Corn Price ($/bu)								
Slgt. Price	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
($/cwt.)	Estimated Feeder Cattle Price								
60	67.98	65.72	63.49	61.28	59.10	56.95	54.83	52.73	50.65
65	75.34	73.06	70.81	68.58	66.38	64.20	62.05	59.92	57.81
70	82.71	80.42	78.15	75.90	73.68	71.48	69.30	67.15	65.01
75	90.09	87.78	85.50	83.23	80.99	78.77	76.57	74.40	72.24
80	97.48	95.15	92.86	90.58	88.32	86.08	83.87	81.67	79.50
	Estimated Feeder Cattle Purchase Weight								
60	737	740	744	747	750	754	757	761	764
65	735	738	741	744	747	750	754	757	760
70	733	736	739	742	745	747	750	753	756
75	731	734	737	739	742	745	748	750	753
80	730	732	735	738	740	743	745	748	750

Table 2.6. Simulated Adjustments to a $0.25 Corn Price Increase

Week	Corn Price	Feeder Price	In-wgt.	Out-wgt.	Multiplier	% of total adjustment completed
0	2.25	78.08	736.40	1,162.70		
1	2.50	77.42	737.56	1,162.89	-2.64	29.19
2	2.50	76.95	737.56	1,162.89	-4.51	49.76
3	2.50	76.62	737.56	1,162.89	-5.82	64.27
4	2.50	76.39	737.56	1,162.89	-6.75	74.50
5	2.50	76.22	738.27	1,163.16	-7.44	82.09
6	2.50	76.10	738.27	1,163.16	-7.92	87.44
7	2.50	76.01	738.27	1,163.16	-8.27	91.21
8	2.50	75.95	738.27	1,163.16	-8.51	93.87
.	.	.	.	.	.	.
.	.	.	.	.	.	.
12	2.50	75.83	738.70	1,163.45	-8.98	99.12
.	.	.	.	.	.	.
.	.	.	.	.	.	.
Equilibrium	2.50	75.81	739.39	1,165.09	-9.06	100.00

Note: Equilibrium parameter values were achieved in week 97.

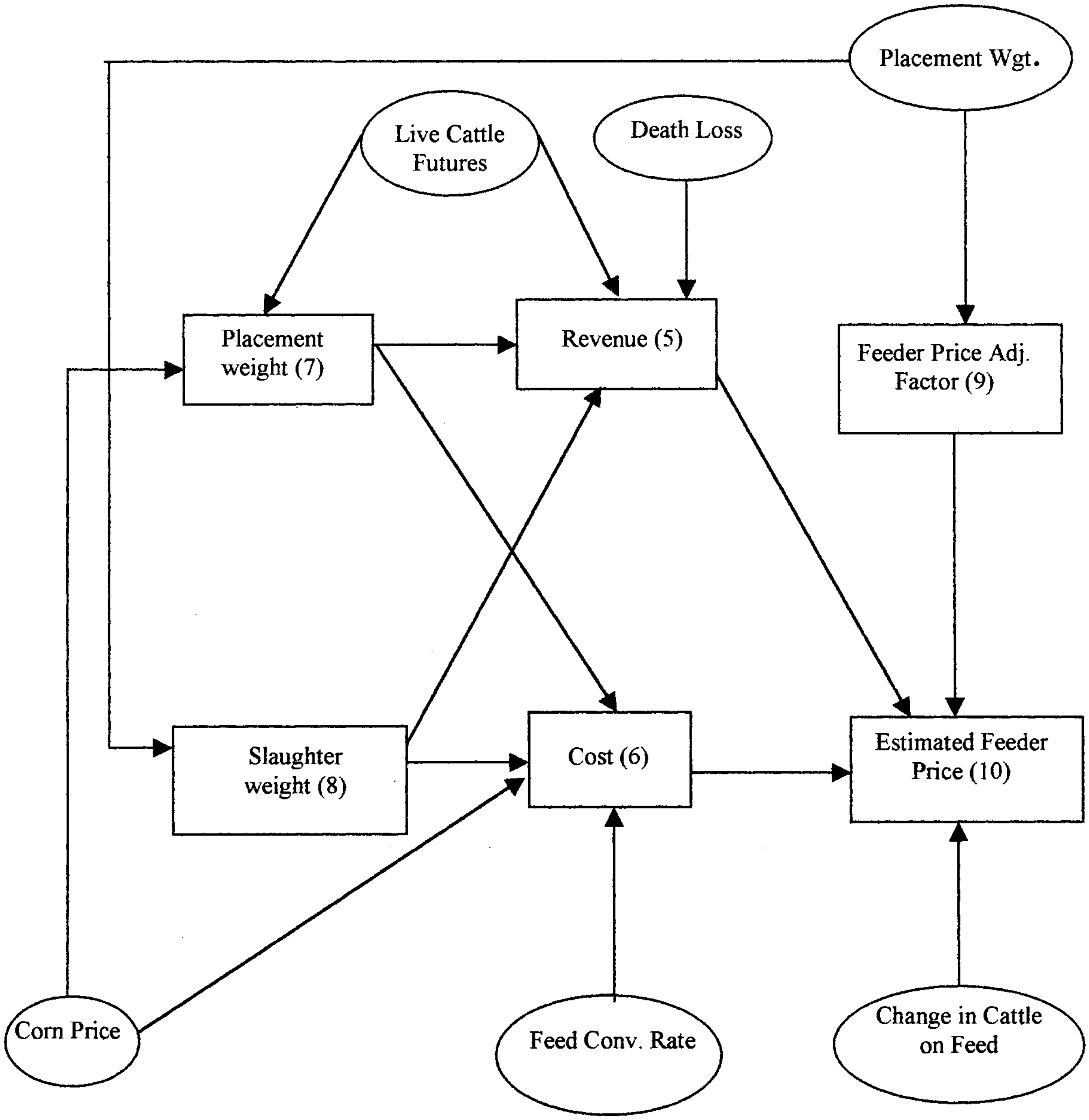
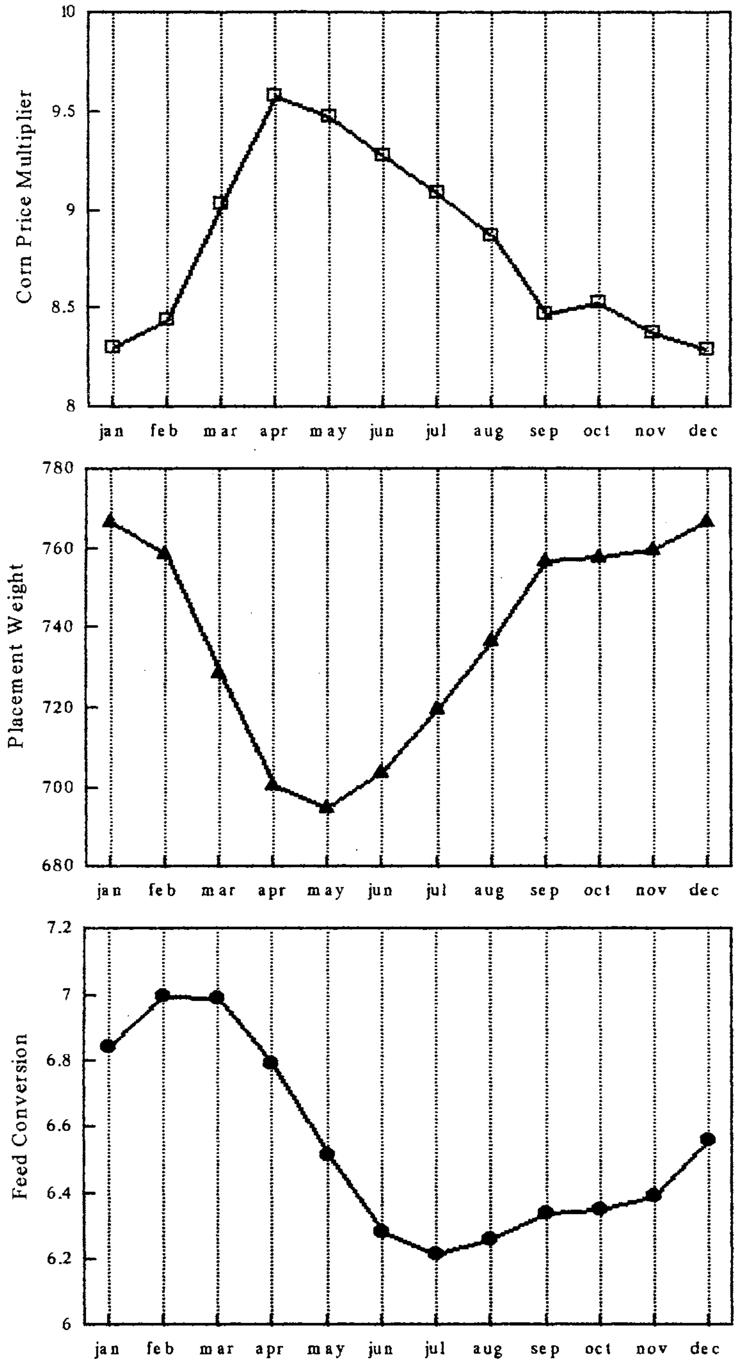


Figure 2.1 Variable and equation relationships in break-even feeder price model



Note: Corn price multiplier graph shows absolute values.

Figure 2.2 Average monthly values of the corn price multiplier, placement weight, and feed conversion rate

Chapter III

Experimental Simulation of Public Information Impacts on Price Discovery and Marketing Efficiency in the Fed Cattle Market

In determining a transaction price, both buyers and sellers depend on information about prices paid by others. In agricultural markets, much of the price and quantity information available to decision makers is collected and disseminated by government agencies. The amount of government-provided information was reduced throughout the 1980s and 1990s and continues to be reduced as government agencies look for ways to cut their budgets in the ongoing effort to reduce federal spending. If public resources are to be efficiently allocated, it is vital to know the potential impact of such reductions on the affected markets.

The fed cattle market--like most agricultural markets--receives considerable information through government reporting.[1] Furthermore, this market has undergone tremendous change in the last fifteen years. The market share of the four largest meat-packing firms increased significantly over this time period. In 1980, the four largest meat-packers accounted for 35.7% of the total steer and heifer slaughter. By 1995, their share had risen to 79.3% (Grain Inspection, Packers and Stockyards Administration). In addition, cattle are increasingly traded on a forward contract basis. Forward contracts and marketing agreements were virtually nonexistent in 1980, but in 1996, 19.1% of the cattle slaughtered by the four largest firms were traded using these instruments (Grain

Inspection, Packers and Stockyards Administration). Structural changes related to the number and size of firms in the market and behavioral changes related to the increased use of contracting and other forms of non-price coordination may have affected the role of information in this market. Information asymmetries may exist due to larger firms having more resources to use in obtaining private information. Larger firms may also have more information simply due to the greater volume of their own transactions. Furthermore, as forward contracting increases, less information is revealed through cash market transactions.

In light of these facts and the limited funding for government collection and reporting of information, a determination of the importance of public information to the efficient functioning of this market is warranted. The debate over mandatory versus continued voluntary price reporting provides additional incentive to investigate the role of information in the fed cattle market. The unwillingness of some firms to report prices has led to concerns that price reports are not representative of the market (Schroeder et al. 1997). Understanding the effect of insufficient public information on price discovery and marketing efficiency in the fed cattle market is necessary if policy decisions related to government price reporting are to be made judiciously.

Policymakers are not the only ones interested in knowing the impacts of policy changes. In the fed cattle market, cattle feeders and meat-packers would certainly like to know how price reporting changes may affect the market in which they operate. For example, will a reduction in the availability of public information result in a bargaining advantage for either packers or feeders? Will it lead to greater risk in the market due to increased price variability? Knowing the answers to such questions could help market participants develop strategies for dealing with any possible public information reductions.

This research seeks to improve policy decisions regarding the level of public price reporting in the fed cattle market by determining how reductions in information affect that market. Specifically, it is necessary to know the effect of reducing public price and quantity information on the level and variability of prices and on production efficiency in the fed cattle market. In pursuing these objectives, this study employs experimental simulation of the fed cattle market to obtain data which are then used in regression analysis.

Background and Theory

The ability of any market to function efficiently with respect to pricing depends in large part on the information available to market participants. Grossman and Stiglitz note that prices cannot perfectly reflect all available information since information is costly. The fact that prices imperfectly reflect information represents the necessary compensation to economic agents who use resources to obtain it. Consequently, an increase in the quality of information or a decrease in its cost will increase the informational content of prices. Other authors note the link between information and pricing efficiency. For example, Stigler equates price dispersion with ignorance in the market. He relates the level of price dispersion to search costs, that is, the cost to sellers of determining the bid prices of competitors and, what is more important, to buyers of surveying the offer prices of sellers. Devine and Marion characterize price dispersion as an imperfection in a market for a homogeneous product. They find that disseminating accurate retail price information reduced price dispersion among items at competing grocery stores and reduced the average price level in the market.

In agricultural markets, government reports have traditionally been the primary source of information concerning both prices and production. Though market alternatives to government reporting may exist, these alternatives may not have the same informational content as government reports (Carter and Galopin).

Irwin recently examined the value of one type of public information--situation and outlook programs. He found that given some reasonable assumptions, public situation and outlook information lead to increased social welfare by increasing the speed of convergence to equilibrium. Such public information increases the speed of convergence, he argues, by educating producers about the underlying economic model and economic conditions and by collecting information less expensively than private firms. Moreover, Irwin hypothesizes that in markets characterized by imperfect information and/or asymmetric information, public information may force informed market participants to reveal more of their information through prices. This competitive impact of public information may be of particular importance in the imperfectly competitive fed cattle market.

While Irwin examines situation and outlook reports, many other authors have evaluated the informational content of government production and inventory reports. Colling, Irwin, and Zulauf found that nearby pork belly and live hog futures prices responded significantly to the *Cold Storage Report* (*CSR*) release. Colling and Irwin note that unanticipated information in the *HPR* does affect the live hog futures market but not enough to permit profitable trading based on that unanticipated information. In a similar study of the live cattle futures market, Grunewald, McNulty, and Biere found that that market also responds to unanticipated information in the *Cattle on Feed Report* (*COF*).

Additional studies have attempted to assess the informational content of government reports by observing the price impacts of report releases. Sumner and Mueller concluded that U.S. Department of Agriculture (USDA) harvest forecast announcements had a significant impact in corn and soybean futures markets. Milonas had previously obtained similar results looking at crop report impacts on corn, wheat, soybean oil, and soybean meal cash prices. Conversely, Patterson and Brorsen found little evidence that the *U.S. Export Sales Report* provided any new information to the market.

All of these studies focused on production or inventory reports rather than price reports. In addition, with the exception of Milanos, they have examined futures market rather than cash market responses to public information. This study is unique in that it investigates how a cash market (the fed cattle market) responds to a reduction in public price information. For this reason, the results of previous studies provide limited insight into what results to expect from this study. Market responses to government reports noted in several studies mentioned above indicate some impact on price discovery. It can by hypothesized that price dispersion (variance) should increase as public information is reduced since participants are forced to make less informed pricing decisions; however, previous studies provide little basis for hypothesizing price level effects.

Fed Cattle Market Simulator Description, Experimental Design, and Data Collection

The Fed Cattle Market Simulator (FCMS) allows experimental simulation of the fed cattle market. Within this simulated market, the decisions made by one firm directly influence the subsequent behavior and performance of other firms and of the market as a whole. Market participants must make a series of marketing decisions (e.g., when and at what price to buy or sell cattle) and then react to the consequences of those decisions.

FCMS participants act as feedlot marketing managers and meat-packing procurement managers. Eight feedlot and four meat-packing teams, consisting of from two to four persons, buy and sell simulated pens of fed cattle. The number of feedlot and meat-packing teams is limited because the FCMS was not intended to represent a perfectly competitive market. Rather, it reflects the fed cattle market, that is, a few, large cattle feeding firms and even fewer, large meat-packing firms.

Participants experience increasing degrees of market complexity, beginning with cash trading only and progressing through the addition of forward contracting and a live cattle futures market. Forward contracts are defined as transactions which occur this week for delivery two or more trading periods in the future. Market price reports do not include these contract prices. Futures market contracts expire at eight trading-period intervals, consistent with the two-month intervals for live cattle contracts on the Chicago Mercantile Exchange (CME). Three contracts—a nearby and two distant—are open at all times. Because the futures contract is specifically designed for this simulated market, the basis is zero.

One week in the FCMS consists of an eight-to-twelve-minute cycle. During the first five to seven minutes of the cycle, feeders and packers negotiate prices and finalize trades. Transactions are conducted face-to-face, and decisions of participants largely determine the direction of market prices and the profitability of each feedlot and meat-packing team. Generally, about 40 trades occur each week. Each feedlot has a number of paper pens of cattle, each sheet of paper representing 100 steers on a show list. Prices are negotiated and sales occur for the range of available weights of show-list cattle, from 1,100 to 1,200 pounds in 25-pound increments. Completed transaction sheets are scanned into a computer for record keeping and analysis.

Throughout the trading period, market information is provided on two digital display bars. One display bar scrolls cash market information (trading volume and high-low prices) which is analogous to current market information available to fed cattle buyers and sellers from the Agricultural Marketing Service, U.S. Department of Agriculture (USDA/AMS). The other display bar scrolls futures market information (trading volume and current prices for three futures market contracts) which is analogous to information available from the Chicago Mercantile Exchange (CME).

The three-to-five-minute period following trading is an information-processing period or "weekend" during which each team updates its show list, calculates break-even prices, and formulates marketing strategy. Each period, the FCMS software provides an individual income statement for each team as well as summary market information for the preceding period. This summary information also resembles that available from USDA/AMS in the real-world fed cattle market.

The data to be used in this research were collected from the FCMS during an agricultural economics course which met weekly in 90-minute sessions during the spring 1996 semester at Oklahoma State University. FCMS-generated data have previously been used in research relating to price discovery in the fed cattle market by Ward et al. and by Dowty. The data for this experiment were collected in a manner similar to the method of those studies.

Trading in the FCMS course began in week 21. Feeder cattle weighing 700 pounds are placed on feed in week 1, gain 25 pounds per week, reach the show list in week 17, and weigh 1,150 pounds in week 19. By week 21, there are two weeks of historical market information generated from a predetermined base of trading activity which is programmed into the simulator. This base of information provides a starting point for market simulation by the participants.

Teams were rotated twice during a twelve-week preliminary learning phase during which no data were collected for analysis. By week 33, final teams had been established. Data collection began at week 37 and continued through week 96--a simulation period of 60 weeks or approximately one year and two months. Teams were rotated a final time after week 72, and trading ended after week 97.

Each FCMS transaction represents a data point. Each transaction involves the sale/purchase of one pen of 100 steers between one feedlot and one packer. During the 60 weeks of the experiment, 2,197 transactions occurred. For each of these, the following data were recorded: week traded, packer purchasing cattle, feedlot selling cattle, weight of cattle, transaction price, and type of transaction (cash or contract). In addition to this transaction data, weekly data were also recorded. These data include the break-even price for 1,150 pound steers, boxed beef price at which meat would be sold that week, closing nearby futures price for the preceding week, previous week's fed cattle marketings, and number of pens of cattle on the show list at the beginning of each trading week.

In this experiment, the amount and type of cash market information available to FCMS participants was changed at predetermined intervals.[2] Two limited information alternatives were specified in addition to complete (or full) information and no (cash market) information. The complete information set consisted of current information displayed on a light bar at the front of the room as well as end-of-week summary information posted on the blackboard at the end of each trading session. Current information consisted of cash and contract trading volume and high-low cash prices during the week being traded. This information was sent directly to the light bar from a scanner used to record transactions. Summary information consisted of weekly average cash prices by weight groups, weekly average boxed beef price, weekly average feeder cattle price, cost of gain, and total volume of cattle traded the preceding week. One incomplete information set consisted only of summary information and another consisted only of current information.

One final note concerning the design of the experiment is in order. In accordance with experimental economics methods, participants were paid based on the profitability of their team (Friedman and Sunder). Performance was not continuously evaluated for payment purposes. Rather, participant performance was evaluated over randomly selected 4- to 8-week intervals. Participants were notified of the beginning of these payment periods but not the duration. These periods were timed so as not to coincide exactly with an information alternative period. Figure 3.1 gives a complete description of the experimental design.

The FCMS transactions data were used to determine what effects a reduction in public price information might have on the pricing and productive efficiency of the cash fed cattle market. Based on pricing efficiency theory, it was hypothesized that reducing the amount of information available to market participants would increase the within-week price variance due to less efficient price discovery. It was further hypothesized that the less informative prices would lead to less efficient production. In the FCMS, the least cost of production or optimal marketing weight for fed cattle is 1,150 pounds. Here, optimal is in a comparative static sense. That is, deviations from the optimal weight result in less efficient use of resources and reduced revenue for the industry compared with what would have been realized by marketing 1,150-pound cattle. Weight deviations from 1,150 pounds can therefore be used as a measure of the productive efficiency lost as a result of reduced information.

Finally, it was hypothesized that reducing information would lead to lower fed cattle prices. This price level change would favor packers. This hypothesis is based on the fact that demand for fed cattle is derived from the retail demand for beef. Packers, by virtue of their position in the market, are in a better position than feeders to assess this retail demand. In the absence of objective market reporting, this fact could give packers an information advantage over feeders.

Model Development

The transaction data from the FCMS are used to estimate three basic models. Two of these, a transactions price model and a price variability model are based on other models employing FCMS data (Ward et al.; Dowty). A third model is developed to give further insight into any loss of productive efficiency resulting from incomplete information. In the FCMS, the least cost or optimal weight for marketing fed cattle is 1,150 pounds. This fact quickly becomes obvious to feedlot and packer teams, as deviations from this optimal weight reduce their revenues. An ordered logit model with absolute weight deviations from 1,150 pounds as the dependent variable is estimated to determine the effect of limited information on participants' ability to efficiently market fed cattle.

The selection of variables for inclusion in the two price related models is based on previous research into fed cattle transaction prices (Jones et al.; Schroeder et al. 1993; Ward 1981, 1982, 1992). Variables chosen from previous research to explain transaction prices for fed cattle included boxed beef prices, futures market prices, total show list, total weekly slaughter, potential profit/loss in the market, and individual buyers (packers) and sellers (feedlots). This previous research draws on the pricing process followed by packers in determining bid prices for fed cattle. Discussion here focuses on the variables specifically arising from this experiment, that is, information level dummy variables. Specifications of the three models are presented below. Complete variable definitions and their hypothesized signs are provided in table 3.1. Table 3.2 provides summary statistics for each of the continuous variables used in the models.

The price level model is

$$(1) \qquad PRC_{it} = \beta_0 + \beta_1 BBP_{t-1} + \beta_2 FMP_{t-1} + \beta_3 TSL_{t-1} + \beta_4 TLST_{t-1} + \beta_5 PPL_t + \sum_{j=1}^{8} \beta_{j6} FDLT_{jit} + \sum_{j=1}^{4} \beta_{j7} PACKER_{jit} + \sum_{j=1}^{n} \beta_{j8} DINFO_{jit} + \beta_9 DPAY_t + v_{it},$$

where *PRC* is the transactions price for one pen of fed cattle, *BBP* is the lagged boxed beef price, *FMP* is the lagged fed cattle futures market price, *TSL* is the total pens of fed cattle slaughtered, *TLST* is the total number of pens on the show list, *PPL* is the potential profit or loss available to the industry, *FDLT* are binary variables identifying the feedlot involved in the transaction, *PACKER* are binary variables identifying the packer involved in the transaction, *DINFO* are binary variables identifying information available at the time of the transaction, and *DPAY* is a binary variable identifying payment/nonpayment periods.

The price variance model is

$$(2) \qquad VPRC_{it} = \alpha_0 + \alpha_1 BBP_{t-1} + \alpha_2 FMP_{t-1} + \alpha_3 TSL_{t-1} + \alpha_4 TLST_{t-1} + \alpha_5 PPL_t + \sum_{j=1}^{8} \alpha_{6j} FDLT_{jit} + \sum_{j=1}^{4} \alpha_{7j} PACKER_{jit} + \sum_{j=1}^{n} \alpha_{8j} DINFO_{jit} + \alpha_9 DPAY_t + v_{it},$$

where *VPRC* is the natural log of v_{it}, the price variance estimate calculated from the price level model, and other variables were defined previously.

The weight deviation model is

$$(3) \qquad WTV_{it} = \gamma_0 + \gamma_1 BBP_{t-1} + \gamma_2 TSL_{t-1} + \gamma_3 TLST_{t-1} + \gamma_4 PPL_t + \sum_{j=1}^{8} \gamma_{5} FDLT_{jit} + \sum_{j=1}^{4} \gamma_{6} PACKER_{jit} + \sum_{j=1}^{n} \gamma_{7} DINFO_{jit} + \gamma_8 DPAY_t + v_{it},$$

where *WTV* is a variable indicating absolute weight deviation from 1,150 pounds, and other variables were defined previously.

Specification of a logit model is possible due to the fact that cattle weight in the FCMS is a discrete variable. Cattle enter the show list at 1,100 pounds. Cattle not sold gain 25 pounds each week until they reach a maximum weight of 1,225 pounds.[3] Thus, absolute weight deviations from 1,150 pounds will always be 0, 25, 50, or 75 pounds. These values are represented by a variable with values of 0, 1, 2, and 3 representing 0, 25, 50, and 75 pound deviations respectively.

In the above models, t denotes the simulation week ($t = 36,\ 37,\ \ldots,\ 96$) and i denotes transactions within a week ($i = 1,\ 2,\ \ldots,\ n_t$). In order to estimate the models, base feedlot and packer dummy variables must be excluded from the estimation to avoid perfect collinearity. Feedlot 1 and packer 1 are used as bases.

Subscripts in the above equations indicate that these are hierarchical models since some variables have the same value for every transaction in a given week (i.e., they have no i subscript). In this experiment, numerous transactions occur each week. Goldstein points out that if modeling does not take into account the hierarchical nature of data, coefficient estimates may be inefficient; and standard errors, confidence intervals, and significance tests may be incorrect. To avoid the problems discussed by Goldstein, both price level and variance models are specified as weighted random effects models (WREM) for unbalanced panel data. The random effects model assumes two components for the error term. Thus the error term in the previous equations (v_{it}) can be represented as the sum of its components:

$$v_{it} = e_{it} + u_t \,. \tag{4}$$

The component e_{it} is the random variation in prices within each week while the second component, u_t, is the random disturbance which is common to prices in each trading week.

Cross-sectional heteroskedasticity will be a problem with this data due to the nature of this experiment. It cannot be assumed that the variance of prices will be constant among the different information periods established in the experiment. Therefore, the natural log of the squared error terms from the basic random effects model is used as the dependent variable in an artificial regression against the independent variables. Predicted values from this regression are then used to generate weights which are applied to the models, resulting in weighted random effects models. All models are estimated using the LIMDEP 6.0 econometric program (Greene).

Two versions of each of the three models are specified using different definitions for the information period dummy variables. The most basic models represent all limited information periods with a single dummy variable. The comparison is thus between full and limited information with no distinction made between the type of information withheld. The second specifications use two information dummy variables: one to represent the withholding of current (within-week) information and another to represent the withholding of summary (end-of-week) information. The interaction of these two dummy variables represents periods when all information is withheld. Thus, under this definition of information periods, the following interaction term (*DINFO1x2*) is included in each of the three model specifications:

(6) $$DINFO1x2_{3it} = (DINFO_{1it} \cdot DINFO_{2it}),$$

where $DINFO_{jit}$ is as defined after equation (1).

Results and Discussion

Results from price level, price variance, and weight deviation models for the single information period specification are given in table 3.3. Table 3.4 shows results from the models using separate dummy variables for current and summary information. (In addition to these econometric results, appendix C summarizes the results of surveys completed by FCMS participants to determine their responses to the reduction in public information.)

Price Discovery Variables. The results of the basic single-information-period price model differ somewhat from previous studies using FCMS data. The effect on price of several of the independent variables seems to have been altered by the withholding of information. Boxed beef price has previously been found to have a strong relationship with fed cattle transaction prices (Ward et al.; Dowty). In this model, however, the coefficient on lagged boxed beef price, while still significant at the 0.01 level, is much smaller than in previous studies. The elasticity of fed cattle price with respect to boxed beef price at the means is 0.371. This compares to elasticities of 0.792 and 0.520 calculated using data from Ward et al. and Dowty.

Boxed beef price was one element of the end-of-week summary information. When this information was withheld, boxed beef price information was not available at all to feedlots. Packers could determine this price from sales data on their profit and loss statements; however, it was not publicly available to them either. This reduced availability of boxed beef price may have weakened the relationship between boxed beef price and fed cattle transaction price.

On the other hand, the relationship between futures market price and transaction price is much stronger in this model than in previous studies. This relationship is stronger than that between boxed beef price and transaction price. This is not consistent with previous FCMS studies; however, given the design of the experiment, it may not be surprising. Futures market prices were never withheld from participants in this study. They may have therefore come to rely more heavily upon these prices than boxed-beef prices in their decision making. The elasticity of fed cattle price with respect to futures price is 0.441. In Ward et al. and Dowty, this elasticity was 0.040 and 0.265, respectively.[4]

The coefficient describing the relationship between lagged total show list and transaction price is negative and significant. This is consistent with the findings of Ward et al. Not consistent with Ward et al. and Dowty is the positive and significant coefficient on lagged total slaughter; however, this coefficient estimate is not particularly robust. In the price level model with two information period dummy variables, it is not significant at the 10% level.

The variation in transaction prices among feedlots is greater in this study than in others using similar data. Average prices received by feedlots in this study had a range of \$0.96/cwt. This compares with ranges of \$0.34/cwt and \$0.49/cwt for Ward et al. and Dowty, respectively. Apparently some feeders found more successful strategies than others for dealing with the lack of information. Average prices paid by packers in this study had a range of \$0.40/cwt. This range is consistent with Ward et al. and Dowty, who found ranges of \$0.38/cwt and \$0.48/cwt, respectively. In both the price level and variance models estimated in this study, significant differences exist between payment and nonpayment periods. Price is significantly higher and variance significantly lower in payment periods. Dowty found no significant price level differences between payment and nonpayment periods; however, he did find that variance was significantly higher in payment periods. Since pay periods enter this experiment in exactly the same manner as in Dowty's experiment, it is difficult to say why the results are not consistent. One logical explanation is that this difference results from the fact that entirely different participants were involved in each experiment.

Results of Price Level Models. The impact of limited information on prices is revealed by the coefficient on the limited information dummy variable. In the basic price model, that coefficient is not significantly different from zero. The effect of limited information on price therefore cannot be determined when all limited information periods are aggregated. In the second specification of the price model in which three information dummy variables are used (current information, summary information, and interaction of the two), removal of the current trading information results in a $2.37/cwt decline in fed cattle prices while removal of both current and summary information results in a $2.52/cwt increase in fed cattle prices. Removal of summary information alone has no significant impact on prices.

Results of the price level models are difficult to interpret. Aggregating the limited information periods suggests that limiting public information does not affect the price level; however, a model specification using more narrowly defined information variables suggests that the price effects of limited information are important and that the effects can be positive or negative. Removing current information reduced prices (favoring packers), whereas withholding all information increased prices (favoring feeders). It could be argued that limiting current information gives packers an advantage since they are in a better position to assess the remaining summary information--particularly boxed beef price and total slaughter figures. With the removal of all information, however, neither packers nor feeders have an advantage. The increase in price simply reflects higher search costs incurred by packers and feeders who must now survey the market on their own to determine a purchase or sale price instead of simply relying on public information (Stigler 1961). Clearly, these hypotheses are ad hoc and are only offered as a possible explanation for the results obtained here. Reasonable alternative hypotheses would argue for opposite results, particularly for the effects of removing all information. More research is needed to clearly define any price level effects that may result from limiting information.

Results of Price Variance Models. The results of the price variance model are more conclusive than those of the price level model when aggregated information periods are considered. The coefficient on the information dummy variable is positive and highly significant, indicating an increase in price variance due to limited information. This is consistent with hypothesized results.

Results again become more ambiguous as efforts are made to determine effects of different types of information. In the second specification of the variance model, variance is increased by removal of current information and by removal of all information. Removal of summary information, however, decreases the variance of prices.

The price variance model provides stronger evidence of the importance of public information to the efficient functioning of the fed cattle market than does the price level model. The aggregate information period model shows conclusively that limiting information increases price variance. Evidence further indicates that limiting current information definitely increases price variance; however, in the second model limiting summary information decreases price variance. It is possible, perhaps even likely, that limiting summary information would lead to greater reliance on current price information. The resulting inertia could perhaps reduce price variability. This does not mean that limiting summary information would result in a more efficient market. On the contrary, if prices fail to quickly register changes occurring in underlying supply/demand conditions, the market would be much less efficient from a resource allocation standpoint in spite of the increased price stability.

Results of Pricing Efficiency Models. The effect of limiting information on the efficiency of the market is further examined using an ordered logit model with absolute weight deviations from the optimal 1,150-pound weight as the dependent variable. Results of the single period model clearly indicate that limiting information results in marketing fed cattle at higher deviations from the least cost weight. The second specification of the model indicates that these higher deviations are due to the removal of summary information.

Direct observation of FCMS transaction data from the experiment clearly shows that weight deviations were toward heavier and less cost-efficient weights. Just over half of all fed cattle were marketed at 1,175 pounds. Only 6% were marketed at the least cost, 1,150 pound weight. This is not at all consistent with results of previous use of the FCMS. Figure 3.2 compares the marketing weights obtained under this experiment with those obtained from the FCMS when no experiment was being conducted. These results suggest that removing summary information results in lost efficiency regardless of the price variance effects of removing information.

The most significant result of the logit model is that the productive efficiency of the industry is reduced. Rausser, Perloff, and Zusman define productive efficiency as requiring that each firm produces in a manner which places the economy on its production possibilities frontier. That is not the case when cattle are fed to heavier-than-optimal weights. Resources must be expended in cattle feeding which would be better utilized elsewhere. This represents a loss to society, not just to cattle feeders.

Summary and Conclusions

Data from the FCMS were used to assess the impact of limiting information on the efficiency of the fed cattle market. Results of the econometric models developed here indicate that the absence of current market information created inefficiencies. This was evidenced by increased transaction price variance and by the increased marketing of fed cattle at less industry-efficient weights as a consequence of the removal of information from the market. The results of this experimental simulation also provide evidence that traditional, predictable economic relationships may be altered in the absence of public market information, thereby contributing to pricing inefficiencies. Differences in econometric results for this study compared with two previous studies suggest that removing and restoring different types and amounts of information into the FCMS altered the normal economic relationships between transaction prices and traditional variables, particularly boxed beef prices but also futures market prices and fed cattle marketings to a lesser extent.

Looking only at price level impacts, it is impossible to determine which sector of the industry stands to lose most from reduced market information. Price impacts were sometimes in the feeders' favor and sometimes in the packers'. Rather than focusing on who stands to gain or lose from reducing public information, the price variance and weight deviation models focus investigate factors which impact the competitiveness of the entire industry. Results of the price variance model indicate that reducing market information definitely increases price variance and, consequently, the price risk faced by all market participants. Results of the weight deviation model reveal that reducing public information leads to a loss in production efficiency, in other words, inefficient use of the resources employed in feeding cattle.

Both of these factors--increased price risk and decreased production efficiency--raise costs in the fed cattle industry. Ginn and Purcell contend that higher costs due to price risk are in some measure responsible for beef's loss of market share to poultry and pork in the 1980s. While their hypothesis is only one of many possible explanations for beef's loss of market share, it does correctly emphasize that higher costs reduce the competitiveness of the beef industry. If reducing public information increases costs due to risk and production inefficiencies—as this research suggests it will—then feeders and packers may need to consider how any public policy change regarding public market information could affect the competitiveness of the entire beef industry rather than focusing on which side may gain a short-term advantage over the other.

Endnotes

1. The term government reporting as used here encompasses the collection and compilation of data as well as its dissemination in government reports.

2. It is critical to note the distinction being made here between cash and futures market information. This experiment involved varying levels of cash market information. Futures market information was available to participants at all times. This is appropriate given the objective of this experiment, i.e., to assess the market impacts of *publicly funded* information such as that provided by USDA/AMS. Futures market information, while public in the sense of being widely available, would more appropriately be considered private information for the purpose of this study since public funds are not used in its collection/dissemination.

3. Feedlots can sell cattle weighing 1,200 pounds. Cattle unsold at the end of the trading week in which they weigh 1,200 pounds are automatically sold to an anonymous packer for a large discount in price, beginning at $5/cwt below the average price that week. All cattle sold to the anonymous packer weigh 1,225 pounds.

4. A price level model containing interaction terms between the single information period dummy variable and these two independent variables was estimated. Interaction terms were not significant. The fact that information was withheld would likely affect participants' reliance on the information, even when it was fully

available. For this reason, interaction terms which compare the impacts of the variables between full and limited information periods will not provide a reliable test of the effect of limiting information. Thus, the models reported in this article do not contain interaction terms.

Table 3.1. Variable Names and Definitions for Price Level, Price Variance, and Weight Deviations Model

Variable Abbreviation	Variable Definition	Expected Sign
Dependent Variables		
PRC_{it}	Transaction price for *i*th pen of fed cattle (\$/cwt.) in week *t*	N/A
$VPRC_{it}$	Estimate of *i*th transaction price variance (\$/cwt.) calculated from price level model in week *t*	N/A
WTV_{it}	Dummy variable indicating absolute value of weight deviation from 1,150# of *i*th transaction in week *t*	N/A
Independent Variables		
BBP_{t-1}	Boxed beef price (\$/cwt.) for Choice Yield Grades 1-3, 550-700 lb. carcasses, lagged one week	+
FMP_{t-1}[a]	Closing live cattle futures price (\$/cwt.) for nearby contract, lagged one week	+
TSL_{t-1}	Total pens slaughtered (100hd./pen), lagged one week	-
$TLST_{t-1}$	Total pens on market-ready show list, lagged one week	-
PPL_t	Potential profit or loss in week *t*. Equal to largest packer's break-even price (\$/cwt.) for 1,150 lb. cattle less the mean feedlot break-even price (\$/cwt.) for 1,150 lb. cattle	-
$FDLT_{ijt}$	Binary variables identifying individual feed-lots involved in *i*th transaction in week *t*. $j = 2, \ldots, 8$.	+/-
$PACKER_{ijt}$	Binary variables identifying individual packers involved in *i*th transaction in week *t*. $j = 2, \ldots, 4$	+/-
$.DPAY_t$	Binary variable identifying week *t* as payment or nonpayment period	+/-
$DINFO_{ijt}$	Binary variables identifying which of *j* available information sets the *i*th transaction in week *t* occurred under.	+/- price level model + variance model + wgt. dev. model

[a] This variable was not used in the weight deviation model.

Table 3.2. Summary Statistics for FCMS Spring 1996 Data Weeks 37 - 96

Variable	Units	Mean	SD
Fed cattle price	$/cwt.	78.30	3.622
Pens slaughtered		36.91	7.511
Pens on show list		129.30	21.316
Boxed beef price	$/cwt.	123.65	5.447
Futures market price	$/cwt.	79.12	2.955
Potential profit/loss	$/cwt.	0.77	3.891
Fed cattle weight	lbs.	1,185.84	21.163

Table 3.3. Estimated Coefficients for Price Level, Price Variance, and Weight Deviation Models Using Single Information Period Dummy Variables

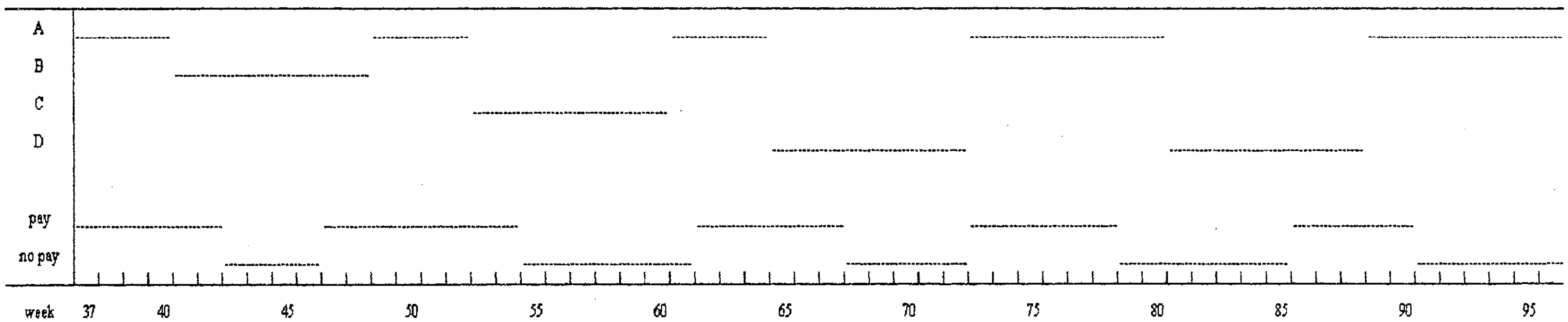
Variables	Price Model	Price Variance Model	Weight Deviation Model
BBP_{t-1}	0.235**	-0.133**	-0.005
	(4.291)	(-6.779)	(-1.731)
FMP_{t-1}	0.436**	0.010	N/A
	(5.863)	(0.384)	
TSL_{t-1}	0.082*	-0.101**	-0.050**
	(2.165)	(-7.406)	(-8.541)
$TLST_{t-1}$	-0.070**	0.011**	0.039**
	(-6.786)	(3.488)	(17.644)
PPL_t	-0.068	0.048**	-0.059**
	(-1.377)	(2.712)	(-5.057)
$FDLT_2$	0.572**	-0.803**	0.446*
	(15.888)	(-4.324)	(2.500)
$FDLT_3$	0.375**	-0.111	0.963**
	(9.914)	(-0.565)	(5.198)
$FDLT_4$	0.960**	-0.657**	1.243**
	(25.529)	(-3.355)	(6.353)
$FDLT_5$	0.678**	-0.165	1.946**
	(16.047)	(-0.852)	(9.852)
$FDLT_6$	0.481**	-0.107	0.770**
	(11.948)	(-0.529)	(3.812)
$FDLT_7$	0.813**	-0.026	1.150**
	(17.831)	(-0.138)	(6.132)
$FDLT_8$	0.459**	0.452*	1.841**
	(9.879)	(2.317)	(9.656)
$PACKER_2$	0.152**	-0.034	-0.916**
	(4.144)	(-0.213)	(-6.241)
$PACKER_3$	0.123**	-0.340*	-0.029
	(3.755)	(-2.429)	(-0.242)
$PACKER_4$	0.404**	-0.929**	-0.937**
	(13.073)	(-6.711)	(-7.749)
DINFO	0.149	0.790**	0.420**
	(0.433)	(7.051)	(4.162)
DPAY	1.193**	-0.259*	0.058
	(3.468)	(-2.363)	(0.590)
Constant	19.576*	17.521**	N/A
	(2.170)	(5.953)	

Note: Single asterisk denotes significance at 0.05 level; double asterisk denotes significance at 0.01 level. t-Statistics are given in parentheses. Price level model measures the fed cattle transaction price level. Price variance model measures the estimated price variance calculated from the errors of the price model. Weight deviation model measures the deviation of slaughter weights from 1150 pounds.

Table 3.4. Estimated Coefficients for Price Level, Price Variance, and Weight Deviation Models Using Information Type Variables with Interaction Term

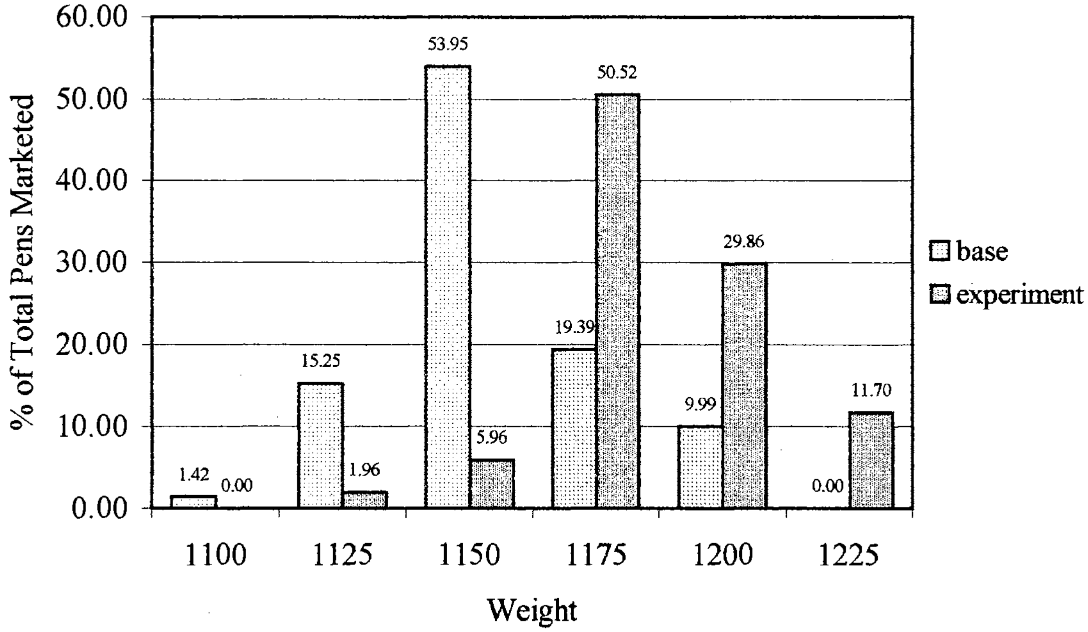
Variables	Price Model	Price Variance Model	Weight Deviation Model
BBP_{t-1}	0.118*	-0.076**	-0.007
	(2.085)	(-3.680)	(-1.639)
FMP_{t-1}	0.327**	0.096**	N/A
	(4.141)	(3.611)	
TSL_{t-1}	0.038	-0.047**	-0.046**
	(1.031)	(-3.515)	(-7.664)
$TLST_{t-1}$	-0.063**	0.026**	0.039**
	(-4.491)	(5.849)	(10.610)
PPL_t	-0.091*	0.048**	-0.054**
	(-2.005)	(2.971)	(-4.261)
$FDLT_2$	0.500**	-0.459**	0.449*
	(9.410)	(-2.751)	(2.440)
$FDLT_3$	0.334**	-0.080	1.007**
	(5.595)	(-0.457)	(5.349)
$FDLT_4$	0.765**	-0.367*	1.266**
	(14.119)	(-2.085)	(6.360)
$FDLT_5$	0.406**	0.190	2.012**
	(6.602)	(1.094)	(9.889)
$FDLT_6$	0.463**	-0.040	0.758**
	(7.642)	(-0.220)	(3.680)
$FDLT_7$	0.649**	0.428*	1.114**
	(9.545)	(2.499)	(5.731)
$FDLT_8$	0.383**	0.071	1.858**
	(5.938)	(0.405)	(9.614)
$PACKER_2$	0.119*	-0.155	-0.857**
	(2.192)	(-1.083)	(-5.829)
$PACKER_3$	0.112*	-0.626**	-0.012
	(2.463)	(-4.984)	(-0.098)
$PACKER_4$	0.399**	-0.597**	-0.891**
	(8.851)	(-4.795)	(-7.265)
$DINFO_1$	-2.370**	0.899**	0.026
	(-3.579)	(4.236)	(0.128)
$DINFO_2$	0.723	-0.557**	1.108**
	(1.135)	(-2.652)	(6.393)
$DINFO1x2$	2.521*	0.808*	-0.763*
	(2.280)	(2.214)	(-2.101)
$DPAY$	1.033**	-0.485**	0.196
	(3.300)	(-4.743)	(1.884)
Constant	43.726**	-0.222	N/A
	(3.953)	(-0.061)	

Note: Single asterisk denotes significance at 0.05 level; double asterisk denotes significance at 0.01 level. t-Statistics are given in parentheses.



Note: A represents full information periods; B represents the removal of current information; C represents the removal of summary information; and D represents the removal of all cash market information. Teams were rotated at the end of week 72.

Figure 3.1 Experimental design for estimating public information impacts on the FCMS



Note: Experimental data consist of 2,197 observations collected from simulator weeks 37 to 96. Base data consist of 2,682 observations collected from simulator weeks 30 to 101.

Figure 3.2 Comparison of FCMS fed cattle marketings by weight group: experimental vs. base data

Chapter IV

Estimated Value of Non-Price Vertical Coordination in the Fed Cattle Market

Every agricultural product sold in a retail market must first go through a number of intermediate steps in reaching that market. Vertical coordination is a broad term referring to all of the methods by which activities at various stages of the production/marketing chain are "harmonized" (Mighell and Jones). In the past, and even today in many parts of the world, it is not unusual for all of these activities to be carried out by the same person or family. In modern developed economies, however, different people perform different functions in converting raw commodities to finished goods.

Traditionally, in modern market economies, prices have been the coordinating mechanism. Price signals originating with consumers are passed from firm to firm down the marketing chain until reaching producers. As early as 1959, Collins noted that the price system was, in some industries, proving to be inadequate as a means of coordinating the activities of various stages of the marketing chain. He argued that prices may not provide clear enough signals to efficiently direct economic activity when decisions made at one stage of production affect the performance of successive stages. Barkema points out that the inability of prices to transmit detailed information is an even greater problem in the modern food market due to increased consumer demands for more specialized food products.

Examples of coordination through non-price means can be found in virtually every sector of the agricultural industry; however, the most dramatic examples of non-price coordination are in the livestock sector. Non-price coordination in the poultry industry has been extensive. Every level of production and marketing from farmer to retailer is coordinated through direct ownership (vertical integration) or contracting. In the last decade, the pork industry has also witnessed a significant increase in the use of non-price coordination methods.

The beef industry has not embraced non-price coordination to the same extent as the poultry and pork industries. While the beef industry has undergone dramatic changes in the last 20 years, these changes have had more to do with the consolidation of firms within the packing and feeding sectors than with changes in the nature of the interface between the sectors (Barkema and Drabenstott). Coordination between the various levels of the beef industry is still primarily achieved by the price system. Because of the adversarial relationship between feeders and packers, coordination between these levels (or more specifically the lack of coordination) may be inefficient. Inefficient coordination increases costs and results in greater risk for beef industry participants. The effect, therefore, of inefficient coordination is to reduce the competitiveness of the beef industry in relation to the more efficiently coordinated poultry and pork industries. Due to the competitive pressure from poultry and pork, it would be extremely useful for beef industry participants to know the potential benefits (in terms of industry-level profits) of improving coordination between the feeding and packing sectors.

In addition to these applied considerations, a study of vertical coordination in the fed cattle market has compelling theoretical justification. The economics literature discusses the nature of, causes for, and conceptual benefits from vertical coordination via non-price methods. However, since economists rarely have the opportunity to measure performance criteria for various forms of vertically coordinated structures, empirical estimates of the value of coordination are noticeably absent in the literature. Similarly, there are no estimates of whether one set of parties (buyers or sellers) or both gain or lose, and how much one set gains or loses relative to the other. As Den Ouden et al. note:

> In spite of the extensive descriptive literature on the potential benefits and costs of improved vertical coordination, there seems to be little quantitative information on its effects both at the overall level of the chain and with respect to the individual stages (p. 287).

The objective of this research is to determine the value of coordinated marketing-purchasing between cattle feeders and meatpackers. Two separate effects of non-price coordination will be noted. First, this research will determine how industry-wide profit is affected by the employment of various non-price coordination strategies. If profits can be increased by the use of non-price coordination, then the incentive to adopt such strategies exists. The second step in this research will be to determine how the different coordination strategies considered will affect the costs of both feeders and packers. For non-price coordination to be an attractive option, costs must be reduced on both sides of the market.

To accomplish the goals of this study, data generated in a semester long session of the Fed Cattle Market Simulator (FCMS) will be used (Koontz, et al.). A comparison of the industry profits actually realized in the simulation will be compared with those which could have been realized using relatively simple "rule-of-thumb" coordination strategies based on slaughtering the volume of cattle packers desire and/or the weight of cattle feedlots desire.

Vertical Coordination Background and Theory

The fact that prices convey information imprecisely provides an incentive for firms to implement non-price methods of coordination. Many authors have explored the incentives to adopt non-price coordination methods. Among them, Frank and Henderson cite "asset specificity" as an incentive for vertical coordination. This incentive appears to be particularly relevant to the fed cattle market. Asset specificity refers to the fact that much of the capital used in a productive process may have no alternative uses. Consequently, costs rise rapidly if these assets are unemployed or underemployed. Contracting can help to avoid this situation.

Frank and Henderson build on the theory of Willamson which divides investments into three categories: nonspecific, mixed, and idiosyncratic. Idiosyncratic investments have very specific uses. Conversely, nonspecific investments can be put to a number of different uses. Mixed investments fall somewhere on a continuum between these extremes. Williamson argues that contracting will be the cost minimizing method of coordination between levels when recurring transactions occur between participants whose investments are mixed. As the characterization of investments becomes more idiosyncratic, direct ownership (vertical integration) becomes the cost minimizing coordination method.

The foregoing discussion of the incentives for vertical coordination is a useful starting point for investigating non-price coordination in the fed cattle market. All of the incentives offered by the various authors discussed here are present to varying degrees in this market. Williamson's focus on idiosyncratic investment is particularly relevant given the fed cattle market structure which has evolved over the last 15 years. The largest packing firms have invested in large plants that must run at full capacity or face steep production cost increases. Koontz and Purcell note that because of their relatively high ratios of fixed to variable costs, packers have strong incentive to operate at full capacity in order to minimize per unit costs. Schroeder et al. point out that several of the noted incentives to contracting also apply to feeders. For example, contracting allows feeders to reduce risk, to obtain more favorable financing terms, and to ensure a buyer for their cattle.

Still, non-price coordination is not carried on in the fed cattle market at nearly the levels observed in other livestock markets. Part of the difference in market structure between different livestock markets can be explained by the biological differences between livestock (Ward). For example, cattle production is subject to much longer production delays than either poultry or pork production. In addition, cattle production relies on the ability of cattle to consume forages. This makes cattle production much more land-intensive than other types of livestock production. However, the lack of non-price coordination in the fed cattle market must, to some degree, be attributed simply to the reluctance of market participants at different levels to cooperate with one another. The current furor over captive supply levels is itself evidence of the adversarial relationship between feeders and packers.

This adversarial relationship should not be surprising to economists. Perry writes that when the investments of participants on one or both sides of a transaction are idiosyncratic, "opportunistic behavior" is likely to result. Such behavior consists of trying to extract all of a trading partner's profit by threatening to dissolve the trading relationship. The presence of opportunistic behavior makes cooperation between the two groups more difficult to achieve; however, it also indicates that the potential gains from cooperation may be substantial. This research is concerned with quantifying these potential gains. As noted, empirical studies of the effects of vertical coordination are virtually nonexistent. This study thus represents an important addition to vertical coordination literature.

Fed Cattle Market Simulator Background

Data for this experiment were collected in the Spring 1995 semester when the FCMS was run as a semester-long undergraduate class at Oklahoma State University. As the name suggests, the FCMS simulates the real-world fed cattle market. Participants are divided into 12 teams consisting of from two to four members. Eight teams role-play as feedlot managers, and four teams role-play as packing plant managers. The teams interact to trade simulated pens of fed cattle. Face-to-face negotiation between feedlot and packing plant teams determines the fed cattle price in the FCMS.

Trading in the FCMS takes place in six-to-eight minute periods which correspond to a week of real time. At the beginning of each of these simulated weeks, feedlot teams receive a set of cards representing cattle entering the showlist. Each card represents one pen consisting of 100 head of 1,100 pound cattle. Each week that the cattle aren't sold, they gain 25 pounds. If cattle are not sold by the end of the week in which they weigh

1,200 pounds, they are automatically sold to an anonymous packer for a large discount beginning at $5/cwt below that week's average price.

The two largest costs faced by feeders are the purchase cost of feeder calves and feed costs. Purchase costs are exogenous to the FCMS. Feeders receive a predetermined number of 700 pound feeder animals at a predetermined price. Ration/feed costs are set exogenously; however, cost of gain depends to a large extent on the actions of the feedlot managers. Cost of gain for 1,100 to 1,150 pound cattle can be calculated simply as pounds of gain times ration cost per pound of gain; however, as cattle reach weights in excess of 1,150 pounds, they begin to incur cost of gain penalties reflecting the fact that heavier cattle convert feed less efficiently than lighter cattle. The penalty for 1,175 pound cattle is 8% of the total cost of gain and for 1,200 pound cattle it is 18% of the total cost of gain. To illustrate, the feed cost for a 1,200 pound animal in the FCMS would be calculated as follows:

$$[(1{,}200 \text{ lb.} - 700 \text{ lb.}) \bullet (RC \bullet 1.18)], \qquad (1)$$

where RC is the ration cost per pound of gain.

The weight of cattle also has an important affect on the prices which feedlots receive for their cattle. Packers discount for three important carcass characteristics when calculating bid prices. These factors are percent of carcasses grading select, percent of yield grade 4 and yield grade 5 carcasses, and percent of carcasses which are light or heavy. The sum of these discounts is the smallest for 1,150 pound cattle. Table 4.1 shows the carcass characteristics assumed for the five weight classes of cattle in the FCMS along with discount factors used by packers in calculating bid prices.

On the packer side, cost is a function of the number of pens slaughtered each week. Each firm faces a U-shaped short-run cost curve. These weekly cost curves were developed for the simulator based on research by Duewer and Nelson. Each curve is different, reflecting the different sizes of the packing plants in the simulator. The optimal weekly slaughter size for the smallest packer is 800 head and for the largest is 1,200 head. The other two plants have optimal weekly slaughter rates of 900 and 1,100 head. Because of the shape of the cost curves, any deviation above or below these optimal slaughter rates results in increased costs for the packers. Table 4.2 reports the short-run cost curves for each plant in the FCMS, and figure 4.1 illustrates the shape and relationship of the four curves.

Marketing decisions affect packer profitability through returns as well as through costs. This is due to the manner in which boxed beef price is determined in the simulator. Weekly boxed beef prices are specified as a function of slaughter levels for the past 9 weeks. The average boxed beef price is $120/cwt and is based on an average slaughter level of 40 pens of 1,150 pound cattle, which is the sum of the four packers' optimal slaughter levels. Deviations from this slaughter level alter the boxed beef price according to a distributed lag of price flexibilities. Given this boxed beef demand specification, slaughtering a larger than optimal number of pens of cattle not only increases packer costs but also reduces packer revenue through the behavior of boxed beef prices. Slaughtering cattle weighing more than 1,150 pounds will also depress boxed beef price by increasing the total pounds of beef on the market. Figure 4.2 graphs the long-run boxed beef demand function used by the FCMS, that is, the price that will result from 9 consecutive weeks of slaughtering a given number of pens. Figure 4.3

graphs the weekly and cumulative distributed lag pattern for the boxed beef price flexibilities, which reveals the impact of a given lagged slaughter level on boxed beef price. The distributed lag model depicted in figure 4.3 was econometrically estimated by Meyer.

Vertical Coordination Simulation Methods

In this study packer and feeder profits from the Spring 1995 FCMS course will be compared to profits obtained using simple non-price coordination strategies. Consideration of FCMS structure as outlined above suggests that strategies which minimize feeding inefficiencies and slaughter/fabrication costs have some potential for improving industry profits. Thus, coordination strategies examined in this study will focus on marketing cattle at minimum cost of production weights (i.e., 1,150 pounds) and marketing as close as possible to an optimal number of pens per week for packing plant efficiency (i.e., 40).

In order to perform the simulation required to make comparisons necessary for this study, a spreadsheet was developed which would calculate aggregate weekly feedlot and packer costs and weekly boxed beef prices based on the number and weight of cattle sold each week. Since all feedlots face identical costs (i.e., they all buy cattle at the same price and have the same cost-of-gain), aggregating feedlots simply involved summing the number of pens marketed at each weight each week and calculating costs for each weight group as illustrated in equation (1).

Aggregating packers was somewhat more difficult since each packer faces a different short-run cost curve. The solution to this problem involved creating an aggregated cost schedule within the spreadsheet used for simulation which contains the cost incurred by each packer from the slaughter of a given number of pens. Such a schedule is given in table 4.2. Using this aggregated industry schedule, the least-cost distribution among packing plants of any number of pens could be determined. Using this aggregation procedure for packer costs, it was only possible to consider total weekly slaughter figures rather than each packer's weekly slaughter level. This method of aggregation assumes that weekly slaughter is distributed among packers in a least-cost manner; however, this is certainly not always the case in reality or in the simulations with live participants. Thus, this method understates packers' costs. The costs resulting from individual packers slaughtering a non-optimal number of pens will be removed in this analysis.

In this experiment, the flow of fed cattle generated by FCMS participants was entered into the spreadsheet simulator. This simulation generates the industry profit totals shared by feeders and packers. This flow of fed cattle was then varied within the spreadsheet according to five simple coordination rules. The total number of cattle marketed was not changed: the same number of cattle was used in each simulation, but the timing of these marketings was varied, which also resulted in the weights and individual weekly volumes changing.

Non-price Coordination Strategies

Data on marketings from weeks 29 through 98 from the FCMS were used to establish baseline profits in the simulation spreadsheet. Costs and returns from this simulation were compared to five simple non-price coordination strategies. All of these strategies represent variations on the premise of minimizing production costs. For feeders, this amounts to avoiding the extra feeding costs that result from marketing cattle at weights other than 1,150 pounds. For packers, it amounts to avoiding the extra processing costs which result when slaughter plant volume is not equal to 40 pens and price discounts which result from the purchase of cattle at weights other than 1150 pounds. In addition, each strategy impacts industry profits through its effect on the total volume of boxed beef produced and the boxed beef discounts received (see table 4.1).

The first strategy was to market 40 pens each week. This strategy avoids all excess processing costs by keeping packers always at the lowest point of the aggregated cost curve. In order to ensure a sufficient supply of cattle on the showlist to meet the 40 pen requirement, cattle must be marketed at heavier weights. Thus this strategy should generate considerable feeding inefficiencies. In addition, the increase in the marketing of heavy cattle will depress the boxed beef price due to increased quantity and quality discounts.

The second strategy was to sell all cattle at 1,150 pounds. This strategy avoids all costs associated with feeding inefficiency and price discounts for undesirable carcass characteristics. The strategy is simple to implement. Each week, all pens of cattle weighing 1,150 pounds are marketed, regardless of how many pens this may be. Since marketings will seldom equal 40 pens, processing costs should increase under this strategy. On the other hand, by avoiding the slaughter of heavy cattle, this strategy should increase boxed beef price.

The third strategy represents a slight modification of the previous one. One-third of the cattle on the showlist weighing 1,125 pounds were sold each week, with the remaining two-thirds being sold the following week at 1,150 pounds. This strategy attempts to maintain a more consistent flow of cattle than the previous strategy—thereby reducing processing costs. The choice of one-third as the proportion of 1,125 pound cattle to slaughter is arbitrary. It is possible that selling some other fraction of cattle earlier would be as effective or even more effective in reducing processing costs. This strategy should also increase the boxed beef price due to the slaughter of some lighter cattle.

The last two strategies are quite similar and represent compromises between the first two. Strategy four was to sell 40 pens per week or less (if 40 weren't available) at weights between 1,125 and 1,175 pounds. The least cost slaughter volume is specified as a target; however, cattle may not be slaughtered at extreme weights in order to reach that target. The fifth strategy was to sell 40 pens per week or less (again, if 40 weren't available) at weights at or below 1,150 pounds. In each of these strategies, the costs of non-optimal marketings will be shared by packers and feeders. In strategy 5, though, boxed beef price should increase significantly since a substantial number of light (i.e., less than 1,150 pounds) cattle will be slaughtered.

Simulation Results

Table 4.3 presents total costs and returns from the simulations along with information on the volume of cattle and boxed beef traded under each of the non-price coordination strategies. Table 4.4 presents the cost and return data on both a per head and per hundredweight of boxed beef basis. It is important to view the results on a per unit basis since each of the coordination strategies results in slightly different volumes of cattle and of boxed beef. The selection of a relevant unit depends to some degree upon one's perspective. Feedlot managers would probably prefer to analyze their costs and returns on a per head basis, while packing plant managers would probably prefer to view those figures per hundredweight of boxed beef. For this reason, results are presented both ways.

All but one of the non-price coordination strategies resulted in higher industry-level profits than those realized by FCMS participants. Strategy 1, consisting of always selling 40 pens, actually resulted in industry losses of \$26.06/head (\$3.56/cwt boxed beef). There are two reasons for this result. First, in order to consistently meet the 40-pen target, the showlist had to be kept full. To do this, cattle had to be held to high weights. This resulted in high price discounts and high feeding costs. In fact, this strategy resulted in the highest price discounts and cost of gain of any other strategy (including no coordination). Second, the high boxed beef supply resulting from the slaughter of a large number of heavy cattle pushed boxed beef prices down, further reducing industry profits. Boxed beef supplies were higher and prices lower under this strategy than any other. From the packer's perspective, however, this strategy is not all bad. Processing costs on a per head and per hundredweight of boxed beef basis were considerably lower under this strategy than under any other.

The second non-price coordination method—sell all cattle at 1,150 pounds—resulted in a \$10.63/head (\$1.48/cwt boxed beef) increase in profits in comparison to no coordination. Nearly all of this gain was due to cost of gain reductions. Cost of gain decreased by \$11.81/head (\$1.37/cwt boxed beef) under this strategy. Net revenue was actually reduced slightly due to the lower volume of boxed beef sold. Processing costs were reduced; however, these costs were over $2/head ($0.88/cwt boxed beef) higher than under strategy 1—always slaughter 40 pens.

The third strategy—sell one-third of each age group of cattle at 1,125 pounds and the remaining two-thirds at 1,150 pounds the following week—was expected to reduce processing costs in comparison to the preceding strategy. On a per head basis, it did exactly that; however, on a per hundredweight of boxed beef basis, processing costs were higher under this strategy than under any other. The average boxed beef price did increase slightly over that from the previous strategy due to the lower boxed beef volume. This strategy had the lowest average live weight and carcass weight per head. On a per head basis, results of this strategy—as expected—are similar to the previous strategy: industry profits increased by around $10/head ($1.45/cwt boxed beef) over no coordination, with the bulk of that increase due to reduced cost of gain. Cost of gain was lower under this strategy than under any other.

The compromise strategies (four and five) worked quite well in increasing aggregate profits—both total and per unit of output. Compared with no coordination, strategy four increased industry-level profits by $22.47/head ($3.14/cwt boxed beef), and strategy five increased profits by $25.10/head ($3.52/cwt boxed beef). The effects of these strategies on costs and returns were very similar. Both resulted in higher net revenue than no coordination due both to increased boxed beef price and reduced price discounts. Both also reduced processing costs (per head and per hundredweight of boxed beef) over no coordination. The primary difference in these strategies is in their effect on cost of gain. Strategy 5 results in a lower cost of gain due to the fact that this strategy avoids the cost of gain penalty associated with 1,175 pound cattle.

BEEFGAIN Simulation

The parameter structure of the FCMS causes the cost of gain for heavy cattle to rise rapidly, that is, 8% for 1,175 pound cattle and 18% for 1,200 pound cattle. This reduces total industry profit. Likewise, as cattle reach heavier weights, the FCMS assumes that more yield grade 4 (Y4) and heavy weight carcasses are present. The FCMS discounts the boxed beef price received by packers by $10/cwt for Y4 cattle and $2/cwt for heavy carcasses. This results in an industry profit curve (i.e., profits to be divided between packers and feeders) by weight which rises from 1,100 pounds to 1,150 pounds and then declines. A key question is how realistic relative to actual market conditions is this pattern of relative profits by slaughter weight.

It should be noted that this profit is the combined profit of packers and feedlots. Figure 4.4 illustrates how industry profit/cwt appears graphically as the area between the break-even prices of feedlots and packers. If one assumes these profits to be shared equally at all weights (a big assumption), the profit pattern for feedlots will also be concave downward and peaking at 1,150 pounds for both the feedlot and packer.

Presumably, most of this decline in profits is suffered at heavier weights by feedlots; however, the spreadsheet simulation done here is not capable of distinguishing how the reduced profits are split between feedlots and packers. Actual profit distribution as generated with live simulations with the FCMS can be referenced to determine how profits/losses are shared by packers and feedlots for different weights of cattle.

Additional simulation to determine the effect on profits of under- or over-finishing cattle was also possible using BEEFGAIN, a feedlot gain simulator developed by animal scientists at Oklahoma State University (Gill and Burditt). This simulator calculates the physical as well as financial performance of cattle on feed based on parameters provided as input. In order to make comparisons between feedlot profits achieved at various slaughter weights, simulation of the feeding of 700 pound feeder steers to a series of different weights was conducted. Slaughter weights used in the simulation correspond to the slaughter weights used in the FCMS (i.e., 1,100 to 1,225 pounds in 25 pound intervals). A feeder cattle price of $74/cwt was used in the simulation. A fed cattle price of $69/cwt was also used. This price was discounted according to the carcass characteristics expected at the different slaughter weights.

Two different fed cattle price-discounting regimes are compared in this study. First, carcass characteristics are not considered in setting price. In this simulation, all cattle receive the same price regardless of weight. The common price used is $67.75/cwt. This price was arbitrarily chosen. The price used in this simulation affects the level of profits but does not alter the relationship between profits and slaughter weight, which is the subject of this investigation. Second, carcass characteristics are based on the results of previous serial slaughter studies (Hicks et al. and Van Koevering et al.). These studies were designed experiments in which cattle of very similar physical characteristics were placed on feed together. All cattle received the same treatment throughout the feeding period. The cattle were divided into four subgroups which were slaughtered at fourteen day intervals beginning with 100 days on feed. At slaughter, the physical characteristics of each carcass were carefully examined and measured. Relevant characteristics for this study include the percent of U.S. Select carcasses, the percent of yield grade 4 or 5 carcasses, the percent of light and heavy carcasses, and the average dressing percentage.

The weights of the serially slaughtered cattle do not correspond exactly with those used in the FCMS; however, the days on feed correspond closely to what is assumed in the FCMS. The four weight groups from the serial slaughter studies are thus assumed to correspond to 1,075, 1,125, 1,175, and 1,225 pounds. Figures on the relevant carcass characteristics for 1,100, 1,150, and 1,200-pound cattle are calculated by linear interpolation. Price discounts corresponding to the undesirable carcass characteristics are based on average market conditions. Price discounts and carcass characteristics used in this discounting regime are given in table 4.5.

BEEFGAIN Results

Results of the BEEFGAIN simulation indicate that profits decrease substantially when cattle are over-finished. The amount of the decline in profits and the rate at which this decline occurs depend to a large degree upon the discounts for undesirable carcass characteristics. These discounts are variable and, like cattle and boxed beef prices, respond to conditions in the market. Figure 4.5 illustrates the relationship between profits and slaughter weights for both of the discounting regimes. In addition, this figure includes a profit curve from the FCMS. This curve represents one-half of the industry-level profits available under average cost of gain conditions (i.e., cost of gain equal to $0.46/lb) in the FCMS. The level of this curve is determined by the feeder cattle and boxed beef prices used in calculating feedlot and packer break-even prices. Again, the level of this curve is not important for an examination of the relationship between profit and slaughter weight. Figure 4.6 illustrates how break-even fed cattle price and cattle weights change throughout the feeding period in the BEEFGAIN simulation.

The no-discount in figure 4.5 illustrates how profits are affected by cost of gain changes as cattle weights increase. The effect of actual cost of gain changes is fairly minor over the range of weights from 1,100 to 1,175 pounds; however, the decrease in profits becomes relatively large at extreme weights.

The profit curve constructed using serial slaughter data and market discounts illustrates how feeding profits and slaughter weights are related in the actual fed cattle market. The addition of price discounts dramatically alters the consequences of under- or over-finishing cattle. In this illustration, maximum profit occurs at 1,150 pounds. Deviations from that weight result in very large reductions in profit. Of course, the rate at which profits decrease will depend upon the amount of the price discounts which, as noted earlier, depend upon market conditions. Still, price discounts will significantly reduce feeding profits for under- or over-finished cattle—compounding the negative impact on profits of cost of gain increases.

The third curve in figure 4.5 illustrates how profits in the FCMS are affected by slaughter weight. The basic shape of the curve corresponds very closely to that of the market-based curve; however, it is slightly compressed. That is, the decline in profits occurs over a narrower range of slaughter weights. The FCMS curve is also somewhat different in that a greater portion of the profit decrease is due to cost of gain effects than in the market-based curve. Nevertheless, a comparison of the two curves confirms that the FCMS is a good approximation of reality with respect to the issue of slaughter weight effects on feeding profits.

Summary and Conclusions

Experimental simulation was used to determine the effects of non-price coordination on industry-level profits and inefficiency costs in the fed cattle market. Results indicate that large gains in industry-level profit can be made using relatively simple non-price coordination strategies. All but one of the non-price coordination strategies increased industry profits substantially. This increase in profits was due both to cost reductions and to boxed beef price increases.

Simulation results also give some insight into why non-price coordination has not been widely adopted in the cattle market. In this study, packers and feeders would favor vastly different strategies. Packers would favor strategy 1—always slaughter 40 pens—because this strategy resulted in the lowest processing costs. Total industry losses incurred under this strategy were due to higher cost of gain and higher price discounts. Assuming that packers could and would pass these high price discounts back to feeders in the form of lower bids for fed cattle, packers could avoid almost all of the increased costs associated with this strategy. At the same time, they would benefit from being able to sell a much greater volume of boxed beef. Feeders, on the other hand, would clearly favor strategy three—sell one-third of the 1,125 pound cattle each week, and sell the remaining two-thirds of the group the following week at 1,150 pounds. This strategy resulted in the lowest cost of gain by avoiding the feeding inefficiencies which result from over-finishing cattle. Not surprisingly, neither of these strategies was optimal in terms of maximizing industry-level profits, though strategy 3 was much closer to optimal than strategy 1.

These results of the simulation confirm the conventional wisdom in the feeding industry that feedlots need to keep their marketings current, that is, to avoid holding cattle in feedlots to heavy weights. Furthermore, this simulation illustrates why feedlot managers sometimes find it hard to keep marketings current, that is, packers have an incentive to keep showlists full to make it much easier for them to maintain a consistent, efficient flow of cattle through their plants. In reality—as in the simulations presented here—packers benefit from marketing strategies which result in high volumes of heavy cattle while feedlots benefit from strategies which result in relatively low volumes of light cattle.

To summarize, simulation results indicate that substantial gains in industry profit could result from the use of non-price coordination in the fed cattle market. Achieving these higher profits will require an unprecedented degree of cooperation between feeders and packers. The reason for this is that coordination strategies which raise industry-level profits are not optimal for packers from a cost minimizing perspective. Because gains in industry-level profits far exceed the increase in processing costs, it is possible that a redistribution of profits could be achieved which would adequately compensate packers for their higher costs. Due to the market power of packers, it seems likely that they would, in fact, receive the lion's share of any profit increases. A more thorough examination of how profits are divided in the FCMS is needed; however, that issue is beyond the scope of this study.

Table 4.1. Carcass Characteristics and Price Discounts in the FCMS

Slaughter Weight	Percent Select	Select Discount	Percent >YG3	YG4 or 5 Discount	Percent Light/Heavy Carcasses	Light/Heavy Discount	Total Discount	Dressing Percentage
1200	25.0	5.00	8.00	10.00	10.0	2.00	-2.25	64.0
1175	29.0	5.00	6.33	10.00	5.0	2.00	-2.18	63.5
1150	33.0	5.00	4.66	10.00	0.0	2.00	-2.12	63.0
1125	37.0	5.00	3.00	10.00	5.0	2.00	-2.25	62.5
1100	41.0	5.00	1.37	10.00	10.0	2.00	-2.39	62.0

Note: All discounts are given in $/cwt.

Table 4.2. Processing Costs per Head for FCMS Packing Plants

Pens Processed/Week	Packing Plant Number 1	2	3	4
1	332.52	329.09	324.10	322.00
2	181.68	178.26	173.26	171.40
3	131.41	127.98	122.98	121.12
4	106.27	102.84	109.58	111.83
5	87.95	91.93	98.45	101.44
6	77.56	81.29	88.48	91.93
7	70.91	73.20	79.86	83.46
8	68.56	68.06	72.80	76.18
9	71.10	66.27	67.51	70.25
10	79.10	68.19	64.19	65.83
11	93.13	74.20	63.03	63.06
12	100.00	84.80	64.25	62.10
13	100.00	100.00	68.05	63.11
14	100.00	100.00	74.63	66.24
15	100.00	100.00	84.20	71.64
16	100.00	100.00	96.95	79.47
17	100.00	100.00	100.00	89.88
18	100.00	100.00	100.00	100.00

Table 4.3. Summary of Results of Simulation of Non-price Coordination in the FCMS

Strategy	No Coordination	1	2	3	4	5
No. of Pens Sold	2,639	2,742	2,630	2,628	2,590	2,576
Ave. Sale Weight (cwt.)	11.57	11.59	11.50	11.42	11.45	11.43
Boxed Beef Yield/hd. (cwt.)	7.31	7.33	7.25	7.17	7.21	7.19
Boxed Beef Sold (mil. cwt)	1.93	2.01	1.91	1.89	1.87	1.85
Ave. Boxed Beef Price	123.05	119.56	123.73	124.50	125.73	126.30
Boxed Beef Rev. (mil.)	237.35	240.14	235.76	234.73	234.67	233.77
By-product Rev. (mil.)	25.96	27.01	25.71	25.50	25.22	25.03
Total Discounts (mil.)	4.43	6.65	4.04	4.08	4.01	3.99
Net Revenue (mil.)	258.88	260.51	257.43	256.16	255.87	254.81
Total Feeder Cost (mil.)	180.53	187.78	179.86	179.82	177.22	176.30
Total C.O.G. (mil.)	57.24	62.03	53.94	52.90	52.67	51.96
Total Processing Cost (mil.)	17.99	17.84	17.72	17.67	17.11	17.04
Total Profit (mil.)	3.12	(7.15)	5.90	5.76	8.88	9.51

Note: Coordination strategies 1 through 5 are as follows:

1) Sell 40 pens/week when available.
2) Sell all cattle at 1,150 pounds.
3) Sell 1/3 of the 1,125 each week and the remaining cattle at 1,150 pounds the next week.
4) Sell 40 pens or less at weights between 1,125 and 1,175 pounds.
5) Sell 40 pens or less at 1,150 pounds or less.

Table 4.4. Summary of Simulation Results on Per Head and Per Hundred-weight of Boxed Beef Basis

Strategy	No Coordination	1	2	3	4	5
Boxed Beef Rev./hd.	899.41	875.79	896.43	893.19	906.05	907.50
By-product Rev./hd.	98.37	98.51	97.75	97.05	97.37	97.16
Discounts/hd.	16.80	24.24	15.36	15.51	15.48	15.49
Net Rev./hd.	980.98	950.06	978.82	974.72	987.93	989.17
Feeder Cost/hd.	684.07	684.84	683.89	684.23	684.24	684.40
C.O.G./hd.	216.92	226.23	205.11	201.31	203.36	201.72
Processing Cost/hd.	68.18	65.06	67.38	67.25	66.06	66.15
Profit/hd.	11.81	(26.06)	22.44	21.93	34.28	36.91
Boxed Beef Rev./ cwt. boxed beef	123.05	119.56	123.73	124.50	125.73	126.30
By-Product Rev./ cwt. boxed beef	13.46	13.45	13.49	13.53	13.51	13.52
Discounts/cwt. boxed beef	2.30	3.31	2.12	2.16	2.15	2.16
Net Rev./cwt. boxed beef	134.21	129.70	135.10	135.86	137.09	137.67
Feeder Cost/cwt. boxed beef	93.59	93.49	94.40	95.37	94.95	95.25
C.O.G./cwt. boxed beef	29.68	30.88	28.31	28.06	28.22	28.07
Processing Cost/ cwt. boxed beef	9.33	8.88	9.30	9.37	9.17	9.21
Profit/cwt. boxed beef	1.62	(3.56)	3.10	3.06	4.76	5.14

Note: Coordination strategies 1 through 5 are as follows:

1) Sell 40 pens/week when available.
2) Sell all cattle at 1,150 pounds.
3) Sell 1/3 of the 1,125 each week and the remaining cattle at 1,150 pounds the next week.
4) Sell 40 pens or less at weights between 1,125 and 1,175 pounds.
5) Sell 40 pens or less at 1,150 pounds or less.

Table 4.5. Market-Based Fed Cattle Price Discounts and Serial Slaughter Carcass Characteristics Used in BEEFGAIN Simulation

Weight Group	% Select	% YG 4	%Light Carcasses[a]	%Heavy Carcasses[b]	Dressing Percentage
1,075	52.46	0.78	1.587	0.000	64.15
1,100	45.88	0.39	0.794	0.000	64.53
1,125	39.29	0.00	0.000	0.000	64.90
1,150	35.27	1.02	0.000	0.000	64.68
1,175	31.25	2.03	0.000	0.000	67.52
1,200	28.97	3.79	0.000	0.782	64.83
1,225	26.69	5.54	0.00	1.563	65.20
Discounts[c]	$7/cwt	$15/cwt	$25/cwt	$10/cwt	

[a] Light carcasses are those weighing less than 550 pounds.

[b] Heavy carcasses are those weighing over 950 pounds.

[c] Discounts are based on carcass price per hundredweight.

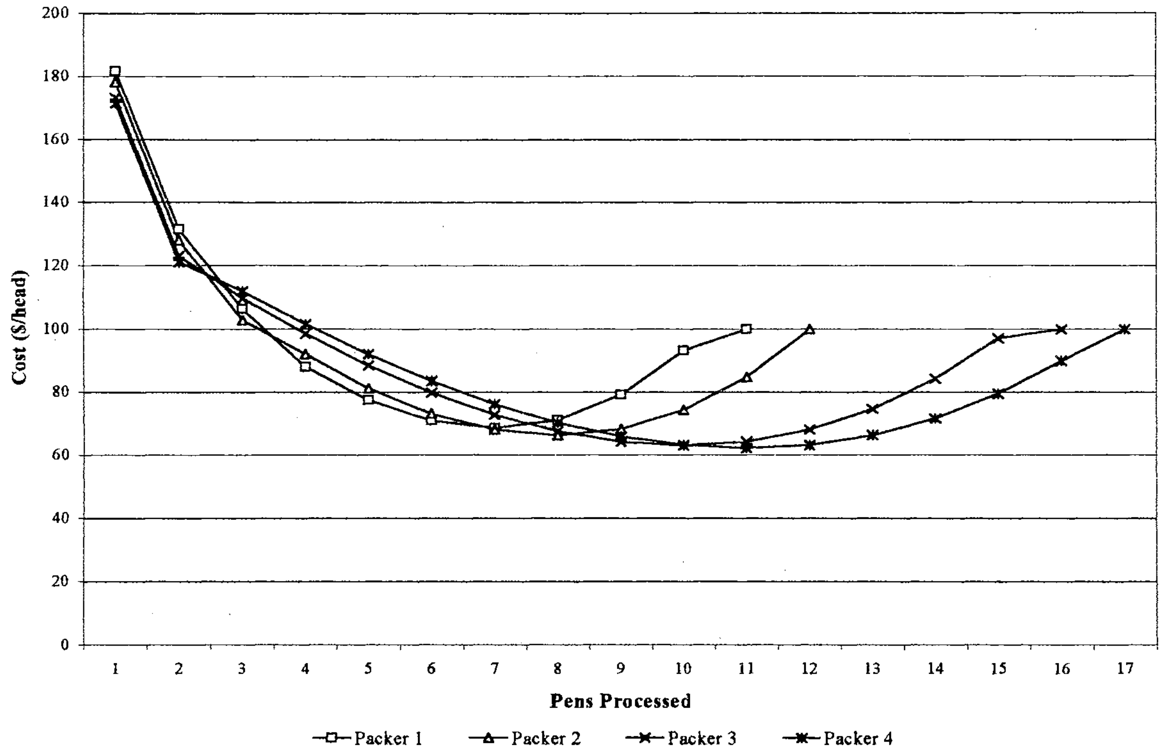


Figure 4.1 FCMS packing plant short-run average total cost curves

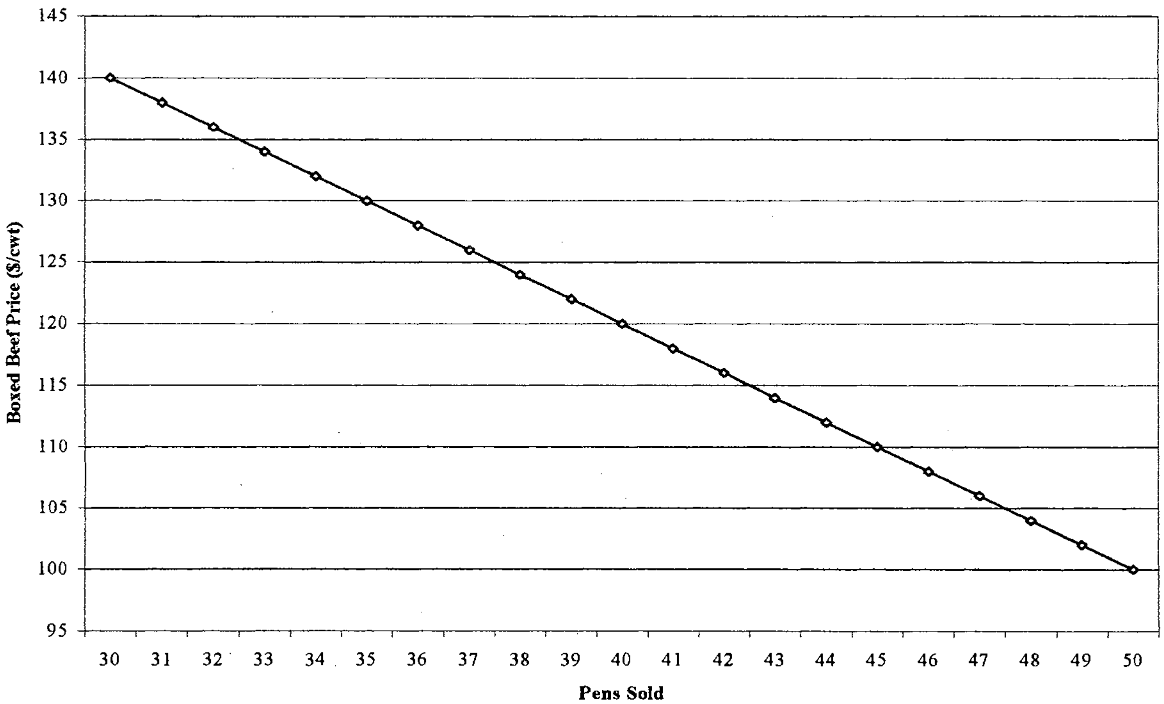


Figure 4.2 Boxed beef demand schedule used in FCMS

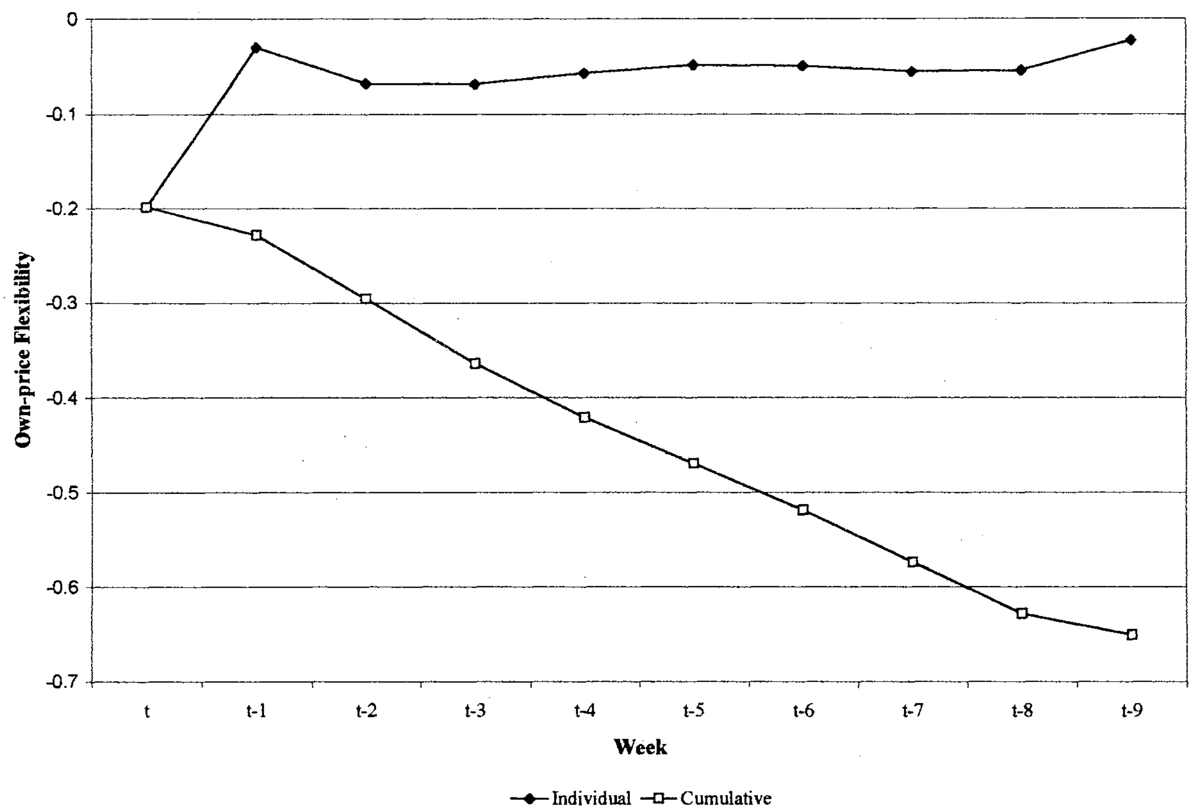


Figure 4.3 Distributed lag of boxed beef price flexibilities used in the FCMS

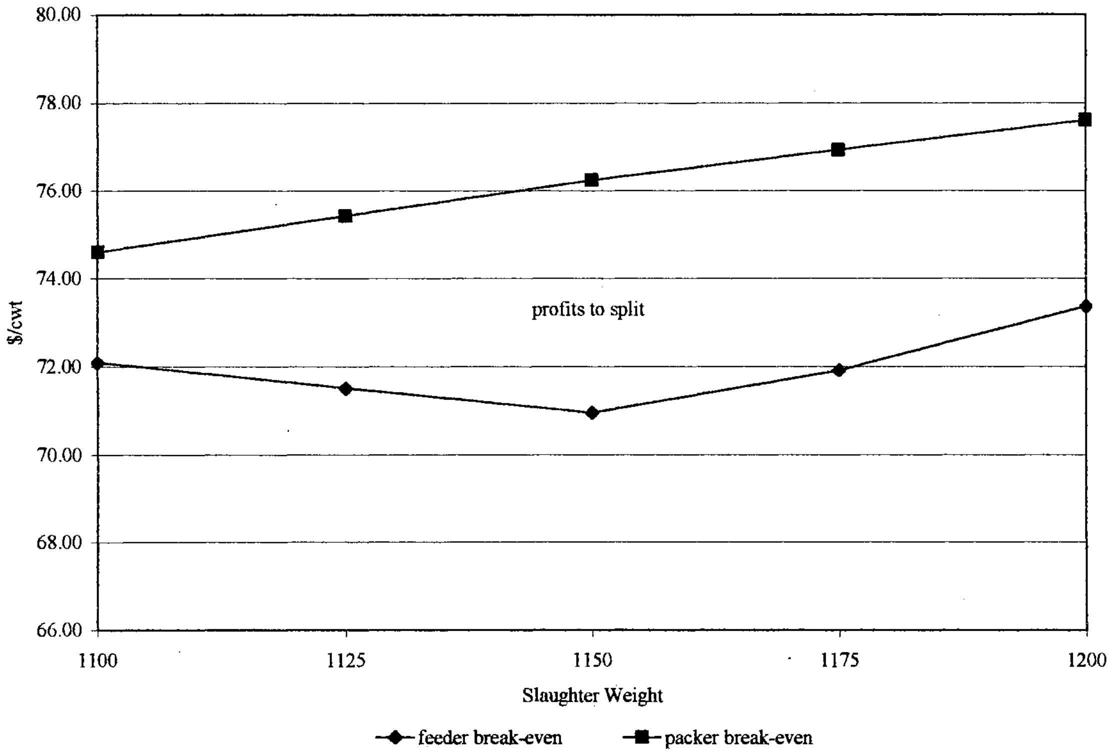


Figure 4.4 Graphic representation of industry-level profits in the FCMS

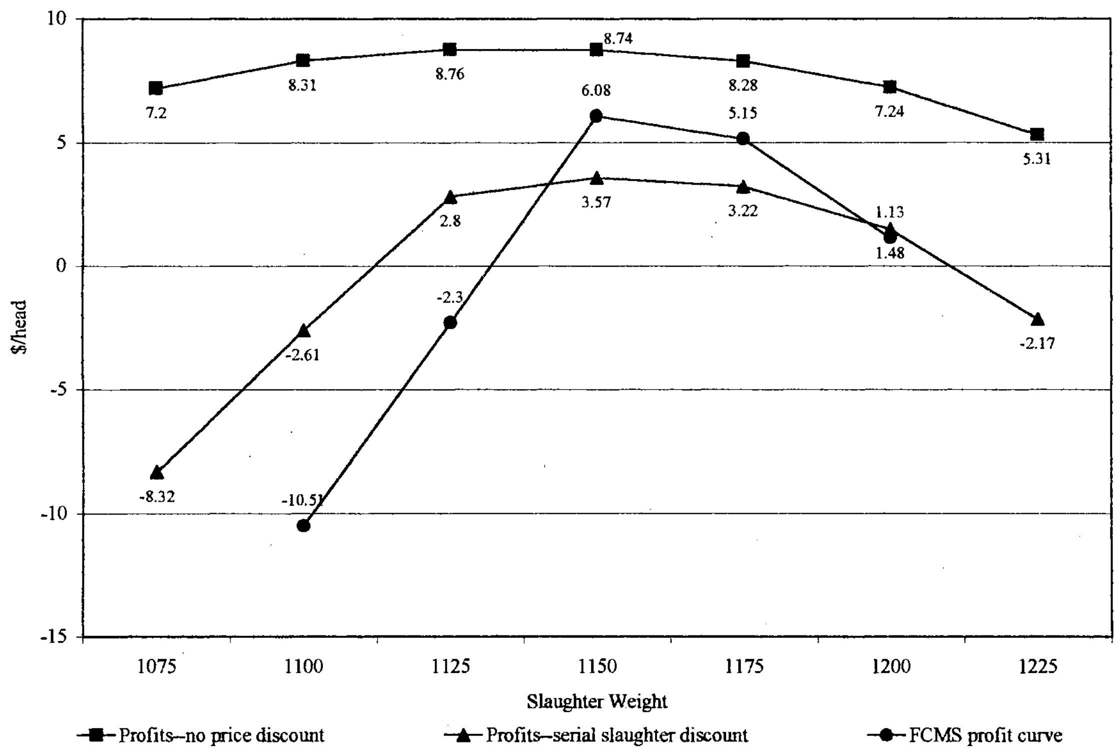
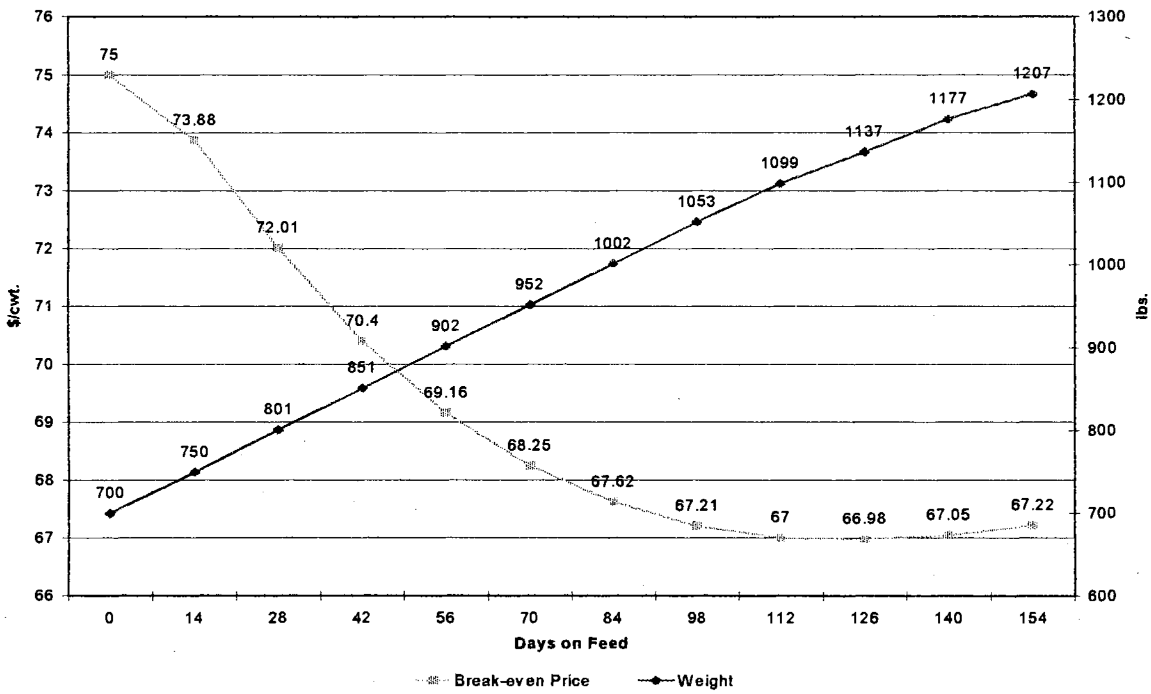


Figure 4.5 Comparison of the effect of slaughter weight on feeding profits using BEEFGAIN and FCMS



Note: Weight and break-even price figures are taken from BEEFGAIN simulation.

Figure 4.6 Fed cattle weight and break-even prices throughout the feeding period

Chapter V

Concluding Remarks

The preceding studies have addressed some important issues related to management, policy, and marketing in the cattle feeding industry. All of these studies have identified potential or existing inefficiencies which could, or in fact do, result in the misallocation of productive resources. The major findings of each article will be recapitulated here.

The Feeder Cattle/Corn Price Relationship

In "The Dynamics of Feeder Cattle Market Responses to Corn Price Change," it was shown that popular estimates of the impact of corn price changes on feeder cattle prices were inaccurate in two respects. First, commonly reported corn price multipliers are generally too low; that is, they underestimate the amount by which a given corn price increase (decrease) will decrease (increase) feeder cattle prices. Second, these corn price multipliers imply that the relationship between corn and feeder cattle prices is constant. This study shows that that is not true. That relationship will change as the values of technical parameters related to the feeding process change. These technical parameters themselves will adjust in response to corn price changes.

The recursive system of equations developed here emphasizes the fact that a *ceteris paribus* explanation of corn price effects on feeder cattle prices is inaccurate and misleading. Corn price changes result in changes to the entire feeding system—in other words, not only feeder prices but also production practices will adjust as corn prices change. These system changes are reflected in the new feeder price. The use of a recursive system of equations derived from break-even budgeting theory and incorporating information on the physical characteristics of cattle on feed is unique in the literature. This method resulted in a model with greatly improved statistical properties when compared to previous econometric models of feeder cattle prices.

Public Information and Price Discovery

Results of the research presented in "Experimental Simulation of Public Information Impacts on Price Discovery and Marketing Efficiency in the Fed Cattle Market" indicate that a reduction in public information would lead to greater variability of fed cattle prices. No definite price level effects from reducing public information could be determined. In addition, this study found that reduced public information resulted in inefficient resource allocation as cattle were fed to higher average weights which resulted in reduced profits due to increases in feed costs and price discounts associated with the undesirable characteristics of heavy carcasses.

Data used in this study were obtained from a controlled experiment using the Fed Cattle Market Simulator (FCMS). The use of experimentation to examine an economic issue makes this study unique. Also uncommon is the fact that this paper addresses the cash market impacts of public price and quantity information. Most studies of the market impacts of information have focused instead upon the futures market impacts of government production or inventory reports.

Vertical Coordination in the Fed Cattle Market

In the final study, "Estimated Value of Non-price Vertical Coordination in the Fed Cattle Market," the employment of relatively simple, non-price vertical coordination strategies was shown to greatly increase industry-level profits in the Fed Cattle Market Simulator (FCMS). This increase in profits was due primarily to higher revenue from boxed beef sales and lower costs of gain for cattle on feed. Coordination strategies which kept feedlot marketings current (in other words, strategies which avoided feeding cattle to heavy weights) resulted in the highest industry-level profits. These results confirm the conventional wisdom of cattle feeders that it is best not to allow cattle to get "backed up" in the feedlot. Interestingly, simulations provided some insight as to why feedlots have a difficult time keeping marketings current: packers find it easier to obtaining their least-cost volume of fed cattle when feedlots are full, that is, when feedlot marketings are backed up. This inherent conflict between optimal strategies on opposite sides of the market represents a significant barrier to achieving the level of cooperation necessary to implement non-price vertical coordination in a non-integrated industry.

This study represents a preliminary effort to provide quantitative estimates of the potential effects of vertical coordination in an agricultural market. Much work on the theoretical justification and motivation for vertical coordination through non-price means has been presented in economic literature for over four decades. Little quantitative work has been done, however. This research thus represents a valuable addition to the already extensive vertical coordination literature.

Suggestions for Further Research

With respect to the first article, more research needs to be done on the role that substitute grains might play in the relationship between corn and cattle prices. Appendix B begins to address that issue by examining the relationship between corn price and cost of gain. Based on that research, the effect of substitute grains on the corn/feeder price relationship appears to be minor over a wide range of corn prices; however, at extremely high corn prices—over $4/bu—the effect may become substantial.

In addition, more work should be done on the impact of corn price changes on the stocker cattle and cow/calf sectors of the beef industry. Changes in production practices within these sectors, particularly the stocker sector, fulfill an important role in allocating resources—specifically grains—across alternative uses. Parsons provides a conceptual framework for analysis of this resource allocation role of the stocker sector; however, more empirical work needs to be done.

With respect to the second article, more research is needed on the possible price level effects of reductions in public information. Sound theoretical arguments can be made for either positive or negative effects. Results presented here are ambiguous as to which direction price level effects may run, if in fact they occur at all.

Finally, with respect to the third article, further research is needed to determine how industry-level profits are divided between fed cattle market participants. This research addressed the issue of how the level of industry-level profits is affected by non-price coordination; however, no conclusions could be drawn about how the market would split those profits. Undoubtedly, market power will play an important role in determining the division of profits. However, in the fed cattle market, the dynamics of production should be expected to result in market power shifting from one side of the market to the other. When cattle are scarce feedlots have tremendous bargaining power; however, when cattle are plentiful, packers have the advantage. This rather unique situation presents an interesting problem which is worthy of further inquiry.

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Appendix A

The break-even budget of table 2.1 was also used to examine the possibility that the change in feeder cattle price reporting practices at the Oklahoma City auction could have contributed to model instability. Prior to 1992, the high and low price range for 100 pound weight ranges was reported. Starting in 1992, the "true" average price over a 50 pound weight range was reported.

The reason that parameter instability could possible result from the change in price reporting practices is clearly illustrated with output from break-even budgeting. Using the budgeting procedures developed in table 2.1, a graph of feeder calf prices against weight can be developed. Under most price scenarios, the curve will be downward sloping. The slope of the curve is determined by the price of corn. If the price of corn is high, feeding light calves will be relatively more expensive, so the premium for them will be reduced. It is even possible that the curve could be upward sloping, indicating that a pound of gain costs more than it is worth. Figures A.1 and A.2 illustrate respectively the impact of corn prices on the slope of the feeder calf price curve and the effect of live cattle prices on the curve. It can also be noted in figure A.2 that the level of the curve is changed by live cattle price changes but that the slope is fairly constant with regard to live cattle price changes.

The shape of these curves was very important to determining the impact of the change in the feeder cattle price reporting system in 1992. Prior to 1992, a price range was reported for each weight group. The high price presumably was usually set by high quality cattle in the lower end of the weight range while the low price was set by low quality cattle in the high end of the weight range. A common practice is to average the two prices to determine the "average" price at the midpoint of the range.

An average over any given weight range can be represented graphically as a line between points on the curve. Because the curves are convex to the origin, such a line connecting any two points on the curve will lie above the actual curve. The greater the range over which prices are averaged, the further above the actual curve the connecting line will lie. What this means is that the calculated average prices over any weight range is a source of upward bias when only the high and low price are reported. Furthermore, the degree to which prices are biased is influenced by the length of the weight range for which the prices are averaged. However, starting in 1992, price reporters reported the price of all cattle sold in a given weight range and reported a "true" average price over each weight range.

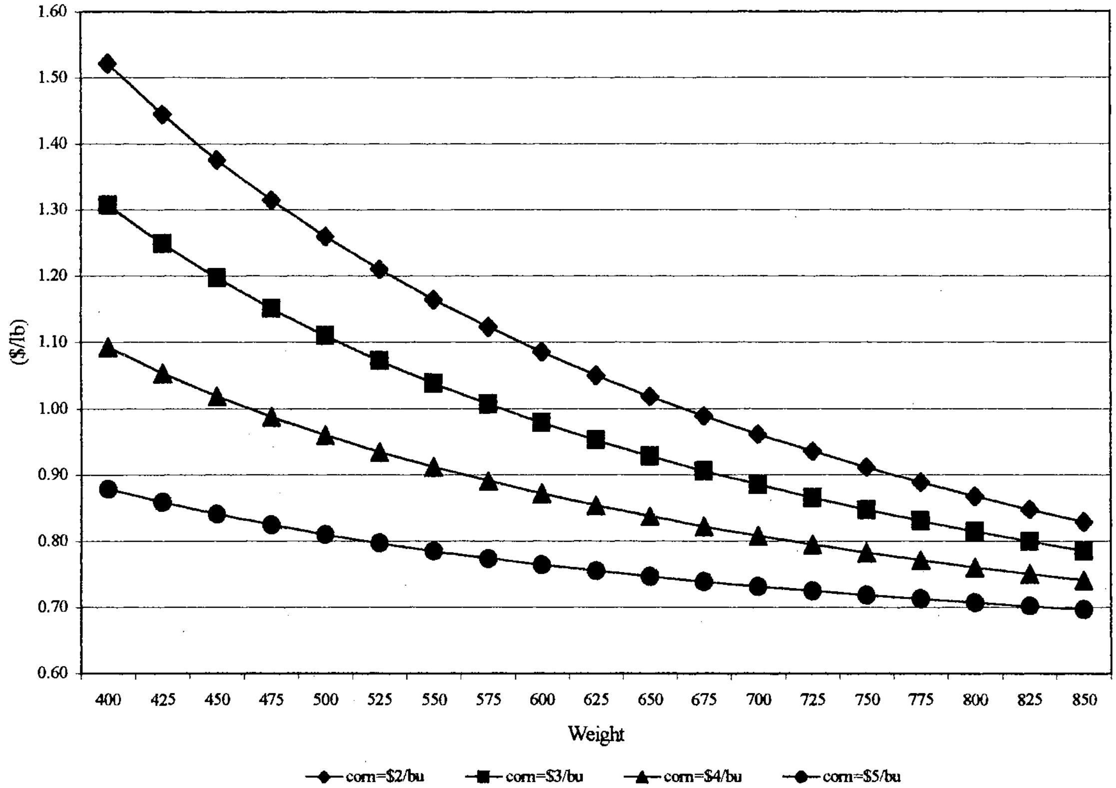
The possibility that reporting true prices over shorter weight ranges beginning in 1992 may have reduced the upward bias in the feeder calf price series was examined with the break-even budget. Using break-even calculations, a series of hypothetical feeder calf prices was generated for a series of weights between 700 and 800 pounds using one-quarter pound intervals. A separate price series was generated for each corn price between \$1.25/bu and \$3.50/bu at \$0.05 intervals. A true average using every price in each series was then compared with an average of the two prices at the endpoints of each series. This endpoint average corresponds to the reported feeder cattle price using the 100 pound weight interval. Subtracting the true average from the endpoint average resulted in an estimate of the amount of bias in the 1985-1991 feeder calf price series. As expected the level of bias was highest at low corn prices; however, the bias was generally much less than \$0.01/lb.

The hypothetical bias estimates were regressed against corn prices to obtain an equation for estimating bias. Results of that regression are presented in table A.1. This equation was then used to adjust downward the reported feeder calf prices from 1985-1991. A partial adjustment model of feeder calf prices using corn and live cattle prices as explanatory variables was then estimated. This model was first estimated using the unadjusted feeder calf price series and then re-estimated using the adjusted feeder calf price series. Parameter stability was not significantly improved by the use of adjusted prices, leading to the conclusion that the change in price reporting practices beginning in 1992 was not a significant source of parameter instability. Parameter instability that was present in the original model was later determined to be primarily due to changes in the technical feeding parameters. Specification of the break-even model as developed in chapter II corrected this problem.

Table A.1. Feeder Cattle Price Bias Estimation

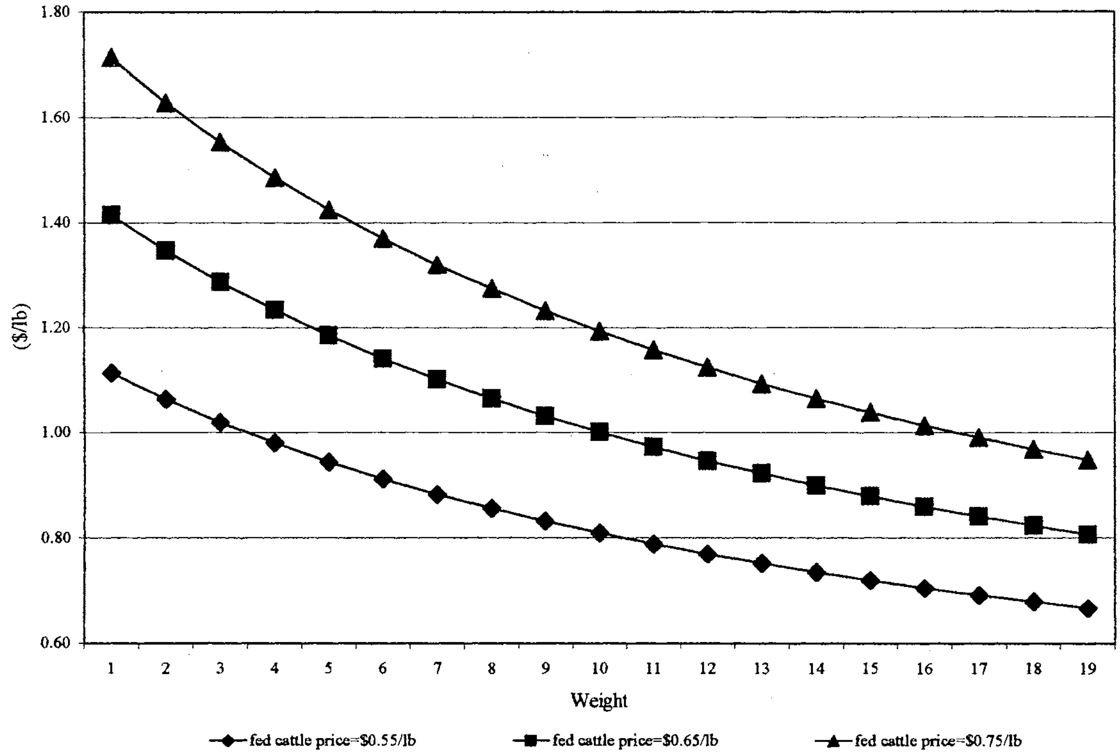
Variable	Estimated Coefficient	Standard Error
Corn Price	0.323*	3.25×10^{-4}
Constant	-0.051*	6.57×10^{-5}
F statistic	60,2574.502*	
R^2	0.999	

Note: Single asterisks denote significance at the 0.01 level.



Note: Fed cattle price in these break-even calculations is $0.65/lb.

Figure A.1 Comparison of break-even feeder cattle prices at different corn prices



Note: Corn price in these break-even calculations is $2.50/bu.

Figure A.2 Comparison of break-even feeder cattle prices at different fed cattle prices

Appendix B

Cost of gain is an important part of break-even budget calculations. Though cost of gain includes feeding-related expenses such as yardage fees, veterinary charges, and interest, by far its largest component is feed costs. Given that the corn is, by volume, the most important ingredient in feedlot rations, it is not surprising that cost of gain is closely related to corn price.

Anecdotal evidence indicates that producers also use corn price as a proxy for feed costs in their break-even calculations. There is little doubt that, for the most part, using corn price as a measure of feed costs in cost of gain calculations is an acceptable practice; however, if corn prices are sufficiently high, it is possible that the relationship between corn price and cost of gain could be altered. Changes in the relationship between corn price and cost of gain could arise for three reasons. First, substitution of relatively cheaper grains for corn may be an option for feedlot managers. Second, changes occurring in placement and slaughter weights of cattle in response to high corn prices can affect feed conversion rate -- another important element in determining cost of gain. Third, if feedlots maintain inventories of corn or if they forward contract some of their corn purchases, cost of gain will not be as responsive to corn price as budgeting assumes. The purpose of this research is to determine the relationship between corn prices and cost of gain. If substitution in feed rations, cattle weight adjustments, and forward contracting and inventories of corn affect the relationship between corn price and cost of gain, then the standard budgeting practice of using corn price as a proxy for feed cost will lead to inaccurate break-even estimates. The inaccuracy of the estimates would presumably be greater the higher the corn price. Since cattle feeders rely on break-even estimates in making purchasing decisions and formulating marketing strategies, it is important for them to know if these estimates are accurate. Results of this study will indicate whether using corn price alone in break-even budgets yields reliable results or if a more comprehensive measure of rations costs is needed.

Theoretical Considerations

Though the mathematics of break-even calculations is quite simple, deciding which parameter values to use can be more difficult. If budgeting is to be at all useful in decision-making, some of the parameter values must be estimated. Feeder cattle prices and placement weights are, of course, observable at the time the decision to place cattle on feed is made; however, fed cattle prices, slaughter weight, and cost of gain must be estimated. The accuracy of budget calculations—and hence the quality of decisions based thereon—depends upon the accuracy of these estimates.

Slaughter weights for feedlot cattle are related to placement weights. This is due to the fact that a certain amount of gain from grain feeding is required if cattle are to grade choice; therefore, a good expectation of slaughter weight can be made by observing whether placement weight is relatively heavy or relatively light. Generally, heavy placement weights correspond to heavy slaughter weights, and light placement weights correspond to light slaughter weights.

For fed cattle price expectations, live cattle futures prices are available. Accurate cost of gain estimation presents something of a problem, however. Cost of gain is a measure of the cost incurred in adding one pound to the weight of the animal. As noted, the largest component of cost of gain is the feed costs. In addition, feed conversion rate—the number of pounds of feed required to achieve a pound of gain—has an important impact on cost of gain.

From a budgeting standpoint, estimating cost of gain is difficult because ration cost and feed conversion rate are not known at the time feeding decisions must be made. The practice of using corn price as a proxy for ration cost has been noted. When corn prices are high, this simplification may lead to errors in budget estimates because at high corn prices, it may be cost-effective to substitute other grains (e.g., wheat) for corn in ration formulation. Least-cost ration programs allow for this possibility. While these least-cost ration programs are useful to feedlot managers for making short-run decisions about ration composition given that feed ingredients have already been purchased, they are considerably less useful to cattle feeders who must make their decisions further in advance.

In addition to substitution of other grains, higher corn prices may lead to changes in the characteristics of cattle entering feedlots. Presumably, cattle will be placed on feed at heavier weights and slaughtered at lighter weights. As mentioned earlier, there is a limit to how much cattle weights can be manipulated, but some amount of adjustment is possible. Finally, given that feedlots maintain some inventories of corn and forward contract corn purchases, the relationship between current corn price and cost of gain will not be as strong as budgets assume.

It is hypothesized that at high corn prices, the net effect of the actions of cattle feeders will lead to a reduction in the use of corn. Consequently, cost of gain will be less responsive to corn price at high corn price levels. This hypothesis is based on the theory that when a factor price increases, maintaining optimal (cost-minimizing) production requires that adjustments be made to reduce the use of that factor. Implicit in the use of corn price as a proxy for feed cost in cost of gain calculations is the assumption that there is a one-to-one relationship between corn price and cost of gain. That is, a 1% increase (decrease) in the price of corn results in a 1% increase (decrease) in cost of gain. Thus, using corn price alone could overstate cost of gain at high corn prices.

Data and Procedures

Data for this experiment were obtained from Professional Cattle Consultants (PCC), a feedlot consulting firm in Weatherford, OK. The data used in the experiment included monthly average feed conversion rate and cost of gain for all pens of cattle slaughtered in a given month and average corn price paid by feedlots in each month. PCC data do not give cost of gain and feed conversion rates for all pens of cattle each month. Rather, the data give average cost of gain and feed conversion rates for the pens slaughtered in a given month. These values are therefore determined over the entire feeding period, not each month. Data cover the period from 1980 through 1996.

The hypothesis motivating this research is that cost of gain will not increase with corn prices at a one-to-one rate. More specifically, it is hypothesized that the elasticity of the cost of gain with respect to corn price will be less than one, the elasticity assumed in the budgeting process. In addition, it is hypothesized to be possible that cost of gain will increase at a decreasing rate as corn prices rise. This suggests that cost of gain should be represented as a quadratic function of corn prices. Alternatively, cost of gain may increase at a constant rate with corn price but at a rate that is lower than the rate of increase in corn price. Conceptually, this would result in a functional relationship between corn price and cost of gain in which the slope parameter on corn price has a magnitude that would result in an elasticity of less than one; that is, a 1% increase in corn price would result in less than a 1% increase in the cost of gain. Due to the importance of feed conversion in determining cost of gain, it should also be included in the model. The estimated model will therefore take the following form:

$$COG = f(CORN, CORN^2, CONV, D1, \ldots, D12, TIME), \quad (1)$$

where *COG* is cost of gain per pound; *CORN* is the corn price/bu; *CONV* is the feed conversion rate; *D1*, ..., *D12* are monthly dummy variables to account for the seasonality of cost of gain; and *TIME* is a linear time trend variable.

Because in the PCC data, cost of gain is determined for the entire feeding period and not simply monthly, it would be inaccurate to match each cost of gain entry with a single corn price. For this reason, the corn price used must be an average for the feeding period. A four-month moving average is used to represent corn price for the entire period on feed. Since days on feed varies for each observation, a more accurate procedure would be to base the length of average on the actual days on feed; however, the monthly corn prices available from PCC do not really allow for this level of precision.

The four-month moving average is lagged one month from the current month to reflect the fact that corn purchases are made, at least to some degree, in advance. Using corn price from the same month which cattle are slaughtered would overstate the importance of that current corn price, particularly for cost of gain of cattle slaughtered earlier in the month. To illustrate the application of the moving average price, if the slaughter month is May, cost of gain is taken to be a function of corn prices in January, February, March, and April. Feed conversion and cost of gain observations correspond with one another so no adjustment is necessary.

Due to the data observation periods overlapping for cost of gain and feed conversion, autocorrelation was expected to be a problem. Because cost of gain and feed conversion are calculated over the whole feeding period, observations on these variables for one month will be related to observations from a number of previous months, the exact number depending on the length of time on feed. This structural peculiarity of the data was expected to be reflected in moving average errors.

If cost of gain is, in fact, concave in corn prices as hypothesized, this fact will be reflected by the signs of the coefficients. The sign on the linear corn price term should be positive while the sign on the coefficient on the quadratic corn price should be negative. If, on the other hand, the relationship is linear, the coefficient on the quadratic corn price should be not significant; however, according to the hypothesis stated earlier, the coefficient on the linear corn price should be of a magnitude that would result in an elasticity of less than one. In either case, the use of corn price as an estimate of feed costs in break-even budgets will lead to an overestimation of cost of gain. The degree to which estimates will be erroneous will depend upon the magnitude of the corn price coefficients. If the coefficient on squared corn price is not significant and if the linear slope parameter results in an elasticity which is close to one, then using corn price alone in break-even estimates should not result in substantial errors. A positive sign is expected on feed conversion rate because cost of gain will increase as more feed is required to achieve a pound of gain.

Modeling Results

Misspecification tests revealed significant autocorrelation in the model estimated using ordinary least squares (OLS). An autoregressive model was estimated to correct for first-degree autocorrelation. The model was re-estimated using maximum likelihood estimation (MLE). MLE was considered appropriate since the distribution of the error terms was shown to be not significantly different from normal by a Jarque-Bera test.

Tests of the residuals showed that the autocorrelation present in the OLS model had been corrected in the autoregressive model. The coefficient on the quadratic corn price was not significantly different from zero. In addition, its sign was reversed. The non-significant quadratic term was dropped and the model re-estimated. Results of the model without the quadratic term are given in table B.1. The lack of significance on the quadratic corn price term indicates that cost of gain increases at a constant rate with corn price; however, as hypothesized there is not a one-to-one correspondence between corn price and cost of gain changes. The coefficient on feed conversion is positive, as expected.

Using the parameter estimates from the model in table B.1 along with the means of corn price and cost of gain, the elasticity of cost of gain with respect to corn price can be calculated:

(2) $$\text{model } \xi_{cog} = \frac{\partial COG}{\partial CORN} \bullet \frac{\overline{CORN}}{\overline{COG}} = 0.0992 \bullet (2.839/0.531) = 0.530.$$

Using the estimated standard error of the corn price coefficient (0.0032), the standard error of the elasticity of cost of gain with respect to corn price can be calculated as follows:

(3) $$\text{s.e. model } \xi_{cog} = [(2.839/0.531)^2 \bullet (0.0032)^2]^{1/2} = 0.017.$$

The preceding calculations show that the elasticity of the cost of gain model is significantly smaller than one, as budgeting assumes. This indicates that cost of gain will be considerably less responsive to changes in corn price than break-even analysis indicates. This can lead to quite large differences in cost of gain estimates. This point is illustrated in figure B.1, which shows the model cost of gain function as well as a unit-elastic cost of gain function plotted against corn price. The difference between these functions is plotted as well. The unit-elastic cost of gain function is constructed so that the average cost of gain from the data series used in the modeling ($0.531/lb) corresponds to the average corn price ($2.839/bu).

As corn price increases, the difference between the unit elastic cost of gain estimates and model estimates becomes larger due to the difference in elasticities. This is clear from table B.2, which shows some of the values used in constructing figure B.1. Using corn price and cost of gain difference information in table B.2, it is possible to calculate an equation for the line describing the difference function in figure B.1. This is given below:

(4) $$cog_{b.e.} - cog_{model} = \{(0.1357 + 0.0400)/(4 - 2)\}(\text{corn price} - 3) + 0.0478.$$

This is just the equation of a line whose slope is given by the term in brackets on the right side of the equation.

Interestingly, at average corn prices (around 2.50/bu), the two different estimates of cost of gain are very close to one another—within less than \$0.01/lb. However, the two estimates diverge rapidly as corn prices become extreme. Note that at low corn price, model cost of gain estimates exceed the budget estimates. This is due to the fact that the model incorporates actual cost of gain figures which include non-feed items such as yardage, veterinary expense, and interest. On the other hand, at high corn prices, the budget cost of gain is substantially larger than the model cost of gain—by nearly \$0.10/lb at a corn price of 3.50/bu and by nearly \$0.14/lb at a corn price of 4.00/bu.

The cost of gain difference equation (4) quantifies the discrepancy between break-even estimates of cost of gain and actual cost of gain values. This equation thus provides a valuable tool to cattle feeders who need to be able to accurately estimate the cost of gain which they should expect cattle being placed on feed to incur. This equation therefore has very practical farm management applications.

Summary and Conclusions

The purpose of this study was to determine if the practice of using corn price as a substitute for ration cost in break-even calculations is justified. It was hypothesized that adjustments made in response to high corn prices would alter both ration composition and cattle weights. The combined effect of these adjustments on ration cost and feed conversion was expected to be reflected cost of gain function which did not increase at a one-to-one rate with corn prices. Results of the cost of gain model presented here provide support for this hypothesis. Cost of gain was estimated to be a linear function of corn price. The responsiveness of cost of gain was shown to be less than that implied by break-even budgets using only corn price.

Using corn as a proxy for ration cost in break-even budgeting will, based on the results, of this study, exaggerate the impact of corn price changes on cost of gain, though not by as much as if the cost of gain function were quadratic. The amount of discrepancy between break-even and model cost of gain estimates is quantified in a linear function of corn price. This functional relationship will allow cattle feeders to achieve a higher level of precision in using break-even budgets as management/decision-making tools.

The results of this study would seem to have important practical application; however, two caveats to the interpretation of these results are in order. First, data used in this study were highly aggregated. As noted, these data were compiled from feedlots all over the nation. At a local or even regional level, the availability of substitutes may be a bigger factor relating corn price to cost of gain than the aggregate data suggest. For example, cost of gain at a feedlot with access to milo or brewer's grain or corn gluten may not show the same relationship to corn price as at a feedlot without such access.

Second, relatively few high corn prices were observed in the period of this study. At sufficiently high corn prices (over $4/bu), the quadratic relationship hypothesized earlier may actually hold. Perhaps too few observations at such high corn prices were available for this effect to be captured in the regressions. It is also possible that the linear relationship holds until corn prices reach a certain critical level. Beyond this level, the relationship between cost of gain and corn price may change. This suggests that a spline function may describe the relationship between cost of gain and corn price more accurately than a continuous function of the variety discussed here. More research is needed to determine if this is actually the case, and if so, at what critical corn price the kink in the function occurs.

Table B.1. **Parameter Estimates from Autoregressive Model of Cost of Gain**

Independent Variable	Estimated Coefficient	T-Ratio 184 d.f.
CORN	0.0992	30.60
CONV	0.0653	18.21
TIME	0.0004	9.59
D2	0.0035	2.31
D3	0.0028	1.44
D4	0.0022	1.00
D5	-0.0027	-1.06
D6	-0.0069	-2.28
D7	-0.0135	-4.03
D8	-0.0163	-4.95
D9	-0.0137	-4.46
D10	-0.0104	-3.68
D11	-0.0051	-2.12
D12	-0.0033	-1.98
AR(1)	-0.8338	20.65
Constant	-0.2190	-7.82

Note: Coefficients were estimated using maximum likelihood estimation.

Table B.2. Cost of Gain from Break-even Budget and Estimated Model

Corn Price	Unit-elastic COG	Model COG	Difference
2.00	0.3741	0.4141	-0.0400
2.50	0.4676	0.4637	0.0039
3.00	0.5611	0.5133	0.0478
3.50	0.6546	0.5629	0.0918
4.00	0.7482	0.6125	0.1357
4.50	0.8417	0.6621	0.1796

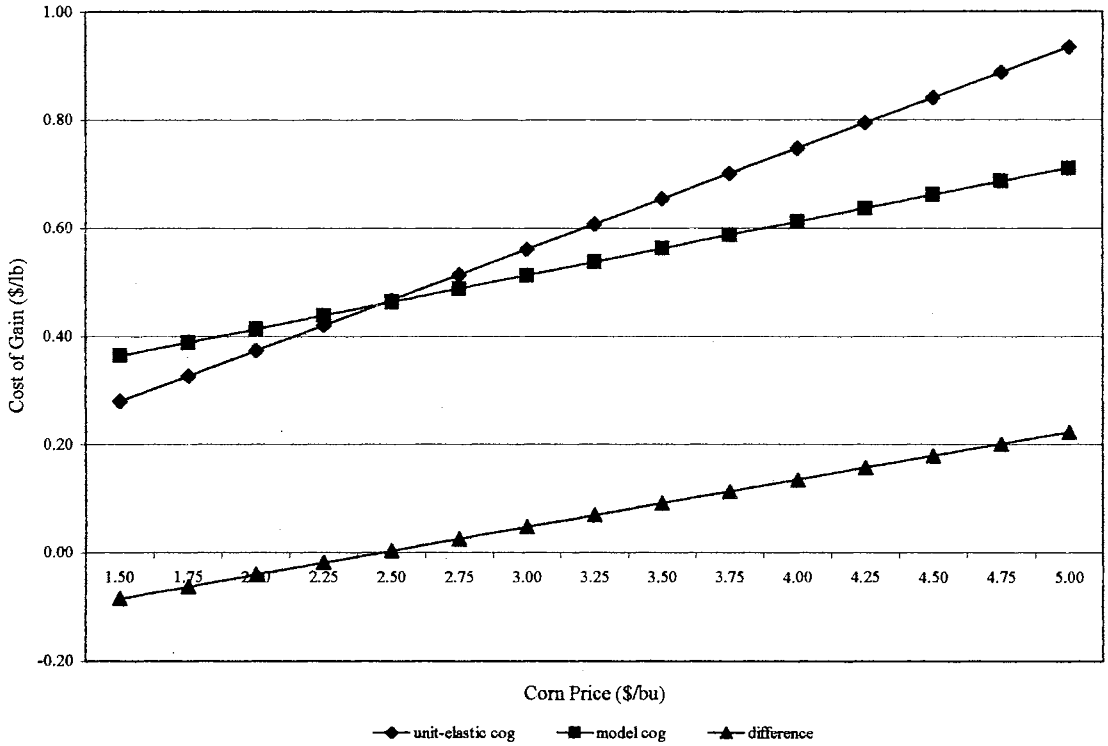


Figure B.1 Break-even and model cost of gain vs. corn price

Appendix C

During the experiment for determining the value of public information, each time the amount of available information was changed students were given a survey which asked them to rate on a scale of 1 to 10 how important the various amounts and types of information were to them in making marketing decisions. They were also asked how much they would be willing to pay for the various amounts and types of information. In addition, they were asked to rate the importance of futures market information, which was available through all information periods. Finally, they were asked to discuss how they compensated for the loss of information. Copies of the surveys used in the experiment are given in Appendix D.

Analysis of Variance (AOV) was conducted on this survey information to assess any differences that might exist between feeders and packers in their attitudes toward and willingness to pay for information. Two significant results were obtained.

First, packers placed significantly less importance on futures market information than did feeders. This is probably due to the fact that in the Fed Cattle Market Simulator (FCMS), packers' profit/loss statements allow them to determine boxed-beef price. They would therefore have less incentive than feeders to use the futures market as a substitute for summary information.

Second, packers indicated that they were significantly less willing than feeders to pay to have various types and amounts of information maintained or restored. They apparently felt more comfortable with their ability to adjust to or compensate for lost information than did feeders.

Participant responses to the question of how they compensated for the loss of information clearly indicate that they missed the withheld information. Responses also indicate a decline in the quality of decision-making due to the loss of information. Common strategies for dealing with limited information included the following:

- greater reliance on feeders visiting with other feeders, packers with other packers;
- more reliance on costs and break-even prices as a basis for price discovery rather than market price signals;
- increased use of previous profit and loss experiences as a basis for price discovery;
- increased use of futures market prices; and
- much more guessing.

Clearly, market participants made less-informed decisions, used whatever information could be found, and make more "same as last time" decisions when market information was limited. It is somewhat surprising that only one firm noted that it increased its use of contracts without public market information. This is a logical response and one that may have become more prevalent had the length of the limited information periods been longer.

Appendix D

PACKER-FEEDER VALUE OF INFORMATION SURVEY

Full Information

Name____

Your Packer Number____________ or Feedlot Number _____________

During the past 4 trading periods, you have participated in the packer-feeder game with "full information". We define full information as: (1) within-week current-market information (the cash market light bar); and (2) end-of-week market-summary information (the chalk board). You also had access to futures market information.

Answer the following questions individually, not as a team.

1. How important was full information (cash market light bar and chalk board) to pricing and marketing/purchasing decision-making in your feedlot/packing plant during the past four weeks? Indicate the importance of full information (cash market light bar and chalk board) to you on a scale of 1 to 10, where 1 means not important and 10 means very important. _________

2. Futures market information is not a direct part of our experiment, but we are interested in your opinion as to its importance. How important was futures market information (the futures market light bar) to pricing and marketing/purchasing decision-making for your feedlot/packing plant during the past four weeks? Indicate the important of the futures market light bar information to you on a scale of 1 to 10, where 1 means not important and 10 means very important. ___________

3. How much did full information (cash market light bar and chalk board) contribute to the profitability of your feedlot/packing plant during the past four weeks? (Note: If you experienced losses rather than profits, think in terms of how much worse your losses would have been without the information.) Indicate the contribution full information (cash market light bar and chalk board) made to your profits per head.
$___________/head in game dollars.

4. How much would you be willing to pay (for example, to a news serve) to maintain full information (cash market light bar and chalk board)? Indicate the amount you would be willing to pay. $__________/head in game dollars.

PACKER-FEEDER VALUE OF INFORMATION SURVEY

Limited Information: Within-Week

Name:____

Your Packer Number ______ or Feedlot Number ____________

Answer the following questions individually, not as a team.

During the past 8 trading periods, you have participated in the packer-feeder game with "limited information". Limited information here means operating without the within-week current-market information (the cash market light bar).

1. How important was the cash market light bar information to pricing and marketing/purchasing decision-making in your feedlot/packing plant during the past eight weeks? Indicate the importance of the cash market light bar information to you on a scale of 1 to 10, where 1 means not important and 10 means very important. ___________

2. Without the cash market light bar information, how important was futures market information (the futures market light bar) to pricing and marketing/purchasing decision-making in your feedlot/packing plant during the past eight weeks? Indicate the importance of the futures market light bar information to you on a scale of 1 to 10, where 1 means not important and 10 means very important. ____ ______

3. How much did the cash market light bar information contribute to the profitability of your feedlot-packing plant? (Note: If you experienced losses rather than profits, think in terms of how much worse your losses would have been without the information.) Indicate the contribution the cash market light bar information made to profit per head. $______________/head in game dollars.

4. How much would you be willing to pay (for example, to a news service) to restore the cash market light bar information? Indicate the amount you would be willing to pay. $__________/head in game dollars.

5. What did you do to compensate for the loss of the cash market light bar information during the past eight weeks?_________________________________
____
____
____

PACKER-FEEDER VALUE OF INFORMATION SURVEY

Limited Information: End–of-Week

Name____

Your Packer Number ______ or Feedlot Number ____________

Answer the following questions individually, not as a team.

During the past 8 trading periods, you have participated in the packer-feeder game with "limited information." Limited information here means operating without the end-of-week market-summary information (the chalk board).

1. How important was the chalk board information to pricing and marketing/purchasing decision-making in your feedlot/packing plant during the past eight weeks? Indicate the importance of the chalk board information to you on a scale of 1 to 10, where 1 means not important and 10 means very important.

   ______

2. Without the chalk board information, how important was futures market information (the futures market light bar) to pricing and marketing/purchasing decision-making in your feedlot/packing plant during the past eight weeks? Indicate the importance of the futures market light bar information to you on a scale of 1 to 10, where 1 means not important and 10 means very important.

   ____

3. How much did the chalk board information contribute to the profitability of your feedlot/packing plant the past eight weeks? (Note: If you are experiencing losses rather than profits, think in terms of how much worse your losses would have been without the information.) Indicate the contribution the chalk board information made to profit per head. $__________/head in game dollars.

4. How much would you be willing to pay (for example, to a news service) to restore the chalk board information? Indicate the amount you would be willing pay. $___ ___________/head in game dollars.

5. What did you do to compensate for the loss of the chalk board information during the past eight weeks?____
   ____
   ____
   ____
   ____
   ____

PACKER-FEEDER VALUE OF INFORMATION SURVEY

Limited Information: Within-Week and End-of-Week

Name:____

Your Packer Number____________ or Feedlot Number______________

Answer the following questions individually, not as a team.

Over the past 8 trading periods, you have participated in the packer-feeder game with "limited information". Limited information here means operating without the within-week current-market information (the cash market light bar AND the end-of-week market summary information (the chalk board).

1. How important was the cash market light bar AND the chalk board information to pricing and marketing/purchasing decision-making in your feedlot/packing plant during the past eight weeks? Indicate the importance of the cash market light bar AND chalk board information to you on a scale of 1 to 10, where 1 means not important and 10 means very important. _________

2. Without the cash market light bar AND chalk board information, how important was futures market information (the futures market light bar) pricing and marketing/purchasing decision-making in your feedlot/packing plant during the past eight weeks? Indicate the importance of the futures market light bar information to you on a scale of 1 to 10, where 1 means not important and 10 means very important. ___________

3. How much did the cash market light bar AND chalk board information contribute to the profitability of your feedlot/packing plant the past eight weeks? (Note: If you experienced losses rather than profits, think in terms of how much worse your losses would have been without the information.) Indicate the contribution the cash market light bar AND chalk board information made to profit per head. $___ ______/head in game dollars

4. How much would you be willing to pay (for example, to a news service) to restore the cash market light bar AND chalk board information? Indicate the amount you would be willing to pay. $___________/head in game dollars.

5. What did you do to compensate for the loss of the cash market light bar AND chalk board information during the past eight weeks?________________________
____
____
____

Appendix E

This is the code for the SAS program used to estimate the break-even feeder cattle price model of Chapter II:

```
data fcmod;
infile 'H:\SIM\FCADJ.TXT';
input mn month $ fcadj c lc dcof iwest owest slmn $;

/*MN=MONTH NUMBER 1 - 132)*/
/*MONTH=MONTH CORRESPONDING TO FCADJ*/
/*FCADJ=FEEDER CALF PRICE AT T ADJUSTED FOR IWEST*/
/*C=CORN PRICE*/
/*LC=LIVE CATTLE FUTURES PRICE 140 DAYS OUT*/
/*IWEST=EXPECTED AVERAGE IN WEIGHT AT T*/
/*OWEST=EXPECTED SLAUGHTER WEIGHT AT T+140*/
/*SLMN=SLAUGHTER MONTH*/

if month="feb" then d2=1;
  else d2=0;
if month="mar" then d3=1;
  else d3=0;
if month="apr" then d4=1;
  else d4=0;
if month="may" then d5=1;
  else d5=0;
if month="jun" then d6=1;
  else d6=0;
if month="jul" then d7=1;
  else d7=0;
if month="aug" then d8=1;
  else d8=0;
if month="sep" then d9=1;
  else d9=0;
if month="oct" then d10=1;
  else d10=0;
if month="nov" then d11=1;
  else d11=0;
if month="dec" then d12=1;
  else d12=0;

if slmn="jan" then conv=6.8164;
if slmn="feb" then conv=6.9632;
if slmn="mar" then conv=6.9679;
if slmn="apr" then conv=6.7729;
if slmn="may" then conv=6.5170;
if slmn="jun" then conv=6.2855;
if slmn="jul" then conv=6.2162;
```

```
if slmn="aug" then conv=6.2641;
if slmn="sep" then conv=6.3426;
if slmn="oct" then conv=6.3537;
if slmn="nov" then conv=6.3971;
if slmn="dec" then conv=6.5809;

time=_n_;

sind=sin(2*3.14159*(mn/132));
sinx=sin(2*3.14159*(mn/66));
cosd=sin(2*3.14159*(mn/132)+(3.14159/2));
cosx=sin(2*3.14159*(mn/66)+(3.14159/2));

rev=((owest*lc)/iwest)*(1-.0087);
cost=(((owest-iwest)*conv*c)/iwest);

lfcadj=lag(fcadj);

proc means;
 var fcadj c lc iwest owest conv dcof rev cost;

proc reg covout outest=fcest;
  model fcadj=lfcadj cost rev dcof cosd sind d2 d3 d4 d5 d6 d7
             d8 d9 d10 d11 d12;
  output out=paout p=yhat r=ehat;

  season: test d2=d3=d4=d5=d6=d7=d8=d9=d10=d11=d12=0;
  cycle: test cosd=sind=0;

data joint;
  merge fcmod paout;
perr=ehat/fcadj;
proc print;
  var month fcadj ehat perr;

lehat=lag(ehat);
ehat2=ehat**2;
yhat2=yhat**2;
yhat3=yhat**3;
lehat2=lag(ehat2);


proc reg;
 model ehat= lfcadj cost rev dcof cosd sind d2 d3 d4 d5 d6 d7
             d8 d9 d10 d11 d12 lehat time yhat2 yhat3;

 jtmean: test lehat=time=yhat2=yhat3=0;

proc reg;
 model ehat2=lehat2 time yhat2 yhat3;

 jtvar: test lehat2=time=yhat2=yhat3=0;

proc iml;
use fcest;
read all var{intercept lfcadj cost rev dcof cosd sind
             d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12} into x1;
```

```
yhat=x1[{1},];
print yhat;
lambda=x1[1,2];
lrf=1/(1-lambda);
x2=j(18,1,lrf);
x2d=diag(x2);
lr=x2d*yhat`;
omega=x1[{2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19},];
print omega;
lrvar=x2d*omega`*x2d`;
lrse=sqrt(vecdiag(lrvar));
print lrse;
lrsesq=diag(lrse);
seinv=inv(lrsesq);
lrd=diag(lr);
tsq=lrd*seinv;
t=vecdiag(tsq);
prob=1-probf(t#t,1,499);
out=lr||lrse||t||prob;
outcol={"lr coef.","stderr","t-stat","p-value"};
outrow={"intercept","lfcadj","cost","rev","dcof","cosd","sind","d2",
         "d3","d4","d5","d6","d7","d8","d9","d10","d11","d12"};
print out[rowname=outrow colname=outcol];

;
run;
```

This is the code for the LIMDEP program to calculate the price level and variance models with on information period dummy variable presented in Chapter III. The code for the model with separate summary and current information period variables is the same except for the lines creating the dummy variables.

```
READ;NVAR=13
    ;NOBS=2197
    ;FILE=A:\VOI96LD.TXT
    ;NAMES=WKD, FDLT, PKR, WT, PRC, TYP, BBP, FMPL,TSL, TLSTL, BEPKC,
           BEFD, BEPK $
CREATE;DFD1=FDLT=1
      ;DFD2=FDLT=2
      ;DFD3=FDLT=3
      ;DFD4=FDLT=4
      ;DFD5=FDLT=5
      ;DFD6=FDLT=6
      ;DFD7=FDLT=7
      ;DFD8=FDLT=8
      ;DPK1=PKR=1
      ;DPK2=PKR=2
      ;DPK3=PKR=3
      ;DPK4=PKR=4
      ;IF (WKD>=41 & WKD<=48 + WKD>=53 & WKD<=60 + WKD>=65 & WKD<=72 +
           WKD>=81 & WKD<=88) DINFO=1;(ELSE)DINFO1=0
      ;IF (WKD>=37 & WKD<=42 + WKD>=47 & WKD<=54 + WKD>=62 & WKD<=67
            +WKD>=73 & WKD<=78 + WKD>=86 & WKD<=90)DPAY=1;(ELSE)DPAY=0
      ;DTYP1=TYP=1
```

```
       ;DWT1=WT=1100
       ;DWT2=WT=1125
       ;DWT3=WT=1150
       ;DWT4=WT=1175
       ;DWT5=WT=1200
       ;DWT6=WT=1225
       ;PPL=BEPKC-BEFD$

CREATE;GROUP=NDX(WKD,0)
       ;TIME=NDX(WKD,1)$

REGRESS;LHS=PRC;RHS=BBP,FMPL,TSL,TLSTL,PPL,DFD2,DFD3,DFD4,DFD5,DFD6,
           DFD7,DFD8,DPK2,DPK3,DPK4,DINFO,DPAY;
           PANEL;STR=GROUP;RANDOM;RES=R2 $
CREATE;LOGRSQ=LOG(R2^2)$

REGRESS;LHS=LOGRSQ;RHS=ONE,BBP,FMPL,TSL,TLSTL,PPL,DFD2,DFD3,DFD4,DFD5,D
FD6,
        DFD7,DFD8,DPK2,DPK3,DPK4,DINFO,DPAY
        ;KEEP=P $

CREATE;EP=EXP(P)
       ;WTB=1/EP $

REGRESS;LHS=PRC;RHS=BBP,FMPL,TSL,TLSTL,PPL,DFD2,DFD3,DFD4,DFD5,DFD6,
           DFD7,DFD8,DPK2,DPK3,DPK4,DINFO,DPAY
           ;PANEL;STR=GROUP;RANDOM;WTS=WTB;RES=R2W $

CREATE;VPRC=LOG(R2W^2) $
REGRESS;LHS=VPRC;RHS=ONE,BBP,FMPL,TSL,TLSTL,PPL,DFD2,DFD3,DFD4,DFD5,
            DFD6,DFD7,DFD8,DPK2,DPK3,DPK4,DINFO,DPAY $
```

This is the code for the LIMDEP program to estimate the logit model of weight deviations presented in Chapter III. Again, this code is for the model with a single information period dummy variable.

```
READ;NVAR=13
     ;NOBS=2197
     ;FILE=A:\VOI96LD.TXT
     ;NAMES=WKD, FDLT, PKR, WT, PRC, TYP, BBP, FMPL,TSL, TLSTL, BEPKC,
           BEFD, BEPK $
CREATE;DFD1=FDLT=1
       ;DFD2=FDLT=2
       ;DFD3=FDLT=3
       ;DFD4=FDLT=4
       ;DFD5=FDLT=5
       ;DFD6=FDLT=6
       ;DFD7=FDLT=7
       ;DFD8=FDLT=8
       ;DPK1=PKR=1
       ;DPK2=PKR=2
       ;DPK3=PKR=3
       ;DPK4=PKR=4
       ;IF (WKD>=41 & WKD<=48 + WKD>=53 & WKD<=60 + WKD>=65 & WKD<=72 +
           WKD>=81 & WKD<=88) DINFO=1;(ELSE)DINFO=0
```

```
      ;IF (WKD>=37 & WKD<=42 + WKD>=47 & WKD<=54 + WKD>=62 & WKD<=67
           +WKD>=73 & WKD<=78 + WKD>=86 & WKD<=90)DPAY=1;(ELSE)DPAY=0
      ;DTYP1=TYP=1
      ;PPL=BEPKC-BEFD
      ;WTVAR=ABS(1150-WT)
CREATE;IF (WTVAR=0) WTV=0
      ;IF (WTVAR=25) WTV=1
      ;IF (WTVAR=50) WTV=2
      ;IF (WTVAR=75) WTV=3 $
SORT;LHS=WTV;RHS=BBP,TSL,TLSTL,PPL,DFD2,DFD3,DFD4,DFD5,DFD6,
          DFD7,DFD8,DPK2,DPK3,DPK4,DINFO,DPAY$

ORDERED PROBIT;LHS=WTV;RHS=BBP,TSL,TLSTL,PPL,DFD2,DFD3,DFD4,DFD5,DFD6,
          DFD7,DFD8,DPK2,DPK3,DPK4,DINFO,DPAY;RES=R1;LOGIT$
```

Appendix F

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 01-12-96 **IRB#:** AG-96-011

Proposal Title: VALUE OF PUBLIC INFORMATION: AN EXPERIMENTAL SIMULATION APPROACH

Principal Investigator(s): Clement E. Ward, Tracy Dowty

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

Signature: [signature] Date: January 15, 1996

Chair of Institutional Review Board

VITA

John D. Anderson

Candidate for the Degree of

Doctor of Philosophy

Thesis: DYNAMIC PRICE ADJUSTMENT, PRICE DISCOVERY, AND VERTICAL COORDINATION IN CATTLE MARKETS

Major Field: Agricultural Economics

Biographical:

Personal Data: Born August 20, 1970 in Batesville, Arkansas, the son of Ivan and Nell Anderson.

Education: Graduated from Mountain View High School, Mountain View, Arkansas in May of 1988; received a Bachelor of Science degree in Agribusiness from the College of the Ozarks, Pt. Lookout, Missouri in May of 1992; completed the requirements for the degree of Master of Science in Agriculture with a major in Agricultural Economics at Arkansas State University in August of 1994; completed the requirements for the degree of Doctor of Philosophy with a major in Agricultural Economics at Oklahoma State University in May of 1998.

Professional Experience: Graduate Assistant, Arkansas State University, January – August 1993; Loan Officer, First National Bank of Izard County, Calico Rock, Arkansas, August 1993 – August 1995; Graduate Research Assistant, Oklahoma State University, August 1995 – May 1998.

Awards: Oklahoma State University Graduate Research Excellence Award, May 1998.