AN INVERSE DEMAND MODEL FOR WEEKLY BOXED BEEF PRICE

By

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INTRODUCTION

Background

Over the last half century, a number of changes have taken place in the United States beef packing industry. Improved technology, refrigeration, new materials handling methods, and the movement of cattle feeding from the eastern cornbelt into the Midwest and Plains led to the emergence of a new class of packing firms. These new packing firms, led by IBP (formerly Iowa Beef Packers, Inc.), were made up of large single storied plants that were located close to the cattle feeders, whereas the old-line packers were located close to the retailers. The new technologies used by these packing plants allowed them to slaughter cattle and transport the carcasses to the wholesalers cheaper than old line packers. The new packers also found cost savings over old-line packers by hiring workers at substantially lower wages. The old-line packers employees were covered by master labor union contracts which included cost of living adjustment clauses. Double digit inflation of the 1970's basically wiped out any cost competitiveness the old-line packers may have had (Crom).

In the 1960's, IBP pioneered a new marketing concept called boxed beef. The concept of boxed beef involves breaking the carcasses at or near the point of slaughter via assemblyline production into subprimals weighing from 5 to 30 pounds, vacuum sealing them in plastic bags, and placing the bags in cardboard boxes for shipment to wholesalers or retailers (Fielding). Butchers at the retail level then divide the subprimals into smaller portions for purchase by the final consumer.

A number of advantages for the use of boxed beef over carcass beef have been suggested. The retailer is able to target purchases to those cuts that sell best in his individual establishment. This provides retailers with increased marketing flexibility and reduced wastes. Reduced costs can be passed on to consumers in the form of lower beef prices. Assemblyline production methods allow workers to perform a specific task thereby working faster and more efficiently than workers at distribution centers who perform a variety of tasks in cutting a single carcass. This provides additional savings to the retailer and consumer. Another advantage is that the boxes are more compact and can be shipped to wholesalers and retailers cheaper than carcasses can be shipped. Vacuum sealed meat is also more sanitary and has a longer shelf life than carcass beef. A hanging carcass may remain fresh for four days while boxed beef will remain fresh for up to three weeks with no loss in color or flavorful juices (Fielding).

In 1984, it was estimated that 55 percent of all beef was boxed at the packing site. It was also estimated that 90 percent of all beef was boxed by the time it reached the retailer (Duewer). In 1983, almost one half of all beef in the nation was slaughtered by the "Big Three" packing firms (IBP, Excel and Swift Independent) (Marion). These firms are also noted for selling primarily boxed beef. Most likely, the only carcasses sold by these firms were carcasses that did not meet boxed beef specifications and were sold to firms in specialized meat production. Consequently, concentration in the boxed beef market is greater than concentration in the beef market as a whole.

Problem Statement

There has always been a great deal of interest in how concentration in the meat packing sector affects the profit sharing of the meat industry. There has also been interest in how certain marketing tools, such as forward contracting and hedging on the futures market, affect the decision process for buying and selling live animals. It would be virtually impossible to change the number of meat packers at random or to remove marketing tools from the real market place in order to see how the market would be affected. To examine the influences of these factors, a fed cattle market simulator was developed at Oklahoma State University (Trapp, Ward, Koontz, and Peel).

Oklahoma State University's Fed Cattle Market Simulator simulates the interaction between feedlots and packing plants through an experimental role playing model. A more detailed overview of the simulator and the use of the demand model to be estimated in this research is given in Appendix A. Due to the complexity of the simulator and space and time constraints, it is not possible to add a third level to the market to simulate the interaction between packers and retailers. Thus a method of calculating what the boxed beef price should be based on the quantity of boxed beef the packers produced each week had to be incorporated into the computer software portion of the simulator. However, a search of the literature found no adequate explanation of how boxed beef prices respond to week to week changes in supply and other exogenous factors. The research problem then becomes, can an accurate model of weekly boxed beef prices be developed to use within the simulator?

Objective

The general objective of this research is to incorporate a realistic boxed beef demand schedule into Oklahoma State University's Fed Cattle Market Simulator by studying the determination of boxed beef prices in the real world. More specifically, the objective of this research is to determine the boxed beef price response to weekly changes in quantities of boxed beef, other beef, competing meats, and seasonal factors.

Organization of the Study

The remainder of this study consists of Chapters II through V. Chapter II presents a review of literature related to beef demand with an attempt to examine both intermediate market demands and weekly demands. Chapter III presents the methods employed in this study to estimate weekly boxed beef demand and supply equations and the data utilized in the empirical estimation. Chapter IV presents the empirical results of the weekly boxed beef demand and supply equations. Finally, Chapter V concludes the study.

CHAPTER II

REVIEW OF RELEVANT LITERATURE

Past research concerning economic factors affecting the beef market has concentrated on either farm-level supply or retail-level demand and has usually utilized either annual or quarterly data. Very little research has been done on demand or supply for meat in the intermediate levels of the market. What has been done can be classified into two separate groups: 1) Studies which consider which level of the market (if any) leads the others in the price discovery process; and 2) Studies which attempt to estimate individual demand equations or systems of supply and demand.

Demand Estimation

The majority of research done for beef demand has dealt with annual, quarterly, or occasionally monthly demand. The focus of this study will be upon weekly demand for beef. Thus, this literature review will focus upon the limited amount of previous research done on weekly demand. However, a brief overview of the large body of research done on monthly, quarterly, and annual demand will be considered first.

Monthly, Quarterly, and Annual Demand Estimates: Quantitative demand analysis for beef could be said to go back to Langemeir and Thompson. They were among the first to suggest separating fed and non-fed beef as proxies for hamburger and table cut beef. Their estimation involved a system of equations estimated through the use of two stage least squares. Although their results were fairly good, no impacts from substitute meats were incorporated into the model. The supply and demand equations were specified at opposite ends of the market i.e. the supply equation was for farm level production and the demand was for retail consumption. The presence of a wholesale market between the farm and retail levels of the market was ignored.

Estimation of demand in the intermediate market levels has usually been accomplished through the use of a system of equations that include all levels from farm to retail. Arzac and Wilkenson developed a livestock and feed grains sector supply and demand model. Commodities considered were beef, pork, chicken, and corn. They used a system of forty-two equations and ten years of quarterly data. Fourteen equations considered wholesale activities. Due to data limitations and timing of some of the decisions, five of the equations were estimated as annual or semiannual events. Twenty-three of the market clearing equations were estimated through truncated two-stage least squares (2SLS). Quarterly dummy variables were used to adjust for seasonality.

Arzac and Wilkenson found severe autocorrelation with their models. Comparing their autoregressive models with their 2SLS models found that the autoregressive models performed better for nonfed beef and steers but worse for pork, chicken, and corn prices within sample. Out of sample comparisons found that their 2SLS model performed better in all cases. Another finding in the Arzac and Wilkenson study is that slaughter numbers and numbers of cattle and hogs placed on feed are responsive to current prices while cattle supplies are not responsive to current prices.

Estimates of demand at levels other than retail are fairly rare. Hayenga and Hacklander attempted to estimate the monthly farm level supply and demand for fed cattle and hogs. They used five simultaneous equations with the demands specified as price dependant. Prices were specified to be a function of quantities of cattle and hogs marketed, income, cold storage, and monthly dummy variables. The equations were estimated through two-stage least squares. They did not include any adjustment for impacts of poultry and they assumed adjustment was instantaneous.

Hayenga and Hacklander's equations had reasonable statistical and theoretical properties. All five equations in their model had R-squares above 0.82. The only real problem they faced was that the substitution between beef and pork could not be analyzed. This was due to the fact that the cross elasticities had opposite signs in the beef and the pork demand equations.

Marsh attempted to estimate the demand for fed cattle and feeder cattle on a quarterly basis. He used a non-stochastic differencing equation with Jorgenson's rational lag structure to estimate the reduced forms. Fed cattle price was specified as a function of quantities of fed cattle, quantities of nonfed cattle, byproduct value, price of carcasses, and expected price of fed cattle. Price of feeder cattle was specified as a function of quantity of placements, price of fed cattle, price of corn, and expected price of feeders in the time period purchased. Dummy variables were present in both equations for seasonality, but no mention of poultry or pork was made in either equation.

Marsh found that the price of fed cattle followed a geometrical decline over time in response to lagged slaughter supplies. He also found that feeder cattle prices followed an oscillatory decline in response to lagged supplies. Both fed cattle and feeder cattle prices had larger responses to changes in their own output than to any other variables. All response due to variables other than own quantity were found to take place in the current quarter. Marsh also determined that the distributed lag models estimated were superior to an autoregressive and a static model also estimated in his research when evaluated by their root mean squared error (RMSE).

Weekly Demand Estimates: Demand estimation using weekly data is still rather new. It is currently making its way into the literature. Most arguments for the use of weekly data in the articles reviewed focus on the fact that consumers adjust their decision process on a weekly basis so demand should represent these adjustments (Capps and Nayga).

Marion and Walker (1978) estimated a weekly retail demand for five meat classes based on data collected from two stores (store A and store B) in Ohio.

The data consisted of thirty-two observations on beef round, beef chuck, beef loin, pork loin and fryers. Observations on twelve weeks were omitted due to holidays falling in those weeks. Dummy variables for trend, temperature, quarterly seasonality, and nearness of payday were also included. Due to collinearity between the temperature and seasonality variables, one or the other had to be omitted from all but the beef loin in store A equations. The variables were measured in natural numbers and fit to a linear relationship. Ten equations were estimated for the five variables and two stores.

Marion and Walker found the demand for wholesale cuts related to pricing at the retail level. Own price variables were negative and significant. Twelve of the fifteen cross price variables had the positive expected sign. Newspaper advertising (measured by number of listings of the individual meats) showed no relationship with product sales in any of the ten models and its presence tended to produce highly unstable results. Nearness of payday affected sales in eight of the ten cases; four through the intercept alone, two through the slope, and two through both the intercept and the slope. The results also indicated that the higher quality meat cuts had higher elasticities.

Funk et. al. (1977) estimated a retail beef demand function utilizing weekly data collected from a supermarket chain in Toronto, Canada. The data consisted of observations from January 1974 through May 1975. An aggregate and disaggregate model was estimated using ordinary least squares (OLS) with beef sales as a function of own store beef price, competitive store beef price, own and competitive store relative price of substitute meats, seasonal adjustments, and own and competitive store number of newspaper adds. Income changes were assumed to be of small enough magnitude in a weekly time period to be excluded.

The results of Funk et. al.'s aggregate model produced a high degree of multicollinearity between the own store and competitive store beef prices with both having the expected negative sign. All cross elasticities were positive. Pork advertising had a negative sign while all other advertising had a positive sign. The disaggregate model, which considered different cuts of beef and pork (cross-cuts), produced eight of fourteen own price elasticities that were negative and significant. There were only three cross-cut price elasticities that were positive and significant and three cross-product price elasticities that were positive and significant.

Capps (1989) wrote one of the first articles utilizing scanner data (i.e. data collected from electronic scanning checkout systems at supermarkets) to estimate a weekly retail demand for seven meat items. The data were collected from a single supermarket in Houston, Texas, and consisted of January 1986 through January 1987 observations on steak, ground beef, roast beef, chicken, pork chops, ham and pork loin. Data were then aggregated from daily observations into seventy-five weekly observations. In addition to meat variables, dummy variables were included to factor in the effects of nearness of a payday, holidays, print space allocated for advertising of the individual meat items, trend, and quarterly seasonality variations. A lagged dependent variable was used to proxy habitual consumption. The model was estimated through a seemingly unrelated regression procedure utilizing a double logarithmic functional form in order to obtain direct estimates of the elasticities. In the final model, other meats were combined into a single category for each equation.

The findings of the Capps (1989) article held that all cross price elasticities were significantly different from zero and had the expected signs. Except for ground beef and ham, the own price elasticities were significantly different from zero and negative. Only two of the twenty-one nearness of payday coefficients estimated proved to be statistically significant. The holiday dummies were also combined into a single variable and, except for ham, were found to be negative and significant. Own advertisement space for each commodity was positive and significant for all commodities except ham. A downward trend was found for steak, ground beef, pork chops, and pork loin while an upward trend was found for ham. No trend was found to exist for roast beef and chicken. Each meat item faced a different seasonality pattern. Consumption habits were evident for steak, chicken, pork chops, ham, and pork loin as indicated by the parameter of the lagged dependant variable being significant.

Capps and Nayga (1991) also estimated retail demand for beef using scanner data collected from a firm operating forty-three supermarkets in Houston, Texas (prices were uniform across the respective supermarkets). The meat items were aggregated into carcass sections of brisket, chuck, ground beef, loin, rib, round, and all other beef. The data were aggregated into weekly observations and consisted of ninety-seven observations beginning in January 1987 and ending in November 1988. The model was estimated using ordinary least squares (OLS) and was specified with quantity of items as a function of price of beef products, pork, poultry, convenience beef (such as TV dinners), advertising (measured by amount of print space), and holidays.

Capps and Nayga found that all own price elasticities were negative, significantly different from zero, and in the elastic range. Only six of the forty-two cross-beef elasticities were significantly different from zero; three had a positive sign and three had a negative sign. Only one of the twenty-eight cross-product elasticities was significantly different from zero. All own advertising elasticities were positive, significantly different from zero, and smaller in magnitude than the own price elasticities. Seasonality was a factor only for loins and all other beef. Holidays were not a factor for any of the meat items.

Unlike the previous research mentioned, which consisted of time series on observed prices and quantities from supermarkets, Purcell and Raunikar (1971) obtained cross-sectional and time series data from a panel of consumers in Atlanta, Georgia. The data were collected weekly from an average of 460 households over a period of five years (1958-1962). A first differencing model was employed with quantity as a function of own price and a weighted average of price of substitutes. The only time dynamics variable incorporated was a trend variable. Seasonality, income, etc. were assumed not to change in sufficient magnitude to influence weekly changes. Positive and negative changes in quantity were analyzed separately.

Purcell and Rauniker found that all own price elasticities were negative and significant while cross price elasticities had mixed results. They also found that beef movement was more responsive in periods of declining prices than in periods of rising prices. They explained this as people are more willing to purchase in periods of declining prices but are less willing to give up the meat in periods of rising prices.

All previous literature cited dealing with weekly data has focused on a narrow geographic market, i.e. several stores, a panel in one city, etc. Only one weekly study focusing on an entire market was found and judged relevant to the objectives of this study. Marsh and Brester used 209 weeks of data to estimate the "intertemporal" and vertical linkages in the beef market (boxed beef, carcass, and slaughter). They estimated price movement through a system of reduced form equations that assumed a predetermined supply. The equations were specified with price as a function of quantity of beef, quantity of pork, quantity of poultry, price of byproducts, and wages. Price dynamics were captured through a rational lag structure. The equations were specified as a first difference model with price as a function of own quantity, quantity of competing meats, and prices at both the upper and lower levels of the market. They did not include any seasonality variables.

Marsh and Brester determined that carcass and slaughter prices were best modeled using second differenced data with an ARMA(1,1) process. Boxed beef prices were best represented by first differenced data with no ARMA process. Their lag structure indicated that boxed beef followed a dampening geometric lag structure while both carcass and slaughter beef followed a pattern of a second degree polynomial. Marsh and Brester determined that the boxed beef price would reach full adjustment in 13.5 weeks, carcass price would reach full adjustment in 12.8 weeks, and slaughter prices would reach full adjustment in 8.7 weeks after a shock to the system.

Lead-Lags Among Market Levels

Research about the lead-lag relationship among different levels of the beef marketing chain do not relate directly to this study. However, consideration of whether the weekly beef demand model is price or quantity dependent, recursive, or simultaneous depends upon ones assumptions about the lead-lag relationships between the market levels. Thus studies estimating the lead-lag relationships are worth examining in this regard. Indeed, some disagreement exists in the literature with regard to which level of the market leads the determination of price.

Franzmann and Walker developed a trend model using monthly data that took into account seasonal and cyclical price variations within the beef industry. They found that seasonality was insignificant for the wholesale level. Also, their wholesale model had a poor statistical fit. Franzmann and Walker then used phase angles to determine which level of the market leads the others. They found that the wholesale level led all other levels of the market.

Barksdale et. al. argued that phase angles only show that the markets adjust at different times. Because phase angles can turn 360 degrees or greater, the researcher would be unable to determine if the difference would actually be a lead or a lag. Barksdale et. al. used cross spectral analysis to determine which level of the market led the other levels. "Causality" tests were used to confirm the direction of the leads and lags. Due to similar directional patterns, it was determined that prices adjust instantaneously.

Boyd and Brorsen used a variant of the Granger Causality test to determine lead-lag relationships for both the beef and pork markets. They used weekly data that was first differenced to remove any trend. Boyd and Brorsen found that the farm level prices led all other market levels.

Schroeder and Hayenga compared two separate tests to determine vertical lags. They used a Granger causality test and a transfer function to determine lag relationships. They found that the retail level lags the wholesale level by three to five weeks.

Chapter Summary

Monthly, quarterly, and annual demand estimations reviewed here were useful for identifying relevant independent variables to include in the boxed beef demand model to be estimated here. They were also useful in identifying alternative methods to employ in estimation.

Based upon the literature on weekly demands, it appears that, in the short run, beef demand is responsive to own prices (quantities) and to some degree other meat prices (quantities) and income. It also seems that weekly changes in beef demand experience some form of time dynamic response that lasts between eight and fourteen weeks for changes in own price (quantity), changes in competing meat prices (quantities) and income have either instantaneous or very short time period impacts on beef demand. Also, dummy variables for paydays and seasonality are, at best, only weakly significant.

It was unclear as to whether weekly demand should be price or quantity dependant. Most of the literature dealing with wholesale demands (Marsh, Marsh and Brester) suggest that wholesale demand should be specified as price dependant. However, Marsh and Brester encountered sign problems with the contemporaneous period own quantity variable in the lag structure of their reduced form pricing model. This raises a question as to whether the parameter estimated was representative of supply or demand forces. It is possible that boxed beef price and quantity are simultaneously determined.

The lead-lag relationship between the markets is not clearly established.

There have been mixed results that show anything from all levels of the market adjusting simultaneously, to the farm level leading the other levels, to the wholesale leading the other levels. However, the bulk of the literature (Boyd and Brorsen, Schroeder and Hayenga, and Franzmann and Walker) suggest that there is Granger causality from the wholesale level of the market to other levels. This would suggest that an inverse demand equation estimated at the wholesale level should be specified as a direct demand. There is still a question as to whether the equation to be estimated should be simultaneous or recursive.

CHAPTER III

DATA AND METHODS

Chapter III will focus on the procedures used to estimate the inverse demand for boxed beef. A supply model will also be introduced to help alleviate simultaneity problems encountered.

Demand Model

Over a longer period of time, say on a monthly, annual or quarterly basis, demand models can and possibly should be specified as quantity dependant. However, demand models on a weekly basis for perishable products are generally specified as price dependant and thus assume quantities to be predetermined. In the case of beef, the product may have already entered the system. In this case, quantities must be moved before spoiling. Therefore, wholesalers and retailers will adjust prices in order to clear the market.

It is recognized that boxed beef is a derived demand. The theoretical specification for boxed beef derived demand is presented in general notation.

[3.1] $$PR=f(QRB,QSUB,M,Y,\mu_1)$$

and

[3.2] $$PBX=g(QBX,W,PR,\mu_2)$$

where PR is the aggregate price of beef at the retail level, QRB is the per capita quantity of beef consumed at the retail level, QSUB is the per capita quantity of substitute meats consumed at the retail level, M is a dummy variable for each month to capture seasonality, Y is per capita disposable income, PBX is the price of boxed beef, QBX is the quantity of boxed beef produced, W is the wage rate for nonagricultural, nonsupervisory labor, and μ_1 and μ_2 are disturbance terms.

A problem arises in estimating equations [3.1] and [3.2] in that no accurate public reports of retail aggregate prices or quantities are available on a weekly basis. This problem plagued Marsh and Brester. Also, equations [3.1] and [3.2] suggest Granger causality from the retail to the wholesale. This has been disputed by Boyd and Brorsen, Schroeder and Hayenga, and Franzmann and Walker. Therefore, the boxed beef demand will be estimated directly.

The theory of consumer behavior tells us that Marshallian (ordinary) demand functions can be specified with quantity as a function of own price, price of substitutes, price of complements, and income. From these ordinary demands, inverse demands can be obtained through duality theory. The inverse demand can then be specified with price as a function of own quantities, quantities of substitutes, quantities of complements, and income (Henderson and Quandt).

Theory would suggest that all possible substitutes and complements should be used when estimating a demand equation. In the case of beef, this would include such items as fruits, vegetables, other meats, and a variety of other items. Practical modelling limitations prevent inclusion of all possible substitutes and complements in the demand equation. Past literature found that many meats are not significant substitutes. This would suggest that other goods would also be insignificant substitutes. It is then reasonable to assume that meat is weakly separable from all other products. The assumption of weak separability is derived from the theory of two stage budgeting (Deaton and Muellbauer). Two stage budgeting states that consumers first allocate a portion of their budget to food and then allocate a portion of the food budget to meat. From the meat allocation of funds, consumers make a buying decision among just the competing meats. The rational of two stage budgeting is even more plausible in the wholesale to retail market. Retailers set aside a certain percentage of shelf space for meat products. Thus, their buying decisions on meat products are based primarily on the preselected amount of shelf and storage space.

Under the assumption of weak separability, the inverse demand for boxed beef is given as:

[3.3]
$$PBX=f(QBX, QOB, PORK, POULT, ADISP, M, H, TREND, \mu)$$

where

PBX = Boxed beef cutout values for choice 2-3, 550-700 lb. carcasses deflated to 1982 dollars

QBX = Per capita quantity of boxed beef consumed per week

QOB = Per capita quantity of other beef consumed per week

PORK = Per capita quantity of pork consumed per week

POULT = Per capita quantity of chicken and turkey consumed per week

ADISP = Per capita income per week deflated to 1982 dollars

M = Monthly dummy variables to take into account seasonality of meat demand

H = Holiday dummy variables to take into account the effects of Christmas, Thanksgiving, Fourth of July, Memorial Day, and Labor Day

TREND = Trend variable to take into account the downward movement of price over the time period examined

μ = Error term.

A data problem arises again for equation [3.3]. There is no publicly reported data on the quantity of boxed beef produced or consumed. Since boxed beef is primarily composed of fed beef and the primary source of fed beef is steer and heifer beef, the per capita quantity of steer and heifer beef (SHB) slaughtered each week is used as a proxy for QBX. QOB is then proxied by the per capita quantity of cow and bull beef (CBB) slaughtered each week. Equation [3.3] can then be rewritten as:

[3.4] $$PBX = f(SHB, CBB, PORK, POULT, ADISP, M, H, TREND, \mu)$$

Supply Model

The question of whether boxed beef supply and demand are determined simultaneously within a one week time period is relevant to this study. Marsh and Brester assumed that supplies were predetermined in the very short run of one week. The own quantity variable estimate for the contemporaneous week in Marsh and Brester's model, however, displayed a positive sign. This would suggest that the coefficient estimated was actually a supply coefficient. A positive sign for the contemporaneous weeks steer and heifer beef variable was also encountered in this research during preliminary estimations made. This led to the belief that simultaneity exists.

To test the hypothesis of simultaneity, the Hausman test as modified by Spencer and Berk was employed (see Spencer and Berk). In this research only one variable, the contemporaneous quantity, was tested for simultaneity. In this case, taking a model specified as:

[3.5] $$Y_{1,i}=X_i\beta+Y_{2,i}\alpha+\mu$$

where $Y_{1,i}$ is a T x 1 vector of observations on the known endogenous variable, X_i is a T x K matrix of observations on variables known to be exogenous, and $Y_{2,i}$ is a T x 1 vector of observations on the variable that may be simultaneously determined. The test can be performed by respecifying equation [3.5] as :

[3.6] $$Y_{1,i}=X_i\beta+(Y_{2,i}-\hat{Y}_{2,i})\alpha_1+\mu$$

where $\hat{Y}_{2,i}$ is the 2SLS estimator of $Y_{1,i}$. If α_1 is statistically significant, then simultaneity is indicated.

The Hausman test yielded a t-statistic of 8.4005 (statistically significant at the 5 percent level) on α_2 for the demand model estimated here. With the hypothesis of no simultaneity rejected, it follows that a supply model should be included in a system with the demand model. Also, results of the demand model indicated that the sign problem with the contemporaneous week of slaughter on the steer and heifer beef disappeared when estimated with 2SLS.

Producers will supply that level of output where marginal cost equals the output price (Henderson and Quandt). In the very short run, say one day, the decision by cattle feeders could be said to be based only on two criteria, price and availability. As long as the price is greater than or equal to the producers' marginal cost of producing the output and the producers operate in a perfectly competitive market, they will sell as much of their product as they can to maximize their profits (minimize their losses) subject to the available inventories they may hold.

In a slightly longer time period, say one week, producers may consider more factors than just the prevailing price and inventories. They may also look at expected prices one month (week) or more into the future. If they expect the price to rise faster than their costs of holding the animals, they will hold it for increased profits. If they expect the price to decline, they will try to sell the animals sooner in order to maximize profits.

It is hypothesized that the quantity of boxed beef supplied (SHB) is a function of the difference between expected price and current price of boxed beef, number of cattle on feed that are in salable condition, and seasonal and holiday shifts. The supply equation can be specified as:

[3.7] $$SHB_t=\alpha+\beta_1 SHB_{t-1}+\beta_2 PDIF_t+\beta_3 PLAC_t+\beta_4 M_t+\beta_5 T+\mu_t$$

where

SHB = Per capita quantity of steer and heifer beef produced

PDIF = Nearby futures price * (1.63) - current price of boxed beef

PLAC = number of head of cattle placed on feed 20 and 21 weeks before slaughter

M = Monthly dummy variables to capture seasonality

T = Trend variable

μ = error term

Nearby futures price was multiplied by a factor of 1.63 due to the fact that, on average, the boxed beef price was 63 percent higher than the slaughter cattle price over the time period.

Since there is no real public reporting of how many cattle are currently in salable condition at the feedlots, a proxy had to be used. In this case, it is the variable PLAC. PLAC was developed from the monthly seven-state cattle on feed report of placements. The monthly reported number of placements was assumed to be total placements for the month. The number was divided by the number of weeks in the month to make a middle of the month average. Linear interpolation was then used in order to obtain weekly placements.

After weekly placements were estimated, various lagged placements were tested to find the highest degree of correlation with current slaughter. It was determined that adding placements lagged twenty weeks with placements lagged twenty-one weeks has the highest degree of correlation. Adding these lagged placements together gives the variable PLAC.

Almon Polynomial Distributed Lag

With perfect information and unlimited resources, economic agents would have the ability to instantaneously adjust to changes in the market. In reality, the effects of an economic shock may not be fully felt in the time period the shock occurred. The shock may cause a series of adjustments over a longer time period. There are a number of reasons that the length of adjustment may vary. These reasons fall into three broad categories: psychological (the buyer believes the change is temporary), technical (the buyer is unable to adjust to current technologies), or institutional (the buyer is unaware of the changes as they take place) (Nerlove).

It would be unreasonable to believe that boxed beef price would reach full adjustment in one week in response to a supply or demand change. Often the necessary data needed to determine that a shift in the market has occurred does not reach buyers until after the shift has taken place. Also storage at the wholesale and retail levels buffers shifts in the market. Finally, quantities of slaughter are highly variable on a weekly basis making fundamental shifts in the market hard to detect in the short-run (Marsh, Marsh and Brester).

To analyze the dynamics of the boxed beef market, the Almon Polynomial Distributed Lag model was chosen over other models, such as the Koyk or Adaptive Expectations models, due to the fact that it does not restrict lagged adjustments to be strongest in the first (contemporaneous) period and then geometrically decline. That is, lagged coefficients follow different patterns depending on the degree of the polynomial chosen. The Almon lag also does not restrict the endpoints of the coefficients to equal zero unless the researcher deems it necessary and then the restriction is testable.

In a simple one variable model, an m^{th} order polynomial with a lag-length of n can be specified as:

[3.8]

$$Y_t=\alpha+\sum_{i=0}^{n}\beta_i X_{t-i}+\mu_t$$

where

$$\beta_i=a_0+a_1 i+a_2 i^2+\ldots+a_m i^m$$

Equation [3.8] can be rewritten as:

[3.9]

$$Y_t=\alpha+\sum_{i=0}^{n}(a_0+a_1 i+a_2 i^2+\ldots+a_m i^m)X_{t-i}+\mu_t$$

Defining Z_i's as:

$$Z_0 = \sum_{i=0}^{n} X_{t-i}$$

$$Z_1 = \sum_{i=0}^{n} iX_{t-i}$$

$$Z_2 = \sum_{i=0}^{n} i^2 X_{t-i}$$

.

.

.

$$Z_n = \sum_{i=0}^{n} i^m X_{t-i}$$

A polynomial lag model can be specified as a function of the constructed Z_i variables rather than the observed X variables:

[3.10]

$$Y_t = \alpha_t + \sum_{i=0}^{m} a_i Z_i + \mu_t$$

Equation [3.10] can be estimated using OLS. Estimates of α_t and a_i obtained through this method will have all of the desirable statistical properties provided that the expected value of the disturbance terms equals zero, the disturbance terms have a common variance and are uncorrelated with each other, and the disturbances are uncorrelated with explanatory variables.

Once the a's are estimated from equation [3.10], the original ß's can be constructed as follows:

$$\beta_0=a_0$$

$$\beta_1=a_0+a_1+a_2+\ldots+a_m$$

$$\beta_2=a_0+2a_1+4a_2+\ldots+2^m a_m$$

$$\vdots$$

$$\beta_n=a_0+na_1+n^2a_2+\ldots+n^m a_m$$

It must be remembered that the n number of lags must be greater than the m[th] degree polynomial. Also, the degree of the polynomial will be at least one greater than the number of possible turning points on the curve relating β_i to i.

Application of the Almon lag procedure to the demand model considered here is as follows. It is hypothesized that all variables with the exception of the dummy variables will generate some type of lagged response. With this in mind, the estimated model can be specified as:

[3.11]

$$PBX_t=\alpha+\sum_{i=0}^{n}\beta_{1,i}SHB_{t-i}+\sum_{i=0}^{n}\beta_{2,i}CBB_{t-i}+$$
$$\sum_{i=0}^{n}\beta_{3,i}PORK_{t-i}+\sum_{i=0}^{n}\beta_{4,1}POULT_{t-i}+\sum_{i=0}^{n}\beta_{5,1}ADISP_{t-i}+$$
$$\sum_{j=2}^{12}\beta_{6,j}M_j+\sum_{k=1}^{4}\beta_{7,k}H_k+\beta_8 TREND+\mu_t$$

The demand equation [3.11] will be estimated along with the supply equation [3.7] through two stage least squares. The Almon Polynomial distributed lag can be estimated directly through SHAZAM (White et. al.).

Determining Lag Length and Degree of Polynomial

One of the biggest problems facing researchers using the Almon Polynomial is that either the lag length or the degree of the polynomial should be set a priori. In reality, neither is usually known. In most cases, ad hoc methods are used to determine the lag length and the polynomial degree (Azzam and Yanagida). Alternatively, Pagano and Hartley propose a test for determining both the lag length and the degree of the polynomial. Both an ad hoc (iterative) method and the Pagano and Hartley method will be used and compared in this research.

Iterative In the iterative method, variables are evaluated individually at different degrees in combination with different lag lengths through sequential testing (Judge et. al.). It is assumed for the iterative method that neither of the beef variables (SHB and CBB) will assume a polynomial of order higher than a fourth degree. A fourth degree polynomial was selected for SHB and CBB because it was believed to be sufficiently flexible to capture any possible dynamics pattern over time (Almon). It is also assumed that none of the remaining variables can assume a polynomial of an order higher than a cubic (third degree polynomial). The model is first estimated with the longest lag believed possible. The model is then continually reestimated with one less lag until the last lagged variable is statistically significant based on the t-statistic. This is done for each degree of the polynomial believed possible.

Marsh and Brester indicated that it took the boxed beef market 13.5 weeks to reach full adjustment to changes in beef quantity. From this, the maximum lag believed possible for SHB and CBB is assumed to be 16 weeks. It has been suggested in the literature (Marsh and Brester, and Marsh) that other variables have no lagged affects. To test this suggestion, lags of up to 10 weeks will be examined in this research. Each variable will be estimated independently from the other variables to determine lag length and degree of the polynomial. The final model will be based on the t-statistics, the R^2, and whether the coefficients are consistent with a priori expectations (Judge et. al).

Pagano and Hartley. The second method used to determine the lag length and the degree of the polynomial will be the Pagano and Hartley (PH) two step method (see Pagano and Hartley). Since steer and heifer beef (SHB) and cow and bull beef (CBB) were the only two variables to demonstrate a distributed lag in the sequential testing, the PH method was applied only to those two variables.

The first step of the PH method is to determine the lag length. This involves the orthogonal reparameterization of the equation in question. In the most general form, take the general polynomial found in equation [3.8] and add a matrix of all other contemporaneous explanatory variables in the equation (G).

We now have equation [3.11] in matrix form.

[3.12]

$$Y_l = G_l \delta_l + X_l \beta_l + \mu_l$$

where G is a (V x K) matrix of contemporaneous explanatory variables, X is a (V x (l + 1)) matrix of lagged explanatory variables (V is the number of observations used for estimation, K is the number of contemporaneous variables other than the lagged variable in question and l is the unknown lag length). ß and δ are the (K x 1) and (l x 1) vectors of coefficients to be estimated, respectively.

By augmenting X_l and G_l into W_l and augmenting β_l and δ_l into ψ_l and replacing the unknown lag l with the longest lag believed possible L, equation [3.12] is transformed into equation [3.13].

[3.13]

$$Y_L = W_L \psi_L + \mu_L$$

where W_L and ψ_L are respectively ((V - L) x (K + L + 1)) and ((K + L) x 1) augmented matrix and vector.

W_L can be decomposed into a orthonormal matrix, Q_L, and an upper triangular matrix, R_L, through the use of the Gramm-Schmidt decomposition. Equation [3.13] then becomes:

[3.14]

$$Y_L = Q_L a_L + \mu_L$$

where $a_L = R_L \psi_L$. Since Q_L is orthonormal, the least squares estimate of a_L is $\hat{a}_L = Q_L' Y_L$ To recover ψ_L, calculate $\psi_L = R_L^{-1} \hat{a}_L$.

To estimate the lag length, Mallow's Cp statistic is used where

$$Cp_{t-j}=1/s^2(RSS_{t-j})-(V-L)+(K+L+1-j)$$

and where RSS_{t-j} is the regression sum of squares and s^2 is the sum of squared errors such that

$$RSS_{t-j}=Y'Y-\sum_{i=1}^{k}a_L-\sum_{i=1}^{l}a_L$$

$$s^2=RSS/(V-K)$$

The lag length should be the lagged value corresponding to the minimum of the Cp statistic and should be evaluated for a series of L's.

The second stage of the PH method is the procedure for selecting the degree of the polynomial. It is similar to the first stage. After the length of the lag (L^*), we rewrite equation [3.11] to make equation [3.15]:

[3.15]
$$Y_{L^*}=Z_{L^*}\delta_{L^*}+X_{L^*}H_{L^*}\alpha_{L^*}+\mu_{L^*}$$

where

$$H=\begin{bmatrix} 1 & 0 & 0 & \dots & 0 \\ 1 & 1 & 1 & \dots & 1 \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ 1 & L^* & L^{*2} & \dots & L^{*L^*} \end{bmatrix}$$

By orthogonal reparameterization of equation [3.15] we arrive at the same hypothesis as equation [3.13] regarding the polynomial degree.

If autocorrelation is present, the PH method can be modified through the Gallant and Goebel method (Azzam and Yanagida). The Gallant and Goebel method involves two steps. The first is to construct a Γ matrix from the estimates of the autocovariances up to the lag r of the autoregressive process:

[3.16]

$$\mu_t + \sum_{j=1}^{r} \rho \mu_{t-j} = v_t$$

The second step is to find a matrix, U, such that U'U = Γ^{-1}. The matrix U is used to transform the original observations. The transformed observations are then used in the PH method. The optimal lag length and degree of the polynomial lag model will be determined before two-stage least squares is applied. The PH method will be performed in SAS 6.06 using the IML (Interactive Matrix Language) program.

Autocorrelation

One of the assumptions of linear regression is that the error terms or residuals are mutually independent (Judge et. al.). The use of time series data may result in high correlation between the residuals. If this occurs, there is autocorrelation.

Detection of autocorrelation can be accomplished through the use of the Durbin-Watson statistic if there are no lagged dependant variables. The Durbin-

Watson statistic can be specified as:

$$d=\frac{\sum_{t=2}^{n}(\mu_t-\mu_{t-1})^2}{\sum_{t=1}^{n}\mu_t^2}$$

where μ_t is the residual resulting from the regression in period t. The range that d may fall into lies between 0 and 4: $d < 2$ implies positive autocorrelation; $d > 2$ implies negative autocorrelation; and $d = 2$ implies zero autocorrelation. The SHAZAM program provides the Durbin Watson Statistic. Durbin-Watson tables were used to accept or reject the hypothesis of zero autocorrelation (Judge et. al.).

If the equation contains a lagged dependant variable, Durbin's h statistic can be used to detect autocorrelation. Durbin's h statistic is given as:

$$h=\left(1-\frac{d}{2}\right)\sqrt{\frac{n}{1-(n*v)}}$$

where d is the Durbin-Watson statistic and V is the square of the standard error of the coefficient of the lagged dependant variable. In large samples, h is distributed as a standard normal and the hypothesis of zero autocorrelation can be determined in this way. The Durbin's h statistic is also provided by SHAZAM.

Data

The data consists of 583 observations from the first week of January, 1980, through the first week of March, 1991, and come from a variety of sources. The number of federally inspected heifers, steers, cows and bulls slaughtered on a weekly basis and their corresponding average dressed weights (ADWH, ADWS, ADWC, and ADWB respectfully) for the same period were supplied by the Western Livestock Marketing Information Project (WLMIP). The WLMIP also provided boxed beef cutout values (Choice 2-3, 550-700 lb. carcasses) for the same period. The pounds of federally inspected pork produced were supplied by the WLMIP for the same period. Numbers for young chicken and turkey slaughter and their average live weights for the weeks of January 2, 1985 through June 15, 1991 were also provided by the WLMIP.

Chicken and turkey slaughter numbers and the average live weights for the weeks January 2, 1980 through January 2, 1985 were collected from the Poultry Market News (U.S. Department of Agriculture).

Two per capita disposable incomes were provided by the WLMIP on a monthly basis. The two incomes were the observed values and a set of deflated values that were adjusted to constant 1982 dollars. It was assumed that incomes were beginning of the month values. Each month's observation was divided by its corresponding number of weeks to obtain an average weekly income for the month in question. This average was assumed to be the weekly income for the midpoint of the month. Linear interpolation between the estimated average weekly incomes for each month was used to obtain a complete set of weekly incomes.

In order to deflate boxed beef prices consistent with the way income was deflated, it was necessary to calculate the income deflator. The income deflator was calculated by dividing the deflated disposable income series by the observed disposable income. A deflated value for boxed beef was then calculated by multiplying the observed values for boxed beef by the derived deflator series.

Futures prices for slaughter cattle was obtained from a data base maintained at Oklahoma State University, which in turn is obtained from a data collection company called Technical Tools. Monthly cattle on feed (COF) estimates were obtained from various issues of USDA Cattle on Feed Reports (U.S. Department of Agriculture). Cattle on feed variables had to be linearly interpolated to obtain weekly observations.

Population numbers were collected on a monthly basis from the U.S. Census Bureau's Annual Summary (U.S. Census Bureau). It was assumed that these numbers were end of the month observations. They were converted to weekly estimates through the same linear interpolation process described for income.

A summary of the conversions from the raw data conducted to obtain the meat quantity variables are found in Table I.

TABLE I

TABLE OF DATA CONVERSIONS

SHB = ((STEER * ADWS) + (HEIF * ADWH)) / POP

CBB = ((COW * ADWC) + (BULL * ADWB)) / POP

PORK = PRK / POP

POULT = ((CHICK * ALWC) + (TURK * ALWT)) / POP

Variables used in Table I are defined as follows:

SHB - Per capita pounds of steer and heifer beef slaughtered per week

STEER - The number of steers slaughtered per week

ADWS - Average dressed weight of steers slaughtered per week

HEIF - The number of heifers slaughtered per week

ADWH - Average dressed weight of heifers slaughtered per week

CBB - Per capita pounds of cow and bull beef slaughtered per week

COW - The number of cows slaughtered per week

ADWC - Average dressed weight of cows slaughtered per week

BULL - The number of bulls slaughtered per week

ADWB - Average dressed weight of bulls slaughtered per week

PORK - Per capita pounds of pork slaughtered per week

PRK - Total pounds of pork slaughtered per week

POULT - Per capita pounds of chicken and turkey slaughtered per week

CHICK - The number of chickens slaughtered per week

ALWC - Average live weight of chickens slaughtered per week

TURK - The number of turkeys slaughtered per week

ALWT - Average live weight of turkeys slaughtered per week

POP - Population of the United States.

Chapter Summary

Chapter III presented the methods and the data used in the empirical estimation of the supply and inverse demand equations for boxed beef. The supply and inverse demand equations were estimated using two-stage least squares and weekly data from 1980 to 1991. Due to data limitations, boxed beef quantities had to be replaced by steer and heifer beef slaughter. Weekly income, population, and cattle on feed data were derived through linear interpolation of monthly data.

The demand equations utilized the Almon Polynomial Distributed Lag in order to capture time dynamic adjustments. A limitation of the Almon Lag is that the lag length and the polynomial degree must both be discovered by the researcher. This was accomplished through both iterative methods and a more formal Pagano and Hartley procedure.

CHAPTER IV

EMPIRICAL RESULTS

This chapter presents empirical estimates and results for the supply and demand models estimated under both the iterative method and the Pagano and Hartley method. The chapter will be organized around the two methods of determining the models.

Iterative Method

Table II presents the results of the iterative estimation of the polynomial lag for the demand equation. Through the iterative procedure, a lag length of ten weeks was determined to be optimal for the steer and heifer beef (SHB) with a fourth order polynomial. The fourth order polynomial was chosen given the adjusted R^2 was maximized at 0.9799. Table II and figure 1 both show that a change in slaughter has the largest effect in the contemporaneous week. The effect then geometrically declines over the next eight weeks. The effect then falls off sharply over the remaining two weeks.

All coefficients except for the lag of ten weeks for SHB were statistically significant at the 5 percent level and all had the expected negative sign. The coefficients for SHB indicate that if slaughter of steer and heifer beef should

TABLE II

COEFFICIENT ESTIMATES FOR PER CAPITA INVERSE DEMAND
FOR BOXED BEEF, 1980-1991
ITERATIVE METHOD

Variables	$\beta_{v,i}$	t-Stat	Variables	$\beta_{v,i}$	t-Stat	Variables	$\beta_{v,i}$	t-Stat
Constant	201.020	6.146*	CBB_{t-3}	-4.961	-1.638**	MAR	0.007	0.009
SHB_t	-6.193	-3.398*	CBB_{t-4}	-7.991	-2.727*	APR	-0.452	-0.502
SHB_{t-1}	-5.543	-6.603*	CBB_{t-5}	-11.087	-4.065*	MAY	0.802	0.802
SHB_{t-2}	-4.985	-5.221*	CBB_{t-6}	-13.840	-5.298*	JUN	0.635	0.571
SHB_{t-3}	-4.601	-4.828*	CBB_{t-7}	-15.843	-5.852*	JUL	0.536	0.474
SHB_{t-4}	-4.413	-4.810*	CBB_{t-8}	-16.687	-5.704*	AUG	0.836	0.727
SHB_{t-5}	-4.374	-4.678*	CBB_{t-9}	-15.964	-5.234*	SEP	1.772	1.581**
SHB_{t-6}	-4.380	-4.645*	CBB_{t-10}	-13.267	-4.587*	OCT	2.015	1.864*
SHB_{t-7}	-4.258	-4.576*	CBB_{t-11}	-8.187	-3.337*	NOV	1.263	1.213
SHB_{t-8}	-3.775	-4.034*	CBB_{t-12}	-0.317	-0.128	DEC	1.574	1.856*
SHB_{t-9}	-2.632	-3.021*	PORK	-1.307	-1.084	XMAS	-0.423	-0.683
SHB_{t-10}	-0.469	-0.564	POULT	0.490	0.793	THANK	0.810	2.028*
CBB_t	-0.344	-0.084	ADISP	0.078	0.590	JUL4	-0.306	-0.658
CBB_{t-1}	-0.730	-0.243	TREND	-0.733	-4.774*	MEM	0.595	1.103
CBB_{t-2}	-2.405	-0.815	FEB	-0.432	-0.776	LAB	-0.566	-1.110
						AR(1)	0.940	64.786*
R^2	0.980							
Adjusted R^2	0.979							
Durbin-Watson	1.599							

* - Statistically significant at the 5 percent level
** - Statistically significant at the 10 percent level

increase (decrease) by 0.2 pounds per capita per week (or about one serving per person) for a long period of time (at least ten weeks), ceterus paribus, the price of boxed beef would decrease (increase) by $1.24/cwt. in the first week of slaughter. The total change to boxed beef price from a sustained ten week change of 0.2 pounds per capita slaughter will be a decline of $9.12/cwt.

As can be seen in figure 1, the change in boxed beef price due to a change in quantity of steer and heifer beef slaughter is relatively small in the first week but cummulates to a large impact over ten weeks. This is probably due to a number of reasons. Psychologically, buyers for retail chains are quite knowledgeable about the beef industry. They know that it takes a fairly long time to get an animal to slaughter. Therefore they expect the supply of slaughter animals to remain relatively constant in the very short run and generally believe any one week change in slaughter to be temporary. Institutionally, buyers for the retail chains likely have very timely information, are forward looking, and are planning for changes. They use tools such as forward contracting and inventory management to try to hold prices at a level that is acceptable. Technically, retailers have a certain amount of storage. Due to the limited shelf life of beef products, they must first reduce storage before being able to take advantage of high volumes or they may be able to try to wait out short periods of low volumes.

A lag of twelve weeks with a third-order polynomial was determined to be optimal for cow and bull beef (CBB). Again, a third-order polynomial was

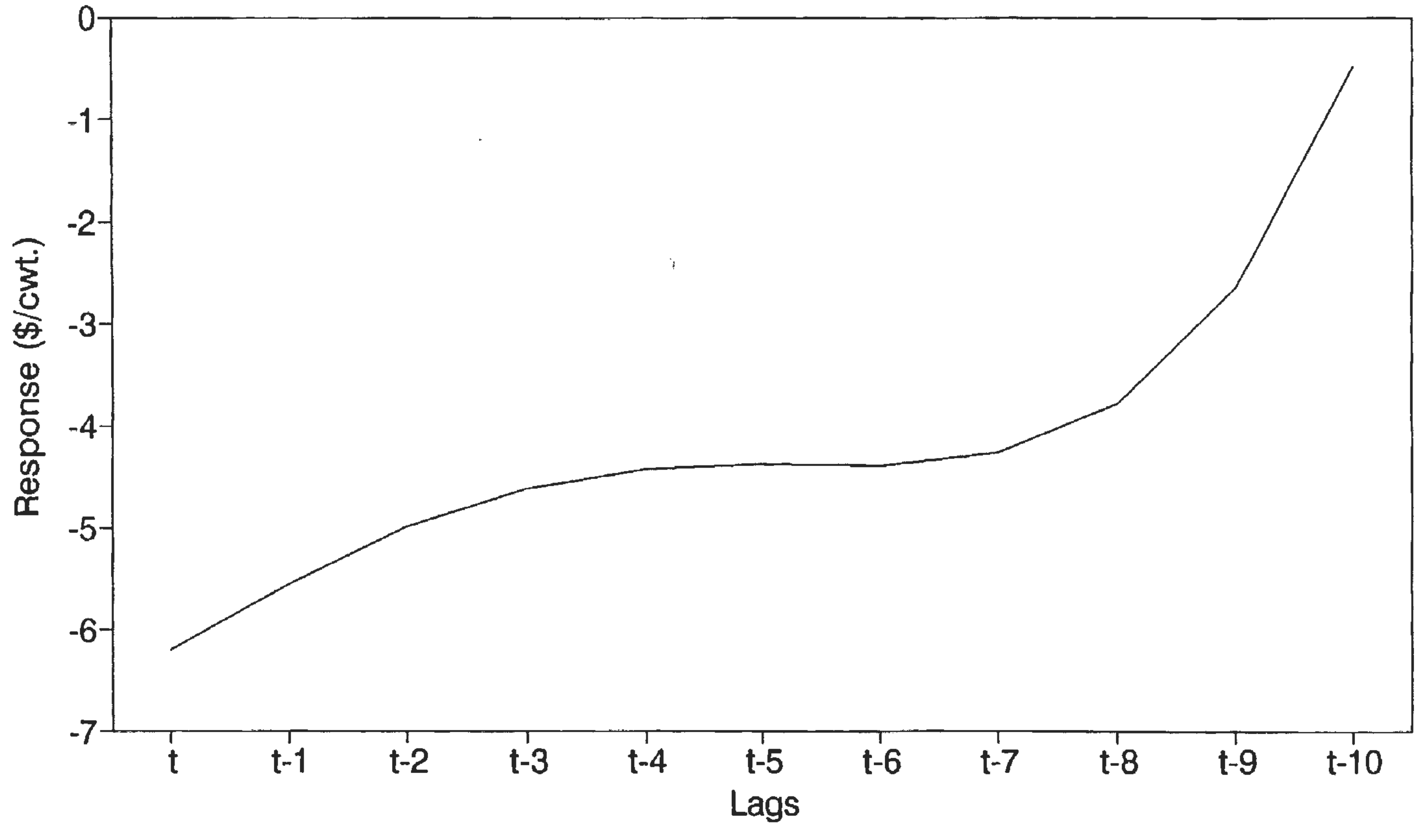

Figure 1. Dynamic Response of Boxed Beef Price to a Change in Steer and Heifer Slaughter from the Iterative Method

chosen because it generated the maximum adjusted R^2 of 0.9812. The pattern of the lagged responses is shown in figure 2. All coefficients for CBB had the expected negative sign and CBB_{t-4} through CBB_{t-11} were statistically significant at the five percent level. The coefficients for CBB indicate that cow and bull beef is a substitute for SHB to the retailer. A constant ceterus paribus increase (decrease) of cow and bull beef slaughter of 0.2 pounds per capita per week will initially decrease (increase) the price of boxed beef by $0.07/cwt. The effects then increases to a maximum effect of a decline in price of $3.34/cwt. eight weeks after the first change in slaughter. The total effect to the price of boxed beef from a sustained 0.2 pound per capita change would be a decrease (increase) of $22.32/cwt. Although this seems unreasonably large in comparison to SHB effects, when the coefficients are converted to flexibilities, the effects then are much more reasonable i.e. average CBB consumption is only twenty-two percent of average SHB consumption, hence a 0.2 pound change in CBB is a much larger percentage than it is for SHB.

Figure 2 presents the shape of the lag structure for CBB. It takes a longer period of time for boxed beef price to adjust to a change in the quantity of cow and bull beef slaughter than to steer and heifer beef slaughter. This is probably due to the same reasons that the lag structure on the steer and heifer beef exists. In addition, the retail buyers are aware that cow and bull beef is primarily a source of frozen beef and spends more time going through cold storage channels. Therefore, a change in slaughter in one

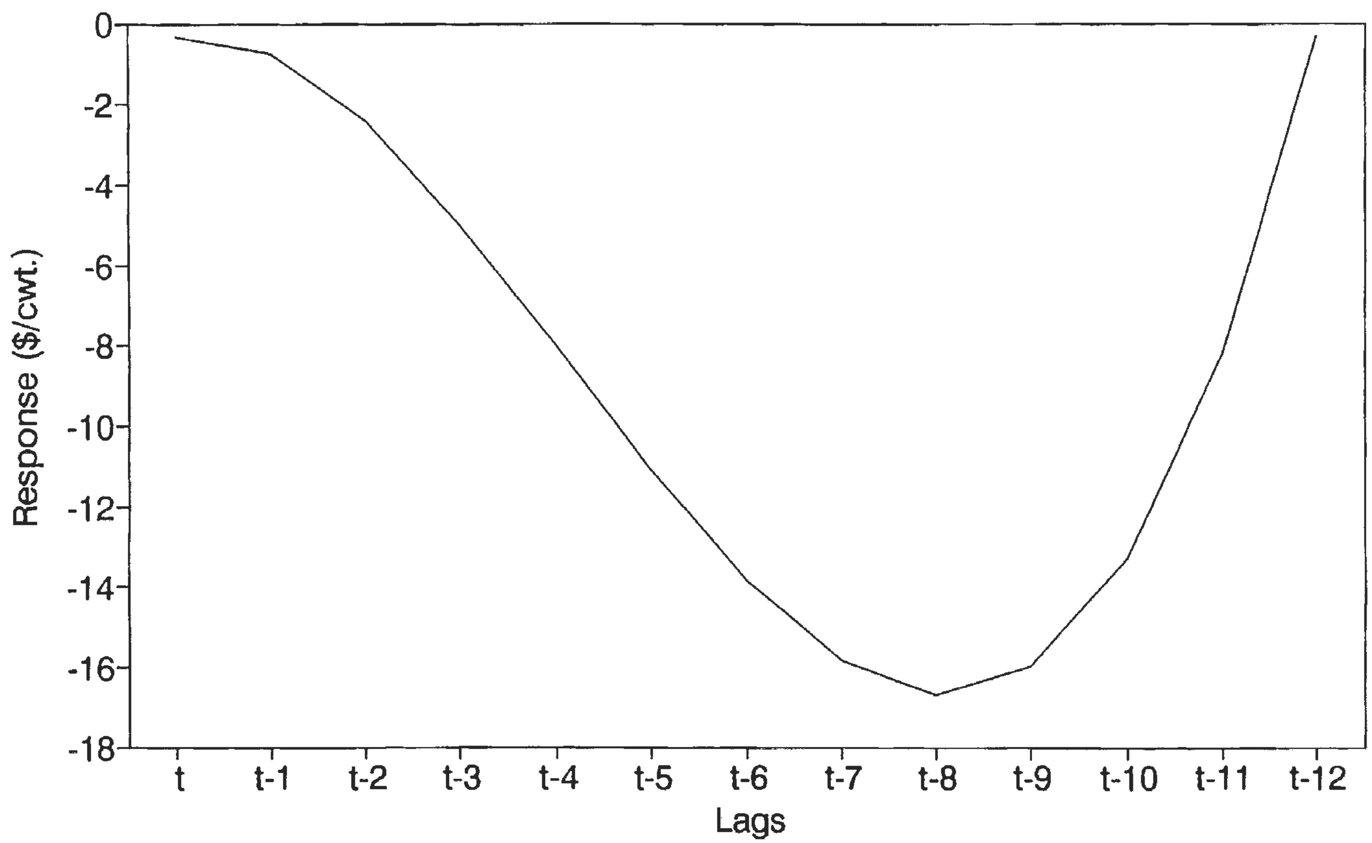

Figure 2. Dynamic Response of Boxed Beef Price to a Change in Cow and Bull Beef Slaughter from the Iterative Method

week is believed to be temporary. The time it takes for CBB to reach its maximum effect is probably both psychological and technical. Psychologically, the meat that comes from CBB is not believed to be a good substitute for boxed beef to final consumers, thus retailers do not want to change the mix of meats on the shelf. Technically, the retailers would wait until stored meat was used before substituting between cow and bull meat and boxed beef in their coolers.

None of the remaining variables (quantities of pork and poultry and disposable income) were found to have a distributed lag structure. The sign on the pork (PORK) coefficient is negative as expected. This suggests that pork is a substitute for beef. However, the PORK coefficient is not statistically significant at the ten percent level. This suggests that there is no relationship between beef and pork in the very short run. The PORK parameter was kept for expository purposes.

The coefficients for the poultry (POULT) variable had an opposite sign from that expected. It was expected that poultry would be a substitute, but it shows a complimentary relationship. Marsh and Brester had a similar problem with pork showing a complementary relationship with beef. They explained that it was due to the desire for variety in diet. Since neither this study nor their study found this complimentary relationship for either poultry or pork to be statistically significant, this unexpected sign is not a problem. The POULT variable was kept for expository purposes.

Real disposable income (ADISP) has the expected positive sign. The coefficient indicates that a one dollar increase (decrease) in real weekly per capita disposable income will cause the price of boxed beef to increase (decrease) by $0.08/cwt, ceterus paribus. However, the coefficient is not statistically significantly different from zero. The parameter was kept for expository purposes.

The trend variable indicates that the real price of boxed beef has been trending downward over the time period specified, ceterus paribus. This is most likely due to improved technologies in producing boxed beef thus making it more affordable. It may also be due to changing demand for beef over the time period. The 1980's produced a great deal of concern for cholesterol and the health effects of eating red meats in the media. This may have caused consumers and thus retailers to reduce their demand for beef. The trend variable is statistically significant at the five percent level.

Of the monthly dummy variables, only September, October, and December were statistically significant at the ten percent level. The signs on these variables were positive. This could be due to reduced quantities found in the supply equation. Retailers have a fixed space available for meat products that they would like to keep filled. They must then pay higher prices during these months in order to keep their coolers filled to a level that is acceptable. There is a lack of seasonality in the remaining monthly dummy variables. This is most likely due to the strong autocorrelation found in the model. Since prices are strongly related to the prices in the period before, price response is fairly slow in the short run. Thus, the seasonality that is evident in the long run is less evident in the short run.

The holiday dummy variables (XMAS, THANK, JUL4, MEM, and LAB) indicated that only Thanksgiving (THANK) was statistically significant at the 5 percent level. A priori expectations were that Christmas (XMAS) and Thanksgiving (THANK) would be negative due to the decreased demand for beef in these seasons while July Fourth (JUL4), Memorial Day (MEM) and Labor Day (LAB) would be positive due to increased barbecue and beef consumption customary to those holidays. The results indicate that the signs were opposite of the expected for XMAS, THANK, JUL4, and LAB. This may possibly be due to incorrect selection of weeks for these holidays. It is not clear what week these holidays impact the market since meat sales to the final consumer may not take place until one to two weeks after slaughter. The dummy variables were matched with the actual holiday weeks.

AR(1) indicates the parameter estimate for autocorrelation. In this case, the autocorrelation is significant. The t-statistic for AR(1) was also the largest and was significant at the 1 percent level proving to have a great deal of effect. A test for second order autocorrelation (t-statistic for an AR(2)) was insignificant. The Durbin-Watson statistic presented in table II is estimated after the correction for autocorrelation and is in the inconclusive range. The autocorrelation coefficient was estimated from the Cochrane Orcutt two step iterative method found in SHAZAM. Autocorrelation in a distributed lag model is indicative of institutional or technological rigidities (Nerlove).

The adjusted R^2 of the model is 0.979. This indicates that 97.9 percent of the variance of the dependant variable is explained by the independent variables with a first order autoregressive process. This is similar to the R^2 found by Marsh and Brester.

Table III presents the coefficient estimates of the supply equation estimated through two-stage least squares. The lagged dependant variable has the strongest statistical significance. Both the price difference variable and lagged placement variable are statistically significant at the ten percent and five percent level respectively. Of the monthly dummy variables, FEB, MAR, APR, NOV, and DEC were statistically significant at the five percent level. XMAS, JUL4, MEM, and LAB were statistically significant at the five percent level.

The lagged dependant variable suggests that if the quantity of slaughter is increasing (decreasing), it will continue to rise (fall) the following week, ceterus paribus. The difference between the nearby futures price and the current price of boxed beef (PDIF) has the expected negative sign. This suggests that if beef price is expected to decline (increase) by $1 in the near future, then the quantity slaughtered will increase (decrease) by .00024 pounds per capita per week, ceterus paribus. The lagged placement (PLAC) coefficient has the expected positive sign. If the showlist should increase (decrease) by one head, the quantity slaughtered would increase (decrease) by 0.00008 pounds per capita,

TABLE III

COEFFICIENT ESTIMATES FOR SUPPLY EQUATION
FROM ITERATIVE METHOD, 1980-1991

Variables	$\beta_{v,i}$	t-Stat
Constant	0.62271	12.079*
SHBt-1	0.56712	16.306*
PDIF	-0.00024	-1.691**
PLAC	0.00008	2.978*
T	0.0000036	0.223
FEB	-0.07810	-5.522*
MAR	-0.07398	-5.768*
APR	-0.04402	-3.324*
MAY	0.01216	0.801
JUN	-0.00878	-0.611
JUL	0.00898	0.631
AUG	0.00790	0.558
SEP	0.00806	0.555
OCT	-0.00680	-0.467
NOV	-0.09129	-5.717*
DEC	-0.02890	-2.066*
XMAS	-0.33513	-12.746
THANK	0.03305	1.171
JUL4	-0.17329	-6.592*
MEM	-0.11274	-4.349*
LAB	-0.06510	-2.535*
AR(1)	-0.31121	-6.461*
R^2	0.544	
Adjusted R^2	0.527	
Durbin-Watson	2.04	

* - Statistically significant at the 5 percent level.
** - Statistically significant at the 10 percent level.

ceterus paribus.

The seasonal dummy variables suggest that slaughter decreases in the months of February, March, April, June, October, November, and December relative to January slaughter. The months of May, July, August, and September show an increase in slaughter relative to January, but none are significant. This holds with a priori expectations. Decreased slaughter may be due to the lower temperatures and the expectations of lower demand by the industry. This may also explain the lack of seasonal response in the boxed beef demand equation. That is changes in seasonal demand maybe being compensated for by changes in supply that keep prices stable.

The holiday dummy variable coefficients show a decrease in all holiday weeks except Thanksgiving. This may be explained by the short weeks that slaughter plants would have during these weeks. Although Thanksgiving shows an increase, it is not statistically significant.

Pagano and Hartley Method

Table IV presents the results of the Pagano and Hartley test for lag length for steer and heifer beef (SHB) in the demand model. Maximum lag lengths of sixteen to eight weeks were used for testing the proper lag length. As indicated in table IV, Mallow's Cp statistic was minimized at a lag of ten weeks or, in the case of a maximum lag of nine weeks, a lag of nine weeks. This would suggest that a lag of ten weeks is appropriate for the steer and heifer beef variable.

TABLE IV

MALLOW'S Cp STATISTIC FROM PAGANO AND HARTLEY TEST FOR LAG LENGTH ON STEER AND HEIFER BEEF

Variables	L16	L15	L14	L13	L12	L11	L10	L9	L8
SHB_{t-1}	1258	1244	1326	1296	1530	1502	1754	1357	1256
SHB_{t-2}	984	972	1041	1016	1213	1189	1401	1066	981
SHB_{t-3}	446	438	482	465	590	575	710	496	442
SHB_{t-4}	402	394	436	420	539	524	652	449	397
SHB_{t-5}	300	293	329	316	420	407	520	341	295
SHB_{t-6}	151	145	174	163	247	236	328	182	145
SHB_{t-7}	124	118	146	135	216	206	293	154	118
SHB_{t-8}	45	40	64	55	125	115	191	70	39*
SHB_{t-9}	18	13	36	26	92	84	155	41*	
SHB_{t-10}	-69*	-73*	-55*	-62*	-8*	-16*	43*		
SHB_{t-11}	-16	-20	1	-8	53	45			
SHB_{t-12}	-21	-25	-5	-13	47				
SHB_{t-13}	40	35	58	49					
SHB_{t-14}	33	28	51						
SHB_{t-15}	58	53							
SHB_{t-16}	55								

* - Indicates the minimum of Mallow's Cp statistic for each column

This is the same result as the iterative process.

Table V presents the results of the test for polynomial degree for SHB. The Cp statistics for this test were derived from the two-stage least squares estimates. The estimates were taken for polynomials of degrees one through nine. Mallow's Cp statistic was minimized at a degree of four. This suggests that steer and heifer beef is best characterized by a fourth order polynomial. This is the same as the polynomial used to estimate the model in the iterative method of testing the degree and lag length.

Table VI presents results of the PH test for lag length on cow and bull beef (CBB). Maximum lags of sixteen down to ten weeks were used to test for correct distributed lag length. Mallow's Cp statistic is at a minimum at thirteen weeks for all maximum lags except twelve in which twelve is the minimum Cp. This indicates that a lag of thirteen weeks is appropriate for CBB. This is one week longer than accepted for the iterative method.

Table VII presents results of the test for degree of the polynomial to apply to the lagged CBB variables. Results of the test show that Mallow's Cp statistic is minimized at a fourth degree (cubic) polynomial. This suggests that a fourth order polynomial is the appropriate polynomial to apply to the CBB variables. This is the same degree as that chosen in the iterative method.

Table VIII presents the results of the two stage least squares demand estimates for the demand equation suggested by the PH method of determining lag length and polynomial degree. The SHB variable has a fourth order

TABLE V

MALLOW'S Cp STATISTIC TEST FOR DEGREE OF POLYNOMIAL FOR STEER AND HEIFER BEEF

	1	2	3	4	5	6	7	8	9
Cp	34.462	34.740	35.880	31.475*	33.612	33.271	34.686	35.997	36

* - Indicates the minimum of Mallow's Cp statistic.

TABLE VI

MALLOW'S Cp STATISTIC FROM PAGANO AND HARTLEY TEST FOR LAG LENGTH ON COW AND BULL BEEF

Variables	L16	L15	L14	L13	L12	L11
CBB_{t-1}	989	938	976	983	919	833
CBB_{t-2}	1000	949	987	993	929	843
CBB_{t-3}	443	409	432	435	394	338
CBB_{t-4}	380	349	370	372	334	282
CBB_{t-5}	229	202	219	221	188	145
CBB_{t-6}	220	194	210	212	180	137
CBB_{t-7}	185	161	176	178	147	106
CBB_{t-8}	142	119	133	134	105	67
CBB_{t-9}	128	106	119	120	92	55
CBB_{t-10}	115	93	106	107	79	43
CBB_{t-11}	103	82	95	96	69	33*
CBB_{t-12}	71	50	62	63	37*	
CBB_{t-13}	49*	29*	41*	41*		
CBB_{t-14}	54	34	45			
CBB_{t-15}	69	49				
CBB_{t-16}	53					

* - Indicates the minimum of Mallow's Cp statistic for each column.

TABLE VII

MALLOW'S Cp STATISTIC TEST FOR DEGREE
OF POLYNOMIAL FOR COW AND BULL BEEF

	1	2	3	4	5	6	7	8	9	10	11	12
Cp	25.47	4.52	2.35	1.14*	12.99	7.71	26.14	26.94	26.39	34.89	35.73	42

* - Indicates the minimum of Mallow's Cp statistic

TABLE VIII

COEFFICIENT ESTIMATES FOR PER CAPITA INVERSE DEMAND
FOR BOXED BEEF, 1980-1991
PAGANO AND HARTLEY METHOD

Variables	$\beta_{v,i}$	t-Stat	Variables	$\beta_{v,i}$	t-Stat	Variables	$\beta_{v,i}$	t-Stat
Constant	203.130	6.223*	CBB_{t-4}	-9.664	-3.228*	APR	-0.123	-0.133
SHB_t	-6.310	-3.370*	CBB_{t-5}	-11.869	-4.082*	MAY	1.131	1.118
SHB_{t-1}	-5.728	-6.636*	CBB_{t-6}	-13.503	-4.406*	JUN	0.866	0.772
SHB_{t-2}	-5.069	-5.079*	CBB_{t-7}	-14.409	-4.567*	JUL	0.731	0.640
SHB_{t-3}	-4.541	-4.616*	CBB_{t-8}	-14.444	-4.736*	AUG	1.043	0.897
SHB_{t-4}	-4.253	-4.576*	CBB_{t-9}	-13.482	-4.658*	SEP	2.049	1.796*
SHB_{t-5}	-4.212	-4.415*	CBB_{t-10}	-11.411	-3.904*	OCT	2.527	2.296*
SHB_{t-6}	-4.324	-4.381*	CBB_{t-11}	-8.134	-2.672*	NOV	1.828	1.697*
SHB_{t-7}	-4.392	-4.442*	CBB_{t-12}	-3.569	-1.270	DEC	1.891	2.162*
SHB_{t-8}	-4.119	-4.214*	CBB_{t-13}	2.350	0.926	XMAS	-0.474	-0.758
SHB_{t-9}	-3.106	-3.530*	PORK	-1.430	-1.166	THANK	0.831	2.060*
SHB_{t-10}	-0.851	-1.026	POULT	0.333	0.541	JUL4	-0.214	-0.458
CBB_t	1.181	0.269	ADISP	0.075	0.565	MEM	0.525	0.961
CBB_{t-1}	-1.428	-0.424	TREND	-0.072	-4.745*	LAB	-0.512	-0.993
CBB_{t-2}	-4.249	-1.184	FEB	-0.254	-0.457	AR(1)	0.937	62.731*
CBB_{t-3}	-7.062	-2.100*	MAR	0.019	0.025			
R^2	0.979							
Adjusted R^2	0.978							
Durbin-Watson	1.660							

* - Statistically significant at the 5 percent level.
** - Statistically significant at the 10 percent level.

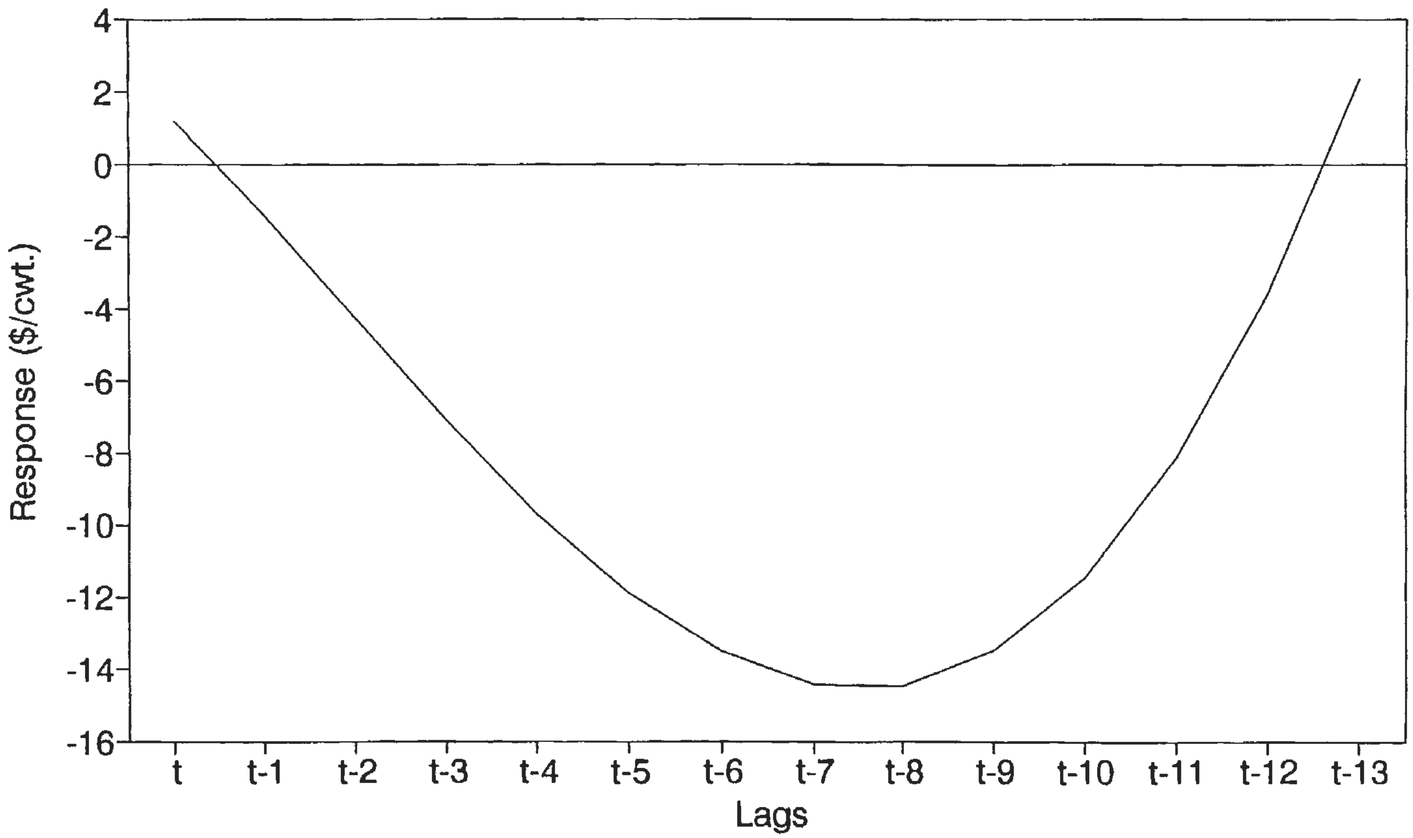

Figure 4. Dynamic Response of Boxed Beef Price to a Change in Cow and Bull Beef Slaughter from the Pagano and Hartley Method

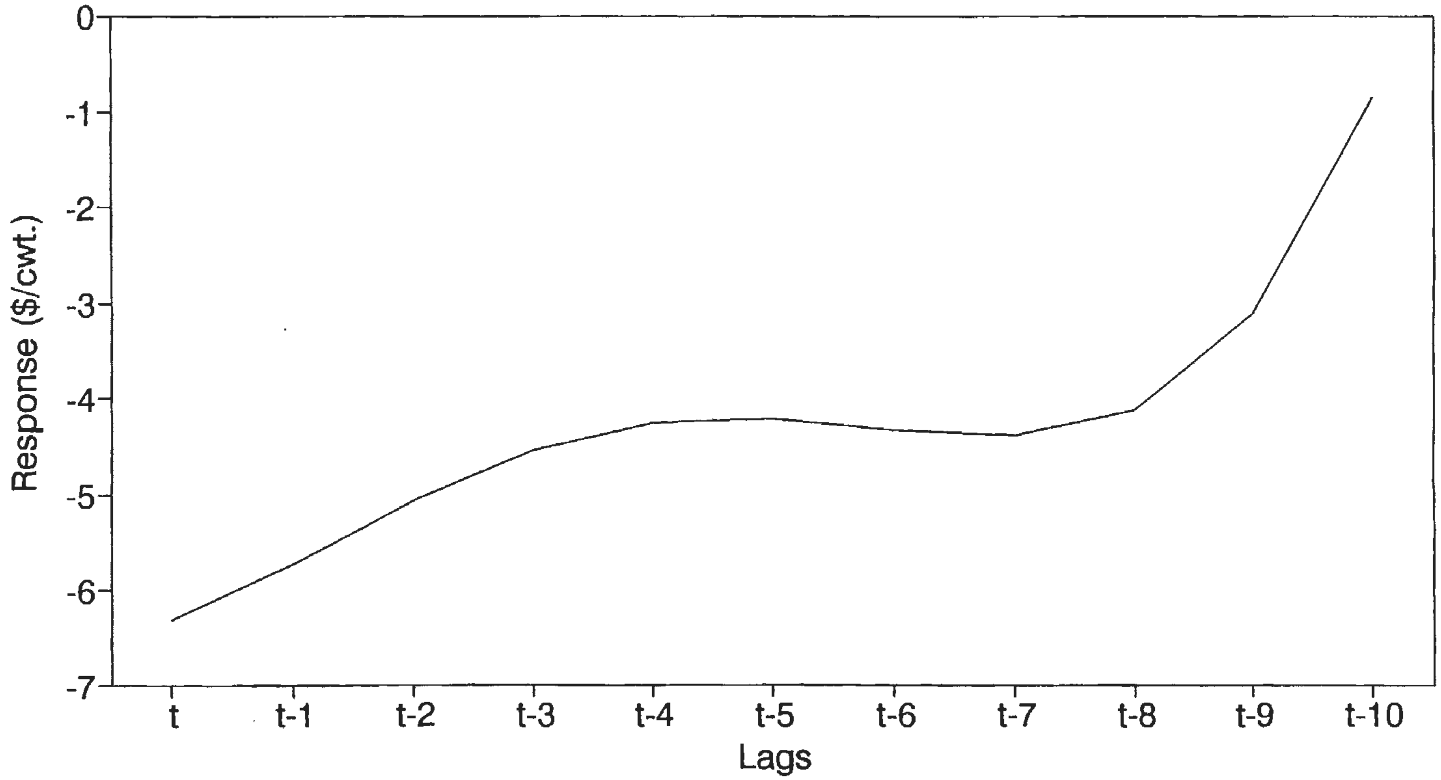

Figure 3. Dynamic Response of Boxed Beef Price to a Change in Steer and Heifer Beef Slaughter from the Pagano and Hartley method

polynomial with ten lags (figure 3). The CBB variable has a fourth order polynomial with thirteen lags (figure 4). There is not a great deal of difference between the estimates obtained from utilizing the Pagano and Hartley method as opposed to the iterative method.

All of the coefficients for SHB have the expected negative signs. SHB_t through SHB_{t-9} are statistically significant at the five percent level. If steer and heifer slaughter should increase (decrease) by 0.2 pounds per capita per week for a long period of time (a minimum of ten weeks), there would be an initial contemporaneous week affect of a decrease (increase) in boxed beef price of $1.26/cwt, ceterus paribus. This would also be the week with the maximum effect (same as the iterative method). The total affect from a sustained ceterus paribus increase (decrease) in steer and heifer slaughter of 0.2 pounds per capita per week would be a decrease (increase) in boxed beef price of $9.38 (compared to $9.12 found in the iterative method).

CBB_t and CBB_{t-13} displayed opposite signs of those expected. However, they were not statistically significantly different from zero, so this is not a problem. The rest of the cow and bull beef slaughter (CBB) coefficients displayed the expected signs and CBB_{t-3} through CBB_{t-11} were statistically significant at the five percent level. If cow and bull beef slaughter should increase (decrease) by 0.2 pounds per capita per week for a long period of time (a minimum of thirteen weeks), there would be an initial contemporaneous week increase (decrease) in boxed beef price of $0.24/cwt, ceterus paribus.

The maximum change would take place eight weeks later with a decrease (increase) in boxed beef price of $2.89/cwt, ceterus paribus. The total effect from a sustained 0.2 pound per capita per week ceterus paribus change in cow and bull beef slaughter would be a decrease (increase) in boxed beef price of $21.94/cwt (compared to $22.32/cwt found in the iterative method).

The sign on the pork variable (PORK) has the expected negative sign. This suggests that pork is a substitute for beef for the retailers. However, the pork variable was not statistically significant at the ten percent level. This suggests that there is no real relationship between pork and beef in the very short run. The pork variable was kept for expository purposes.

The sign on the poultry variable (POULT) did not have the expected sign. The sign suggests a complimentary relationship between poultry and beef. POULT was not statistically significant at the twenty percent level. This suggests that retailers do not consider poultry products to be related to beef products in the very short run. The poultry variable was also kept for expository purposes.

Disposable income (ADISP) displayed the expected sign, but was not statistically significant. The coefficient on ADISP suggests that a one dollar increase (decrease) in real disposable income would cause the price of boxed beef to increase (decrease) by $0.08/cwt, ceterus paribus. ADISP was kept for expository purposes.

Of the monthly dummy variables, February and April were negative relative to the January intercept. The remaining variables displayed a positive sign. Of the monthly dummy variables, September, October, November, and December were statistically significant at the five percent level. It was expected that these months would display a negative sign. This may be due to seasonality encountered in the supply equation. The lack of seasonality is most likely due to strong autocorrelation found in the demand model. Since the prices are strongly related to the prices one period before, the seasonality is smoothed over in week to week boxed beef pricing. Thus the seasonality evident in the long run is not as evident in the short run.

Thanksgiving and Memorial day were the only two positive holiday dummy variables. A priori expectations were that Christmas and Thanksgiving would be negative due to the shift in demand customary to these times of year from beef to more traditional holiday meals such as turkey and ham. A priori expectations for the remaining holidays were for positive coefficients due to barbecue demand. The lack of any strong significance also supports the idea that holidays are not a factor in boxed beef pricing, with the exception of Thanksgiving. Again, sign problems may be due to incorrect selection of weeks for the holidays.

AR(1) indicates the parameter estimate for autocorrelation. In this case, autocorrelation was severe. The t-statistic for AR(1) was also the largest and was significant at the one percent level proving to have a great deal of effect. The Durbin-Watson Statistic presented in the table is estimated after the first order autocorrelation estimate has been performed. The D-W statistic is in the inconclusive range. A test for second order autocorrelation (t-statistic for an AR(2)) proved to be insignificant and was subsequently rejected. The autocorrelation coefficient was estimated from the Cochrane Orcutt two step iterative method found in SHAZAM. Autocorrelation in a distributed lag model is indicative of institutional or technological rigidities (Nerlove).

Table IX presents results for the supply equation estimated through two-stage least squares along with the demand model determined to be optimal through the Pagano and Hartley procedure. Due to the lack of any real change between the iterative and the PH procedure, there is very little difference between the two supply models. In all cases, change in the parameter value is less than one percent.

TABLE IX

COEFFICIENT ESTIMATES FOR SUPPLY EQUATION FROM THE PAGANO AND HARTLEY METHOD, 1980-1991

Variables	$\beta_{v,i}$	t-Stat
Constant	0.62266	12.084*
SHB_{t-1}	0.56719	16.315*
PDIF	-0.00024	-1.705**
PLAC	0.00008	2.977*
TREND	0.0000035	0.221*
FEB	-0.07815	-5.528*
MAR	-0.07398	-5.770*
APR	-0.04404	-3.326*
MAY	0.01213	0.799
JUN	-0.00880	-0.613
JUL	0.00894	0.629
AUG	0.00787	0.556
SEP	0.00803	0.553
OCT	-0.00683	-0.469
NOV	-0.09131	-5.719*
DEC	-0.02890	-2.068*
XMAS	-0.33514	-12.747
THANK	0.03300	1.170
JUL4	-0.17324	-6.590*
MEM	-0.11273	-4.348*
LAB	-0.06510	-2.535*
AR(1)	-0.31143	-6.468*
R^2	0.544	
Adjusted R^2	0.527	
Durbin-Watson	2.04	

* - Statistically significant at the 5 percent level.

** - Statistically significant at the 10 percent level.

Comparison of the Two Models

In order to compare the two models, the price of boxed beef was predicted using the forecast command in SHAZAM. The prices were estimated both within sample and out of sample. In order to estimate out of sample, the models where reestimated with fifty-two fewer observations (first week in March, 1990, through the first week in March,1991) and these fifty-two weeks were then predicted from the reestimated model. Root mean squared error was used as an accuracy evaluation criterion. Table X presents the results of this comparison.

Both within sample and out of sample root mean squared errors were smaller for the model using the Pagano and Hartley procedure. This would suggest that the Pagano and Hartley model is superior to the iterative model. However, the difference was very small, so no real comparison should be made. The results of the predictions are presented graphically in figures 5 through 8. The figures suggest in all cases, there is still a problem in accurately capturing the turning points of boxed beef price. This is not surprising given the strong autocorrelation present. Since the price this period is highly dependant on the price last period, the model will consistently fail to predict turning points by one time period.

TABLE X

COMPARISON OF THE ROOT MEAN SQUARED ERRORS
FROM THE REESTIMATED MODELS
MARCH, 1990 - MARCH, 1991

	Iterative	Pagano and Hartley
In Sample RMSE	1.2219	1.1988
Out of Sample RMSE	1.4070	1.3899

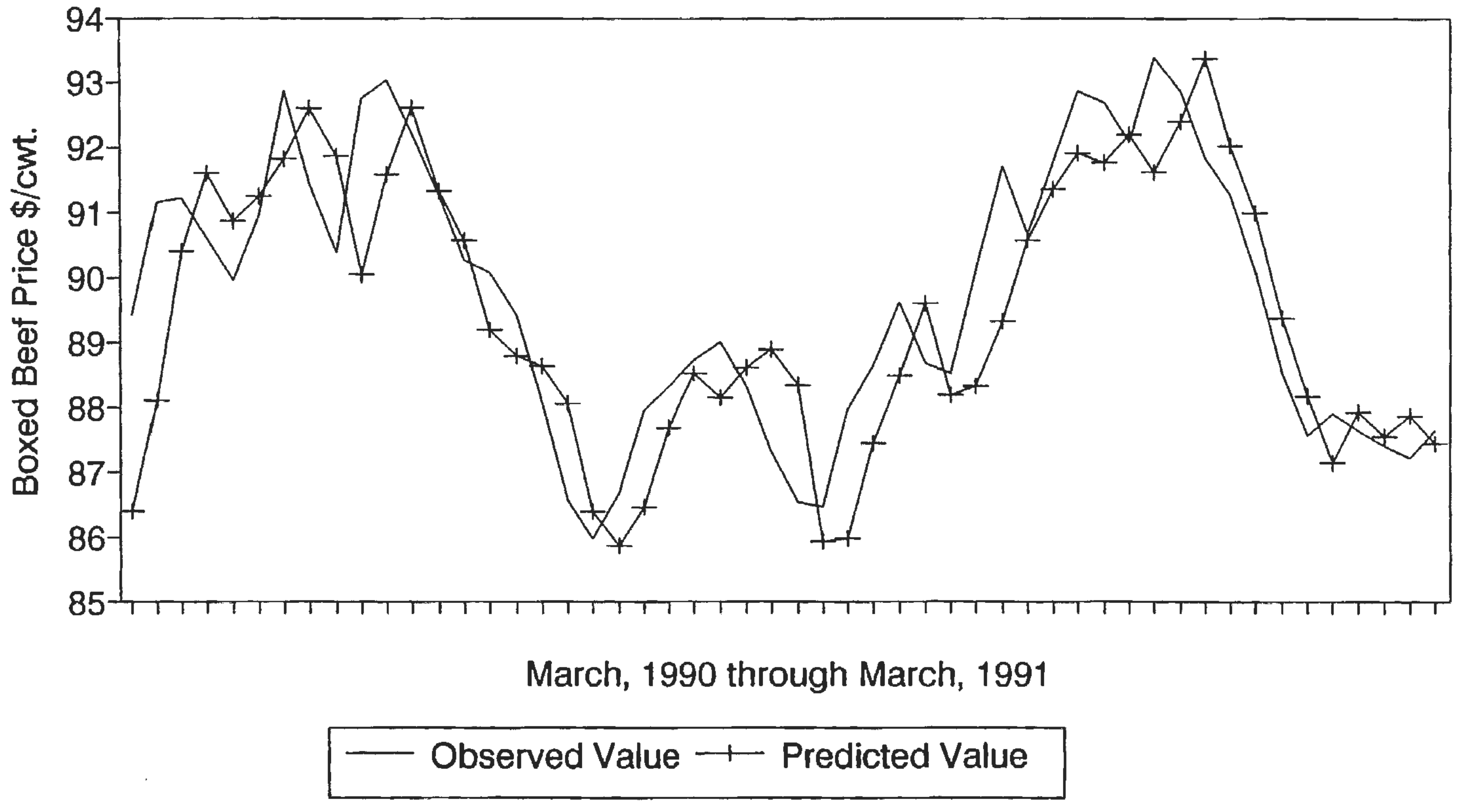

Figure 5. Observed vs. Predicted Boxed Beef Price from th Iterative Method, Within Sample

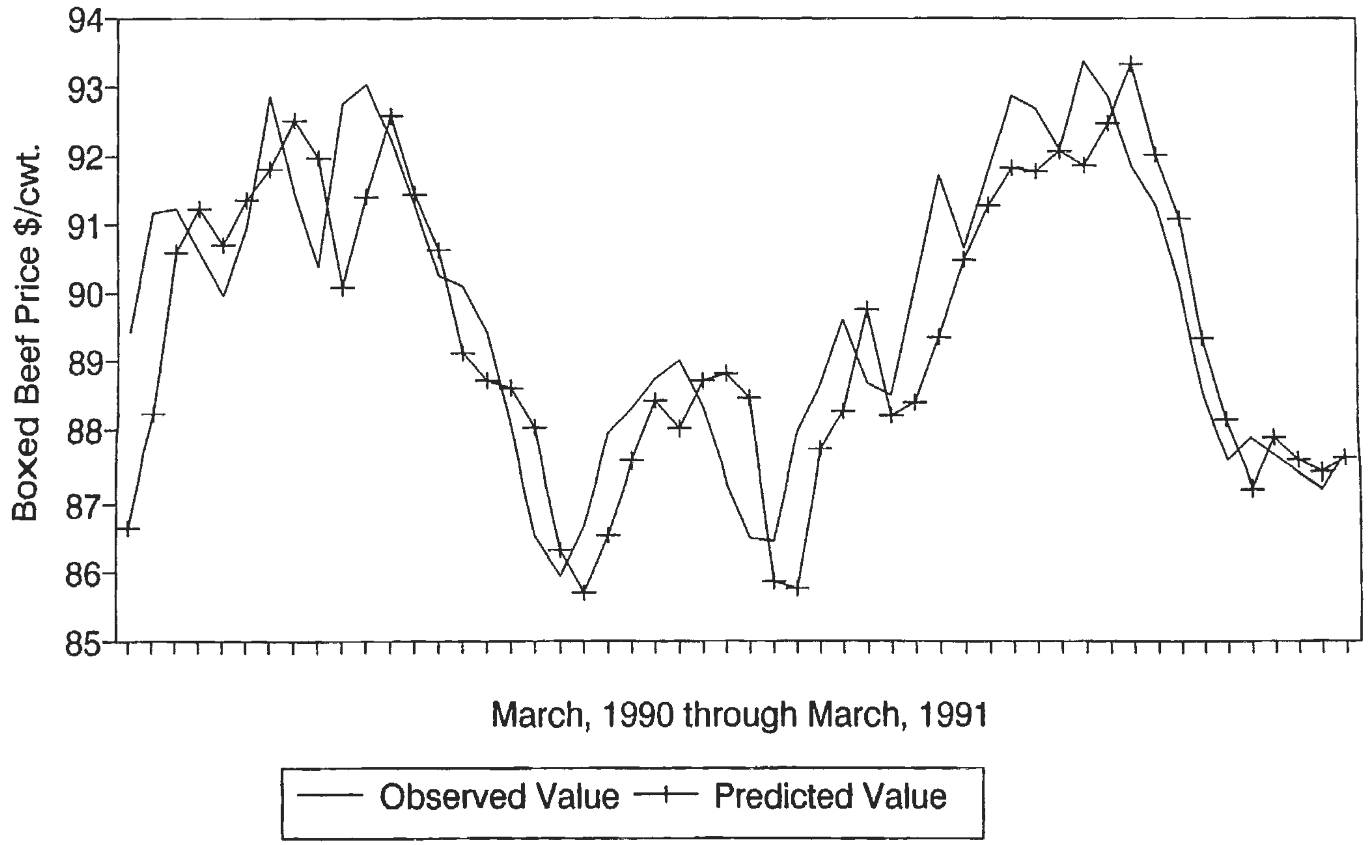

Figure 6. Observed vs. Predicted Boxed Beef Price from the Pagano and Hartley Method, Within Sample

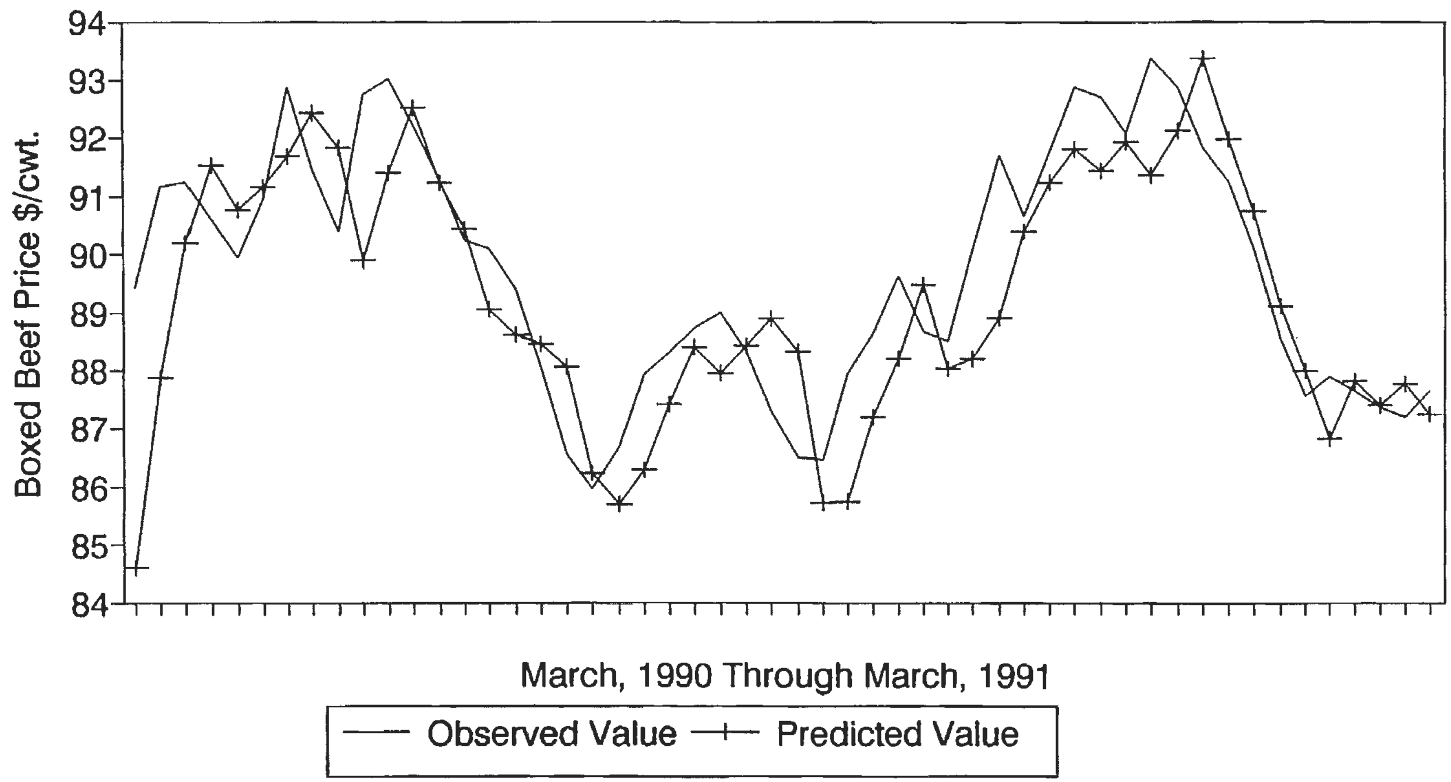

Figure 7. Observed vs. Predicted Boxed Beef Price from th Iterative Method, Out of Sample

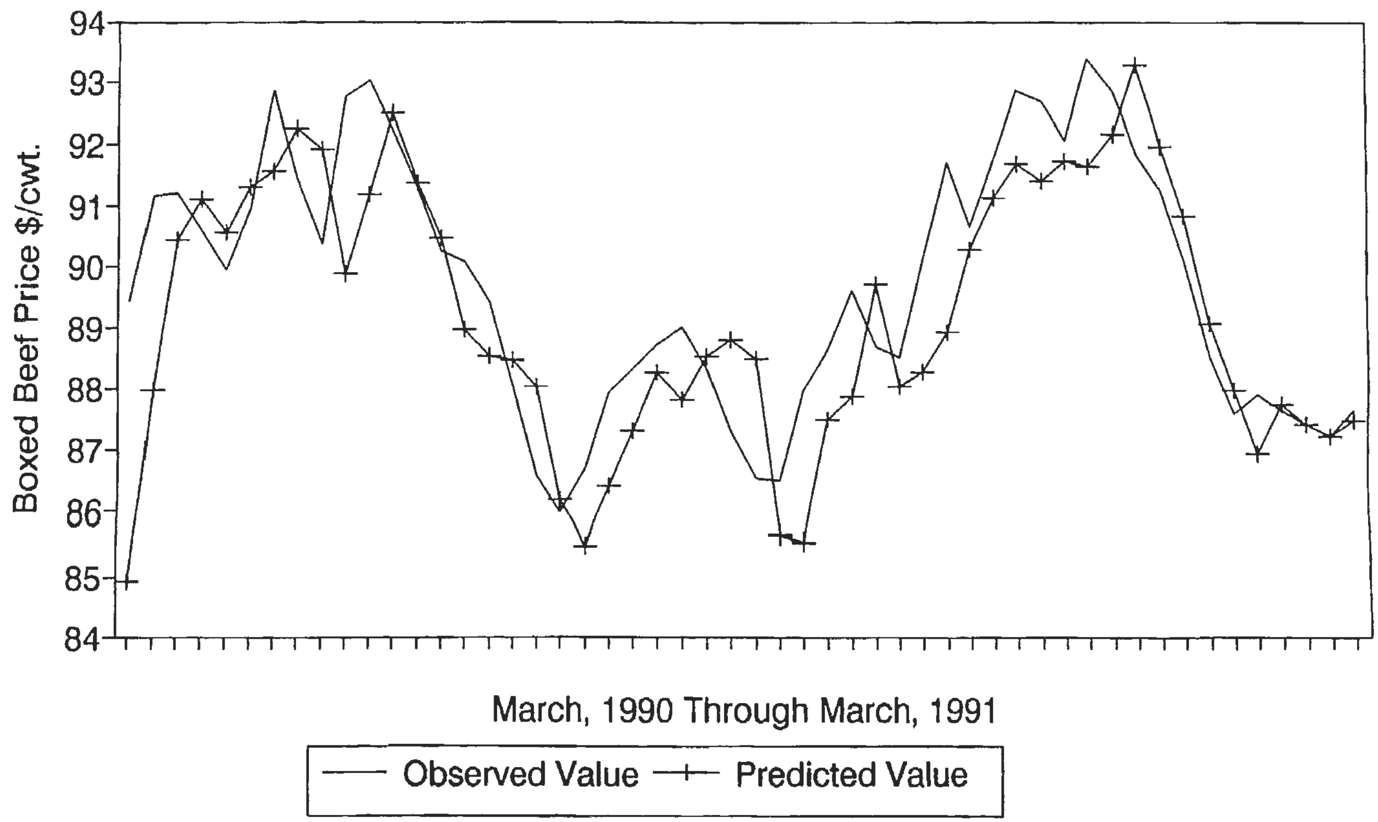

Figure 8. Observed vs. Predicted Boxed Beef Price from the Pagano and Hartley Method, Out of Sample

Chapter Summary

Chapter IV presented the empirical results of the weekly supply and inverse demand functions estimated for boxed beef. Two methods (iterative and Pagano and Hartley) were used to determine the polynomial degree and the lag length for the demand equation. A comparison of the two demand models found that the model estimated under the PH method was slightly better.

The iterative method determined that there should be a lag of ten weeks with a fourth-order polynomial on steer and heifer beef supply and a lag of twelve weeks with a fourth-order polynomial on cow and bull beef supply. No other variables were found to have a distributed lag. The PH method determined that there should be a lag of ten weeks with a fourth-order polynomial for steer and heifer beef and a lag of thirteen weeks with a fourth-order polynomial for cow and bull beef. No other variables were tested using the PH method. The optimal lag length estimated for both beef variables is shorter than the lag of 13.5 weeks suggested by Marsh and Brester for boxed beef. They also follow a slightly different pattern than the geometric decline suggested by Marsh and Brester. Marsh and Brester did not separate the two types of beef. They also assumed that supplies were predetermined.

The supply models estimated in both cases were so similar they were judged as identical. The signs were as expected, but the fit was not as good as hoped for. Autocorrelation was not as severe a problem in the supply models compared to the demand models.

CHAPTER V

SUMMARY AND CONCLUSIONS

Relatively little is known about how the price of boxed beef responds to economic influences on a week to week basis. Since somewhere between fifty-five and ninety percent of all beef that reaches the retailer is boxed, it is very important for the industry to understand what influences boxed beef price response. In addition, economists interested in beef markets need information on boxed beef price movement. The major objective of this study was to determine boxed beef's price response to weekly changes in quantities of boxed beef, other beef, competing meats, income, and seasonal factors. In order to accomplish this objective, a review of past studies on demands for meats was conducted to determine the proper methods to use and to identify relevant variables.

Methods Used

A brief overview of research on monthly, quarterly, and annual demands helped to identify relevant variables and models to be considered. A review of a much smaller body of research that considered weekly demands was also conducted. This portion of the review helped to identify the expected dynamic structure to be considered when using weekly data. Only Marsh and Brester had conducted any type of demand analysis for boxed beef on a weekly basis.

For a weekly model, the literature reviewed indicated it would be unreasonable to assume that prices would reach full adjustment in one time period. Therefore, it was determined that some sort of distributed lag model should be used. From the research reviewed and a priori beliefs about the lag structure of the parameters, it was determined that the Almon Polynomial Distributed Lag model should be used to model the boxed beef demand equation. The Almon lag model was chosen for its flexibility in the shape of the lag structure and because no restriction is required on the endpoints. Two methods of determining the degree of the polynomial and the length of the lag were used and compared. They were the iterative method suggested by Judge et. al. and the Pagano and Hartley Method.

Due to sign problems reported by Marsh and Brester for boxed beef price response to a contemporaneous change in boxed beef supply, simultaneity between boxed beef price and supply was tested. This involved specifying a supply model. Test of whether or not simultaneity existed was done with the Hausman test as modified by Spencer and Berk.

As is the case with many research efforts, this study encountered data limitations. These limitations necessitated the use of proxy variables, the use of linear interpolated data, and the use of a CPI to deflate wholesale prices.

Due to the unavailability of a number of variables, proxies had to be used.

A boxed beef quantity data series was not available, so steer and heifer beef slaughter was used as a proxy for boxed beef. This is under the assumption that boxed beef is primarily made up of steer and heifer beef. Cow and bull beef was used as a proxy for all other beef due to the lack of information on beef other than boxed beef being marketed on a weekly basis. Other proxies included lagged placements as a proxy for cattle in salable condition and pork and poultry slaughter as a proxy for wholesale marketings of pork and poultry.

Due to lack of information on a weekly basis for income, population, and cattle on feed (placements and marketings), these variables had to be linearly interpolated in order to obtain weekly observations. This removed a lot of the week to week variability that would be normal for these variables. This then means that variability of the dependant variable due to variability of these independent variables was not fully captured in the estimation process.

In order to properly compare wholesale prices over time, they should be deflated by a wholesale price index (WPI). However, a WPI was not available. The consumer price index (CPI) was used in place of the WPI. This may cause an upward bias in estimates of the real price.

Results

The iterative method determined that there is a ten week lag with a fourth-order polynomial on steer and heifer beef, and an twelve week lag with a third-order polynomial on cow and bull beef. No other variables were determined to have a distributed lag. The PH method determined that there should be a ten week lag with a fourth-order polynomial on steer and heifer beef, and an thirteen week lag with a third-order polynomial on cow and bull beef. No other variables were tested for a distributed lag. Based on root mean squared errors of estimates, it was determined that estimates from the model determined through the PH method might be superior to the model determined through the iterative method. However, the difference was small.

Both the iterative and Pagano and Hartley models showed similar patterns for steer and heifer beef (SHB) coefficient values. The estimated lag structure for the SHB variable followed an almost geometric decline over time until the final two weeks in which the effects dropped off rather rapidly. Brester and Marsh previously found a definite geometric pattern. The difference in patterns is probably due to the difference in methods between this research and their research. Primary method differences between this study and the Brester and Marsh study were: a) Supply and demand were specified as simultaneous in this study while Marsh and Brester assumed predetermined supplies: b) This study used level data where Marsh and Brester used first differenced data: c) This study utilized Almon's polynomial distributed lag whereas the Marsh and Brester study utilized a rational lag. The general lag pattern found here and by Marsh and Brester is hypothesized to be due to psychological (professional buyers are skeptical that a one week change is permanent), technical (available freezer space), and institutional (buyers are forward looking and plan for shocks to the system) reasons.

The distributed lag pattern for the cow and bull beef (CBB) variables for both the iterative and Pagano and Hartley models also followed very similar patterns. The distributed lag pattern for the CBB variables follows a smooth curve peaking at t-8 weeks. This pattern is most likely due to similar psychological, technical, and institutional reasons cited for the distributed lag found in the SHB variables. The probable reason that the CBB variable does not reach its full effect for eight weeks may be related to the fact that consumers do not fully want to substitute the beef that comes from cow and bull beef for boxed beef. Therefore, retailers are more reluctant to substitute the meats on their shelves. It also may be due to the ability of retailers and consumers to store the lower quality meat from cow and bull beef for a longer period of time with no perceived loss of quality versus storing higher quality steer and heifer meat.

For both models, the seasonal effects that were found for the demand equations were not as expected. This may be due to the desire of retailers to keep a certain amount of shelf space available for boxed beef. There were strong seasonal effects for the supply equations. The seasonality found in the supply may be removing or masking the seasonality normally observed in demand. Additionally, the strong autocorrelation present in the demand model may mask any seasonal pattern.

The pork variables for each model were as expected, but were not statistically significant. Sign problems were experienced with what is traditionally considered a competing meat, poultry. However, the unexpected sign found for poultry was not statistically significant. There was also a strong downward trend in both models. This is probably due to improved technologies and more competition in the boxed beef trade over the time period studied. It is also possible that demand has changed over the time period studied. This changing demand could be due to changing demographics or movement away from beef due to health concerns. However, examining these topics was not the objective of this research.

Overall, the demand models estimated explained nearly all of the variability of the boxed beef price with R^2's greater than 0.97. Due to strong autocorrelation, the models still do not accurately capture turning points. The autocorrelation suggests that prices are very strongly related to prices in the previous period. Therefore, turning points will be missed in the estimation.

The simultaneity between boxed beef demand and supply proved to be significant. Simultaneous versus non-simultaneous specification of the demand model changed the sign of the contemporaneous variable of SHB from positive to negative.

The supply models estimated were not as accurate as the demand models with R^2's less than 0.6. This may be due to the lack of understanding about what effects the supply decisions at this level of the market. It also is due to the lack of good information on certain variables, such as a showlist (cattle in salable condition). Additional research in specifying weekly fed beef supply is warranted. A better understanding of how weekly feedlot marketing decisions are made needs to be developed.

Implications of the Study

This study has a number of implications. One is that the boxed beef market is subject to complex dynamics. Major adjustments to quantities will effect prices for a period of months. The adjustments to prices will last up to a full quarter. This would suggest that research utilizing weekly, monthly, and even quarterly data to examine price movement should consider utilizing some sort of distributed lag models. It would also suggest that retail buyers go through some sort of complex decision making process based on psychological, technical, and institutional capabilities.

Another implication is that week to week changes are complicated by simultaneity between supply and demand. This suggests that the common assumption of predetermined supplies made by economists examining week to week price movements in the meat industry may be invalid and should be reconsidered. Because of this, producers, retailers, and other professionals who examine the beef market must be aware of factors effecting both supply and demand.

Also, although this study did not focus on forecasting, its results indicate that reasonably accurate forecasting of boxed beef price can be done for several weeks into the future given records of past steer, heifer, cow, and bull beef slaughter and reasonable estimates of beef slaughter several weeks into the future. This would support the need for research into the area of forecasting what slaughter would be in the future. While forecasts of future beef slaughter are critical, they make up a only a part of the total influence upon near term prices. Hence it is equally important to know where the market has been as well as where it is going.

Finally, although the Pagano and Hartley method of determining lag length and degree of the polynomial to apply to the Almon polynomial distributed lag is technically more accurate, it did not yield significantly different results from the iterative method. This would then suggest that some form of research should be done to find if it is warranted to utilize Pagano and Hartley's method over the somewhat simpler iterative method. It is suggested that some form of a Monte Carlo style study should be considered to find out if the two methods are truly significantly different.

REFERENCES

Almon, Shirley. "The Distributed Lag Between Capital Appropriations and Expenditures." Econometrica. 33(January 1972):178-196.

Arzac, Enrique R., and Maurice Wilkinson. "A Quarterly Econometric Model of Untied States Livestock and Feed Grain Markets and Some of Its Policy Implications." American Journal of Agricultural Economics. 61(May, 1979):297-308.

Azzam, Azzeddine, and John F. Yanagida. "A Cautionary Note on Polynomial Distributed Lag Formulations of Supply Response." Western Journal of Agricultural Economics. 12(July, 1987):60-64.

Barksdale, Hiram C., Jimmy E. Hilliard, and Mikael C. Ahlund. "A Cross-Spectral Analysis of Beef Prices." American Journal of Agricultural Economics. 57(May, 1975):309-315.

Boyd, Milton S., and B. Wade Brorsen. "Dynamic Relationships of Weekly Prices in the United States Beef and Pork Marketing Channels." Canadian Journal of Agricultural Economics. 33(November, 1985):331-342.

Capps, Jr., Oral, "Utilizing Scanner Data to Estimate Retail Demand Functions for Meat Products," American Journal of Agricultural Economics, 71(August, 1989):750-760.

Capps, Jr., Oral, and Rodolfo M. Nayga, Jr., "Demand for Fresh Beef Products in Supermarkets: A Trial with Scanner Data." Agribusiness: An International Journal. 7(May, 1991):241-251.

Cooperative Extension Service. Western Livestock Information Project. Lakewood, CO. Personal Contact.

Crom, Richard J. Economics of the U.S. Meat Industry. USDA, ERS Agricultural Information Bulletin Number 545.

Deaton, Angus, and John Muellbauer. Economics and Consumer Behavior. Cambridge University Press, 1988.

Duewer, Lawrence A. Changing Trends in the Red Meat Distribution System. USDA, ERS Agricultural Economics Report number 509, Washington D.C.

Fielding, William. "Boxed Beef Share of the Market Increasing." Cargill Bulletin (June, 1983):6-7.

Franzmann, John R., and Rodney L. Walker. "Trend Models of Feeder, Slaughter, and Wholesale Beef Cattle Prices." American Journal of Agricultural Economics. 54(August, 1972):507-512.

Funk, T.F., Karl D. Meilke, and H.B. Huff. "Effects of Retail Pricing and Advertising on Fresh Beef Sales." American Journal of Agricultural Economics. 59(August, 1977):533-537.

Gallant, A. Ronald, and J. Jeffrey Goebel. "Nonlinear Regression with Autocorrelated Errors." Journal of the American Statistical Association. 71(March, 1976):961-967.

Hayenga, Marvin L., and Duane Hacklander. "Monthly Supply-Demand Relationships for Fed Cattle and Hogs." American Journal of Agricultural Economics. 52(February, 1970):535-544.

Henderson, James M., and Richard E. Quandt. Microeconomic Theory A Mathematical Approach. McGraw-Hill Book Company, 1980.

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

Langemeir, Larry, and Russel G. Thompson. "Demand, Supply, and Price Relationships for the Beef Sector, Post World War II Period." American Journal of Agricultural Economics. 49(February, 1967):169-183.

Marion, Bruce W., The Organization of the U.S. Food System. NC 117 Committee. USDA University of Wisconsin-Madison, Lexington Books, D.C. Heath & Co., Lexington, Mass.

Marion, B.W., and F.E. Walker, "Short-Run Predictive Models for Retail Meat Sales," American Journal of Agricultural Economics. 60(November, 1978):667-673.

Marsh, John M.. "A Rational Distributed Lag Model of Quarterly Live Cattle Prices." American Journal of Agricultural Economics. 65(August, 1983):539-547.

Marsh, John M., and Gary W. Brester. "Intertemporal Price Adjustments in the Beef Market: A Reduced Form Analysis of Weekly Data." Western Journal of Agricultural Economics. 14(December, 1989):235-245.

Nerlove, Marc. "Distributed Lags and Demand Analysis for Agricultural and Other Commodities." Agricultural Handbook. United States Department of Agriculture. 141(June, 1958).

Pagano, Marcello, and Michael J. Hartley. "On Fitting Distributed Lag Models Subject to Polynomial Restrictions." Journal of Econometrics. 16(June, 1981):171-198.

Purcell, Joseph C., and Robert Rauniker. "Price Elasticities from Panel Data: Meat, Poultry, and Fish." American Journal of Agricultural Economics. 53(May, 1971):216-221.

SAS Institute Inc., SAS User's Guide: Basics, Version 5 Edition. Cary, N.C.: SAS Institute Inc. 1985.

SAS Institute Inc., SAS/IML User's Guide, Version 5 Edition. Cary, N.C.: SAS Institute Inc. 1985.

Schroeder, Ted C., and Marvin L. Hayenga. "Short-Term Vertical Market Price Interrelationships for Beef and Pork." North Central Journal of Agricultural Economics. 9(July, 1987):171-180.

Spencer, David E., and Kenneth N. Berk. "A Limited Information Specification Test." Econometrica. 49(July, 1981):1079-1085.

Technical Tools. 334 State St., Suite 204. Los Altos, CA. 94022.

Trapp, James N., Clement E. Ward, Stephen R. Koontz, and Derrell Peel. Department of Agricultural Economics, Oklahoma State University, Stillwater Oklahoma. Personal Interviews (1990-1992).

U.S. Census Bureau. Annual Summary. U.S. Government Printing Office, Washington D.C. Various Issues (1980-1992).

U.S. Department of Agriculture. Livestock, Meat and Wool Market News. Agricultural Marketing Service, Kansas City, MO. Various Issues (1980-1991).

U.S. Department of Agriculture. Poultry Market News. Agricultural Marketing Service, Kansas City, MO. Various Issues (1980-1986).

U.S. Department of Agriculture. Cattle On Feed. National Agricultural Statistics Service, Washington D.C. Various Issues (1980-1991).

Ward, Clement E. "Market Structure Dynamics in the Livestock-Meat Subsector: Implications for Pricing and Price Reporting," Key Issues in Livestock Pricing: A Perspective for the 1990's, Research Institute on Livestock Pricing, Blacksburg, VA., Dec. 1987, p 8-54.

White, Kenneth J., S. Donna Wong, Diana Whistler, and Shirley A. Haun. SHAZAM User's Reference Manual Version 6.2. McGraw-Hill, 1990.

Wohlgenant, Michael K. "Demand for Farm Output in a Complete System of Demand Functions." American Journal of Agricultural Economics. 71(May, 1989):241-252.

APPENDIX A

DESCRIPTION OF OKLAHOMA STATE UNIVERSITY'S

FED CATTLE MARKET SIMULATOR

The ultimate objective of Oklahoma State University's Fed Cattle Market Simulator is to simulate the feedlot to packer interface as closely as possible in order to evaluate how different marketing structures and marketing tools effect the market. An intermediate/secondary objective is to teach students, through simulated experiences, how the feedlot to packer subsector operates. More generally, the teaching intent of using the simulator is to demonstrate, through experience, how economic concepts such as breakeven analysis, cost curves, supply and demand, etc., are used in marketing and decision making. To date the simulator has proven to be very effective in achieving the intermediate/secondary objective. The use of the simulator as a training tool has evolved beyond the University classroom. It has been used in the industry as a training tool for meat processing firm management personnel (Excel Corporation) and feedlot managers (Caprock Industries). Continued refinement of the simulator is being undertaken in order to progress toward using the simulator as an experimental economics tool.

A simulation is conducted by first instructing students (participants) about the factors that effect each side of the market (i.e. the buyer and seller sides) and then placing them into the roles of feedlot sales staff and packer order buyers. Feedlots are given a supply of cattle (a number of paper slips, each representing 100 head of cattle) and are instructed to try to sell them to the packers within five trading periods for the best price they can get (each trading period is around five minutes in length and is equivalent to one week of trade in the actual market). The packers, in turn, must purchase cattle as cheaply as possible in order to produce their commodity (boxed beef) and make a profit. Cattle supplies and costs for each feedlot and packing plant are calculated by a computer program. After a period of time trading only cattle for cash, the participants are allowed to forward contract the cattle. When it is felt that the participants understand the cash trading and forward contracting, a futures market is introduced.

The simulator is set up with five interactive entities (figure 9). On the cash side of the market, the computer has a preprogrammed list of feeder cattle placements that is then given to each of eight feedlots. After the feeder cattle are in the feedlots for seventeen weeks (trading periods), they go onto a showlist (fed cattle for sale). The eight feedlots negotiate to sell their showlist cattle to one of four meatpackers. After the price and quantity of fed cattle is negotiated, the information is turned back into the computer which calculates the boxed beef price for each of the trades and reports an average boxed beef price, slaughter price, and total slaughter volume back to the market news for public reporting. This information is then compared to information taken directly from the feedlots and packers during the negotiation process by market news reporters.

Market news is made up of three to five individuals who pick up the cattle from the trades and enter the information into the computer. At the same time, market news reports the number of pens of cattle traded and a price range

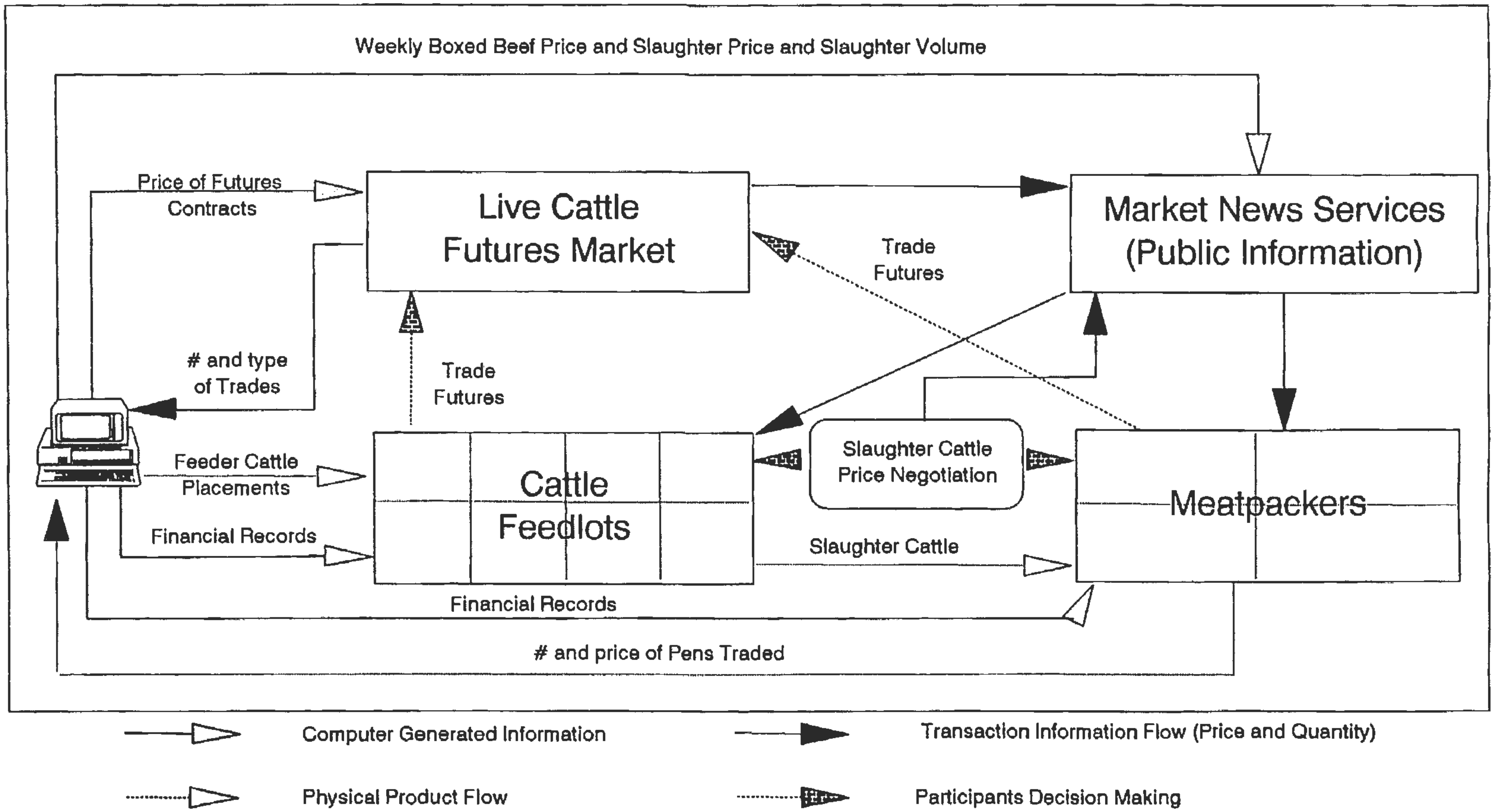

Figure 9. Fed Cattle Market Simulator

through a classroom medium (such as a chalkboard or overhead projector). They also report the number of pens that are delivered under contract for that week, but no price range is reported for contracted trades. Market news also reports computer generated information back to the participants in the game and keeps a running history of past market information.

There is also a live cattle futures market that both feedlots and meatpackers can use to hedge cattle or speculate. For this market, the participants must decide whether or not to trade futures contracts, whether the trade is a buy or sell, and how many contracts to trade. After the decision to trade is made, the trades are reported to the computer which calculates a price for the contract. Price and quantity information from the futures market is then reported to market news for public information. At the end of four trading periods, the computer reports back to the feedlots and meatpackers their financial records and information on current costs so they can plan future activities.

Use of the Demand Model Within the Simulator

Within the feedlot to packer simulation game, the supply of cattle is predetermined to illicit reactions to specific market conditions. Due to the fact that the game represents a region of the total market and is assumed to be independent of other regions and competing markets, several modifications to the beef market demand equation are required to use it in the simulation game.

First, since the game is set up to control all exogenous factors, only the response of boxed beef prices to changes in boxed quantities are of interest. Because the game simulates a supply series or a region, the supply levels are of a totally different magnitude than the data series used in the estimation process. Thus the parameters as estimated and reported in chapter IV of this study must be changed in order to fit the programmed supplies. This is done by calculating the flexibilities of the estimated equation at the mean. To calculate the original flexibilities, equation [A.1] can be used:

[A.1]

$$f_i=\beta_{1,i}*\frac{\overline{QSHB}}{\overline{PBX}}$$

where f_i is the flexibility, $\beta_{1,i}$ are the coefficients for QSHB, $\overline{QSHB}$ is the mean of the quantity of steer and heifer beef slaughtered, and $\overline{PBX}$ is the mean price of boxed beef.

Second, using the calculated flexibilities, new coefficients to be used within the game can be calculated through equation [A.2]:

[A.2]

$$B_i=f_i*\frac{\overline{CPBX}}{\overline{CQSL}}$$

where B_i is the new coefficient, $\overline{CPBX}$ is the desired mean price of boxed beef in the game, and $\overline{CQSL}$ is the mean of the quantities of cattle programmed into the simulation game. From the new coefficients, the equation to be used within the game will then be:

[A.3.1]

$$CPBX_t=A+\sum_{i=0}^{n}B_iCQSL_{t-i}$$

where

[A.3.2] $$A=\overline{CPBX}-\sum_{i=1}^{n}\beta_i\overline{CQSL}$$

and is a constant. The value of A can be changed to simulate shifts in demand due to changes in income or the supply of competitive meat products.

Validation of the equations performance within the simulation game can be performed mathematically verifying that the transformed equation yields the same length of response delays and flexibilities as the original equation.

Conversion of Estimated Parameters to Use Within the Simulator

The first step in converting estimated parameters to parameters that are usable within the simulation game is to calculate the flexibilities at the mean (see equation [A.1]). The estimated flexibilities calculated at the mean are presented in table XI. Since the Pagano and Hartley model was judged to be superior to the iterative model (see chapter IV), it will be the model that will be used to determine the equation used within the simulator.

The calculated flexibilities indicate the boxed beef price will decrease (increase) by 0.09568 percent for a 1 percent increase (decrease) in the per capita slaughter of steer and heifer beef (identified as SHB in tables XI and XII) in the first week (short run), ceterus paribus. In the long run, the price of boxed beef will decrease (increase) by 0.71122 percent in response to a 1 percent ceterus paribus increase (decrease).

TABLE XI

FLEXIBILITIES ESTIMATED AT THE MEAN FROM BOTH THE ITERATIVE AND THE PAGANO AND HARTLEY METHODS

Variable	Iterative	Pagano and Hartley
SHB_t	-0.09391	-0.09568
SHB_{t-1}	-0.08405	-0.08686
SHB_{t-2}	-0.07559	-0.07686
SHB_{t-3}	-0.06977	-0.06885
SHB_{t-4}	-0.06692	-0.06449
SHB_{t-5}	-0.06633	-0.06387
SHB_{t-6}	-0.06642	-0.06556
SHB_{t-7}	-0.06457	-0.06660
SHB_{t-8}	-0.05724	-0.06246
SHB_{t-9}	-0.03991	-0.04709
SHB_{t-10}	-0.00711	-0.01291
Long Run SHB	-0.69182	-0.71122
CBB_t	-0.00115	0.00395
CBB_{t-1}	-0.00244	-0.00478
CBB_{t-2}	-0.00804	-0.01421
CBB_{t-3}	-0.01659	-0.02362
CBB_{t-4}	-0.02673	-0.03232
CBB_{t-5}	-0.03708	-0.03970
CBB_{t-6}	-0.04629	-0.04516
CBB_{t-7}	-0.05299	-0.04819
CBB_{t-8}	-0.05581	-0.04831
CBB_{t-9}	-0.05339	-0.04509
CBB_{t-10}	-0.04437	-0.03816
CBB_{t-11}	-0.02738	-0.02720
CBB_{t-12}	-0.00106	-0.01194
CBB_{t-13}		0.00786
Long Run CBB	-0.37333	-0.36687
Pork	-0.01594	-0.01744
Poult	0.00947	0.00644
Adisp	0.21547	0.19970

The short run change to the boxed beef price from a 1 percent increase (decrease) in the per capita slaughter of cow and bull beef (identified as CBB in table XI) is a decrease (increase) in the boxed beef price by -0.00395 percent, ceterus paribus. The long run effect of the same ceterus paribus shift is a decrease (increase) in the price of boxed beef of 0.36687 percent.

A 1 percent increase (decrease) in the per capita slaughter of pork (identified as PORK in table XI) will cause boxed beef price to decrease (increase) by 0.01744 percent, ceterus paribus. A 1 percent increase (decrease) in the per capita quantity of chicken and turkey slaughtered (identified as POULT in table XI) will cause the price of boxed beef to increase (decrease) by 0.001997 percent, ceterus paribus. A 1 percent increase (decrease) in real per capita disposable income (identified as ADISP in table XI) would cause the price of boxed beef to increase (decrease) by 0.1997 percent, ceterus paribus. All of the flexibilities mentioned will only hold at the means.

From equation [A.2], the parameters that are used within the simulator can be determined. The current version of the simulation game is set up so that the equilibrium price of boxed beef ($\overline{CPBX}$) is $120. The current equilibrium quantity of slaughter ($\overline{CQSL}$) is set for forty pens (4000 head) of 1150 pound cattle with a dressing percentage of 63 percent. Also as stated in the previous section, only the flexibilities from SHB_{t-i} variables will be used to form the equations. The list of coefficients derived are presented in table XII. The intercept term reported in table XII is calculated from equation [A.3.2].

TABLE XII

COEFFICIENTS TO BE USED WITHIN THE SIMULATION GAME

Variables	Pagano and Hartley
Intercept	205.3464
SHB_t	-0.28704
SHB_{t-1}	-0.26059
SHB_{t-2}	-0.23058
SHB_{t-3}	-0.20655
SHB_{t-4}	-0.19346
SHB_{t-5}	-0.1916
SHB_{t-6}	-0.19668
SHB_{t-7}	-0.19979
SHB_{t-8}	-0.18737
SHB_{t-9}	-0.14127
SHB_{t-10}	-0.03873

Evaluation of the Equations Performance

The transformed boxed beef price equation was validated by testing its response to a one time change (impulse) and a permanent change (step) in slaughter of four pens (10 percent change from equilibrium quantity of 40 pens to 44 pens).

The price response for the impulse change is presented graphically in figure 10. The response pattern in figure 10 is the same as the response pattern in figure 3 as reported in chapter IV and takes ten periods to complete. That is, the response follows the same lag length and pattern as the model estimated through the Pagano and Hartley Procedure.

The price response for the step change is presented graphically in figure 11. The price drops from the equilibrium price of $120 to $111.47, or 7.11 percent for a ten percent decrees in slaughter. This implies a long run flexibility of .711, which is the same as that estimated by the Pagano and Hartley method. It also takes ten trading periods to fully adjust. The sensitivity response patterns displayed in both figure 10 and figure 11 indicate that the converted Pagano and Hartley boxed beef equation generates the same relative magnitude and length of response as the estimated equation, and is thus computationally correct.

Evaluation of the Fed Cattle Market Simulator

The simulator has been used with students, professional economists, and industry clientele. Evaluation questionnaires have been given to all groups regarding the simulator's effectiveness and realism. Two separate evaluations will be reported on here. The first evaluation was received from professional agricultural economists participating in a teaching workshop at the Southern Agricultural Economics Association meetings in 1991. The second evaluation was taken when the simulator was used within a group of industry management personnel from Excel corporation (a meatpacking company) and Caprock (a feedlot company). The questionnaires used are presented in

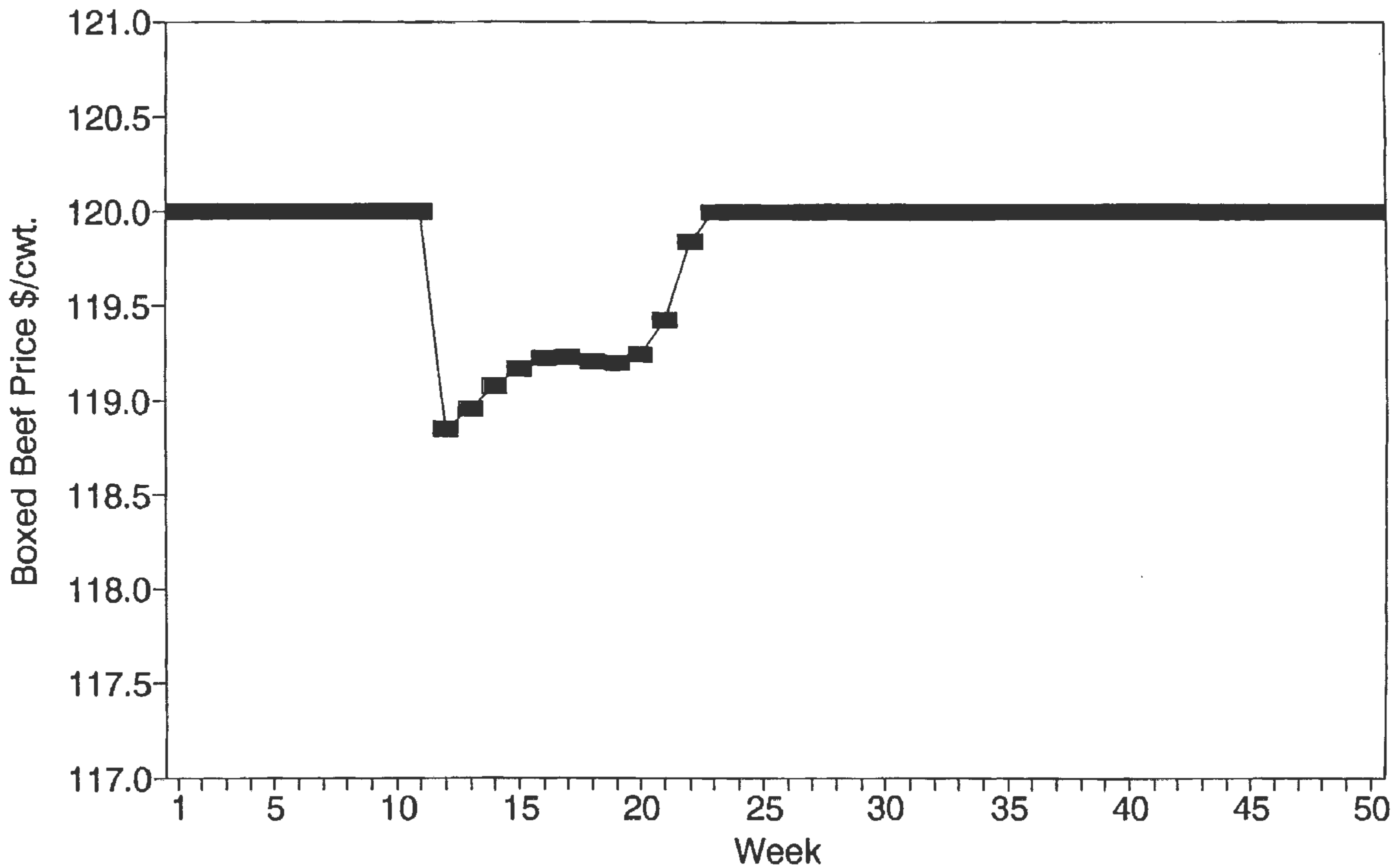

Figure 10. Ten Percent Sensitivity Test Pattern - Impulse Change

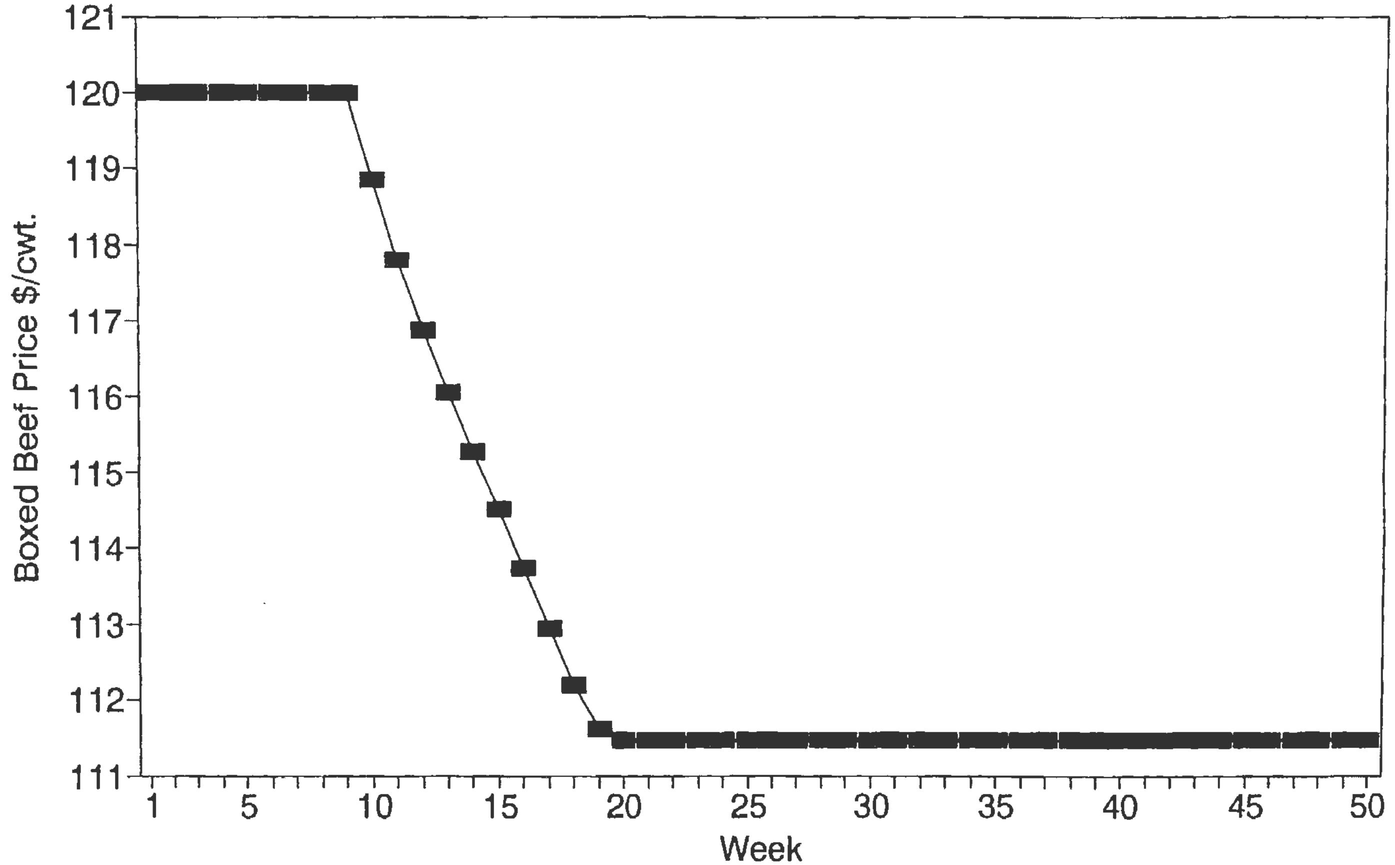

Figure 11. Ten Percent Sensitivity Test Pattern - Step Change

Appendices B and C.

The participants for the Southern Agricultural Economics Association were asked three basic questions about the game: Rate the effectiveness of the simulator as a classroom teaching tool; Rate the effectiveness of the simulator as an extension teaching tool; and Rate the effectiveness of the simulator as an experimental economics research tool. They were asked to rate the simulator on these criteria based on a scale of one to seven with seven being very effective and one being very ineffective. There were eleven respondents to the questionnaire. The response to the effectiveness of the simulator as a classroom teaching tool ranged from five to seven with an average score of 6.09. The response to the effectiveness of the simulator as an extension teaching tool ranged from three to seven with an average score of 5.82. This indicates that the professional economists believe the simulator to be very effective as a teaching tool. However, when asked to rate the effectiveness of the simulator for experimental economics research, only eight participants responded with a range of scores from two to six with an average score of 4.5. This would suggest that the simulator still needs some work in order to get results that the profession would believe representative of the real world.

The participants in the simulation done with Excel and Caprock employees were asked two questions relevant to this study: Overall industry and market realism of the simulator; and Effectiveness of the simulator as a learning or training tool. They were asked to rate these criteria on a scale of one to seven with one being very effective (true) and seven being very ineffective (false). In all, twenty-one people responded to the survey. In response to the question of industry and market realism, the responses ranged from one to three with an average score of 2.52. This would suggest that people who work in the industry believe the game to be very representative of the way the true market works. The response to the effectiveness of the simulator as a learning or training tool ranged from 1 to 3 with an average score of 1.81. This, like the survey from the Southern Agricultural Economics Association, indicates that the simulator is very effective for teaching.

APPENDIX B

QUESTIONNAIRE FOR SOUTHERN AGRICULTURAL ECONOMICS ASSOCIATION MEETINGS

SESSION EVALUATION

FED CATTLE MARKET SIMULATOR

Steve Koontz, Derrell Peel, Jim Trapp, and Clem Ward
Oklahoma State University
528 Agricultural Hall
Stillwater, OK 74078

Name ____

Institution/Organization ____

Primary Responsibility/Appointment ______________________________

____

Which role did you play in the "game"? (Circle one) Packer Feedlot

We are most interested in your reaction to the Fed Cattle Market Simulator (FCMS) as a classroom teaching tool, extension teaching tool, and a research tool. Your honest and sincere comments are appreciated.

1. How would you rate the potential effectiveness of the FCMS as a classroom teaching tool? (Circle one)

1	2	3	4	5	6	7
Very Ineffective						Very Effective

2. What concepts/principals does the FCMS have the greatest potential of effectively teaching students?

____

____

____

How would you rate the potential effectiveness of the FCMS as a extension teaching tool? (Circle one)

1	2	3	4	5	6	7
Very Ineffective						Very Effective

4. What concepts/principals does the FCMS have the greatest potential of effectively teaching adult learners?

____

____

____

5. How would you rate the potential effectiveness of the FCMS as experimental economics research tool? (Circle one)

1	2	3	4	5	6	7
Very Ineffective						Very Effective

6. To which research question/issues does the FCMS have the greatest potential of contributing answers/information?

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7. What do you see as the most serious weakness or limitations of the FCMS for teaching, extension, or research?

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8. Would you have an interest in cooperating in some way with the project team in further developing the FCMS as a teaching, extension, or research tool? (Circle one) Yes No

9. Please provide any other comments or suggestions you have for improving and using the FCMS.

____

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THANK YOU for participating and for completing the evaluation.

APPENDIX C

QUESTIONNAIRE FOR EXCEL AND CAPROCK

FED CATTLE MARKET SIMULATOR
SESSION EVALUATION with EXCEL CORPORATION

Steve Koontz, Derrell Peel, Jim Trapp, and Clem Ward
Department of Agricultural Economics, Oklahoma State University
528 Agricultural Hall, Stillwater, OK 74078

Name ____

Position ____

We are interested in your reaction to the Fed Cattle Market Simulator (FCMS) as a realistic training and education tool. Your honest and sincere evaluation is appreciated.

1. How would you rate industry and market realism captured by the FCMS?

1 Very Realistic	2	3	4	5	6	7 Very Unrealistic

2. What changes could be made to the FCMS which would improve the realism? We are looking to identify crucial elements of the real world which may not now be incorporated. However, we have to be careful and not try to incorporate all of the details in fed cattle trading because of computer and classroom time limits. In other words, we have to recognize the realism/feasibility tradeoff.

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3. How would you rate the effectiveness of the FCMS as a learning or training tool?

1 Very Effective	2	3	4	5	6	7 Very Ineffective

4. What are the most important things that participating in the FCMS accomplishes? What are the most important things that the FCMS fails to accomplish? In other words, what is this "game" good for and what are its limitations?

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____

5. Would you be interested in cooperating with this research team in further development of the FCMS as a learning or training tool? YES NO

6. Do You have any other comments? Please write them on the back of this page.

THANK YOU for participating in this session and completing this evaluation.

VITA

Steven E. Meyer

Candidate for the Degree of

Master of Science

Thesis: AN INVERSE DEMAND MODEL FOR WEEKLY BOXED BEEF PRICE

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Missoulla, Montana, February 8, 1967, the son of Sharon Meyer.

Education: Graduated from Custer County District High School, Miles City, Montana, in May of 1985; received Bachelor of Science Degree in Agricultural Business Management from Montana State University in June, 1989; completed requirements for the Master of Science Degree at Oklahoma State University in May, 1993.

Professional Experience: Teaching Assistant, Department of Economics and Agricultural Economics, Montana State University, September, 1988, to January, 1989; Graduate Research Assistant, Department of Agricultural Economics, Oklahoma State University, September, 1990, to October, 1992.