FACTORS ASSOCIATED WITH STEER PRICES

by

JOÃO FERNANDO MARQUES

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TO

MY FATHER'S MEMORY

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INTRODUCTION

Short run fluctuations in the live cattle prices occur often. This is partly due to seasonal movement, but seasonal fluctuations are not as evident now as formerly. Fluctuations introduce a certain degree of uncertainty in the decision-making process of producers and all other participants in the beef sector of the economy. The price variability that has characterized the beef industry makes it difficult for the participants in beef marketing to make plans and to reach their economic goals. Long run fluctuations in the price of live animals are fairly predictable since they are due to recular cyclical forces, and have been studied by a large number of researchers. Seasonal fluctuations that have characterized the price of slaughter steers and heifers in the past have largely disappeared due to a more stabilized supply of live animals resulting from the increased importance of the large feedlot operations. The lack of seasonal patterns does not however, prevent short run fluctuations in beef prices. Factors that cause such fluctuations ought therefore to be examined in order to make price predictions. Short run variations in cattle prices, logically, should be explained by forces that cause demand and supply shifts over time.

OBJECTIVES

The primary objective of the present study is to formulate a quantitative model that can predict monthly steer prices through hypothesized price determinant variables.

Some exogenous variables enter the regression equation in the same time period as the dependent variable. The absence of time lags in certain variables will limit the model to a conditional model. Forecast of steer prices beyond the estimation period (future) will require some additional models to estimate the value of the dependent variables.

REVIEW OF SELECTED LITERATURE

Beef price models range from those attempting to forecast monthly[1] relationships to those attempting to derive yearly[2] and quarterly[3] relationships. Several statistical and econometrics methods used have been associated with a variety of purposes. Some models were useful in developing a short-run cattle price forecast, and some others have the scope to estimate the economic relationship among the primary price determinants. To accomplish the objective of estimating economic relationship among variables, a system of simultaneous equations that allows estimates of demand and supply was used. In such equations the coefficients are taken as elasticities or flexibilities.

If the primary objective of the model is to forecast the value of a dependent variable, the single equation least square method is used.

Since the objective of the present study is to develop a short-run price forecast model, two short-run models will be reviewed.

Hayenga and Hacklander developed two models for short-run monthly price forecast. In order to make price predictions, the development of supply equations was required.

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[1] Marvin Hayenga and Duane Hacklander, Short-Run Livestock Price Predictions Models, (East Lansing, Michigan: Michigan State University, 1970) Agricultural Experiment Station Research Bulletin No. 25.

[2] Larry Langemeier and Russel Thompson, "Demand, Supply and Price Relationships for Beef Sector, Post World War II Period," Journal of Farm Economics, Vol. 49, No. 1, 1967, pp. 169-183.

[3] Wilbur R. Maki, Forecast Beef Cattle and Hog Prices by Quarter-Years, (Ames, Iowa: Iowa State University, 1959), Agricultural and Home Economics Experiment Station Research Bulletin No. 473.

Basically, the estimated supply equation is the following form:

$Qt = f(S_{F1}, S_{F2}, S_{F3}, H_{F1}, H_{F2}, H_{F3}, D)$

Qt = Total commercial beef production

S_{F1} = Number of steers on feed weighing 500-700 pounds at beginning of quarter

S_{F2} = Number of steers on feed weighing 700-900 pounds at beginning of quarter

S_{F3} = Number of steers on feed weighing 900-1100 pounds at beginning of quarter

H_{F1} = Number of heifers on feed weighing less than 500 pounds at beginning of quarter

H_{F2} = Number of heifers on feed weighing 500-700 pounds at beginning of quarter

H_{F3} = Number of heifers on feed weighing 700-900 pounds at beginning of quarter

D = System of monthly dummy variable.

By using the least square method, the regression equation estimates the empirical association between the cattle on feed (by category) and commercial cattle slaughter.

The equations used in this study showed a high correlation between the animals in the heavier categories and the rate of slaughter in the earlier periods. For example, commercial cattle slaughtered in the period t + 1 was correlated with steers of the 700-900 lb. category and heifers of the 700-900 lb. category, with an R^2 of .93.

Steers 700-900 pounds and heifers 500-700 pounds explained about 82 percent of the variation in total slaughter in period t + 3. This seems to show that the supply of beef in a given month is mainly predetermined by the number of animals on feed in each weight category.

Two models were developed for short-run price forecasting.

a) $P_m = f(Qc, Qp, PPI, Co, Pks, D)$

The monthly average steer price in this model was found to be a function of cattle and hog slaughter per work day, per capita personal income, percentage of cows to total cattle slaughtered, and of pork storage inventories at the end of the previous month.

P_m = Average monthly price of choice 900-1100 pound steers at Chicago ($/100 pound)

Qc = Monthly U.S. commercial beef production, divided by the number of work days

Qp = Monthly U.S. commercial pork production, divided by the number of work days

PPI = Monthly U.S. per capita personal income

Co = Percentage of cattle slaughtered consisting of cows

Pks = Ending inventory of cured and frozen pork, at the end of the previous month

D = (0, 1) Monthly dummy variables

Over the period January, 1962 to June, 1968, the model explained 84 percent of the variation in monthly steer prices.

The second model developed by the same study utilizes the results of the above equation to forecast prices. Current steer prices and a set of dummy variables were the two other variables included in the equation.

b) $Pm + i = f(Pm, \Delta Qc, D)$

$$\text{where } \Delta Q_c = \frac{Q_{c_{m+i}} - Q_{c_m}}{Q_{c_m}}$$

and i corresponds to the month in the future.

This model presents a poorer fit as the time lag between the current month and the forecasted month is increased. The equation that predicted prices one month in the future had an R^2 of 89 percent, while the equation that predicted prices six months in the future had an R^2 of only 50 percent. The Durbin-Watson statistics showed the presence of serial correlation in the residuals. Durbin-Watson statistics decreases as the time lag between current period and the period forecasted increases.

PRICE DETERMINATION: THEORETICAL FRAMEWORK

This chapter reviews briefly the theoretical determination of short-run[1] prices in a purely competitive model.[2] In this type of model, the market demand curve and the market supply curve are determinants of the market price. Market demand indicates the quantity of goods and services that consumers are willing to buy during a given period of time at different prices. For purposes of illustration, the market demand in this chapter will be assumed to be sloping downward: that is, as price of a commodity declines, consumers will be willing to buy a greater amount of the commodity. The market supply curve indicates the quantity of goods and services that firms are willing to produce and sell during a given period at different prices. Again for illustrative purposes, the supply curve is assumed to be positively sloping. Firms will be willing to supply larger quantities of goods and services as prices increase.

Thus, the short-run market price is determined by the intersection of both demand and supply curves. In Figure 1, DD is the market demand curve and SS is the market supply curve.

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[1]Short-run in a beef industry will be considered a period of time which producers cannot adjust the number of cattle on feed.

[2]No intention is made in this paper to discuss the difference between pure and perfect competition nor to discuss the assumptions underlying those market concepts, for a complete presentation see, Kalman J. Cohen and Richard M. Cyert, Theory of the Firm: Resource Allocation in a Market Economy, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 2nd Edition, 1975), pp. 45-110.

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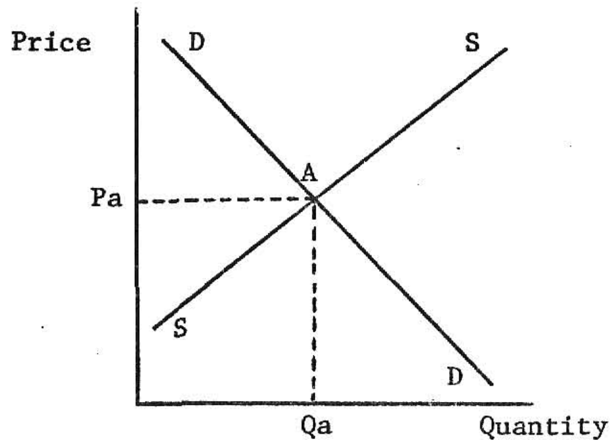

Figure 1. Market supply, market demand and short-run equilibrium

The intersection, A, shows the quantity and price equilibrium. Firms are willing to sell and consumers are willing to buy Qa at Pa. This position holds until demand and/or supply shifters cause a change in demand and/or supply curves.

Assuming that there is no shift in demand, but supply is increased from S_1S_1 to S_2S_2, the new position in equilibrium is shown in Figure 2.

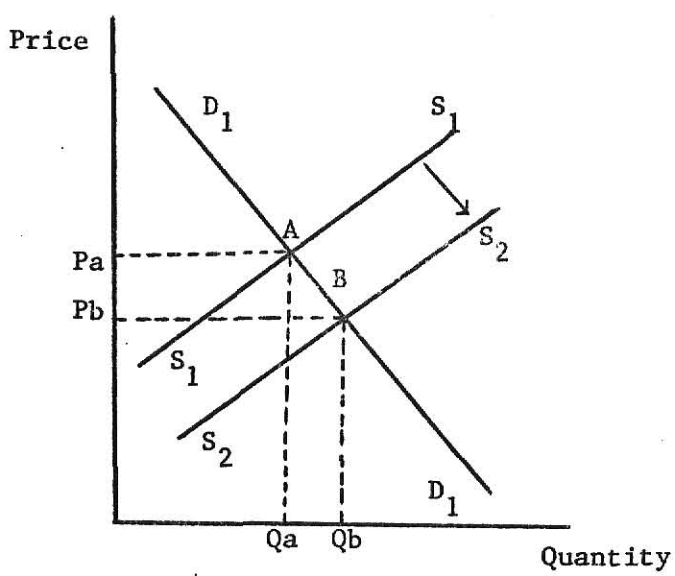

Figure 2. Shifting market supply curve

Firms will supply a larger amount, at each price; when the supply curve in Figure 2 shifts to the right, from S_1S_1 to S_2S_2. Since there is no change in demand, changes in supply have an inverse relationship with price. As one can see in Figure 2, the supply curve shifted from S_1S_1 to S_2S_2 to meet the demand curve at B, where the quantity is larger and price lower than point A. It is obvious that if the supply curve had shifted to the left the inverse relationships would hold.

Now assume that the supply curve stays constant and the demand curve shifts. Figure 3 depicts the relationship when the demand curve is allowed to shift.

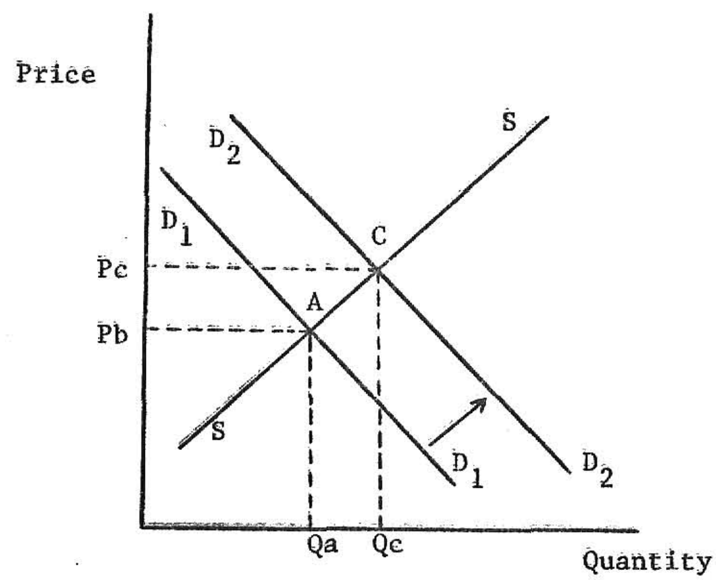

Figure 3. Shifting market demand curve

At point A, Qa and Pa are the initial equilibrium quantity and price. As market demand increases from D_1D_1 to D_2D_2, or as consumers are willing to buy more goods and services at each given price, market price and quantity purchased increase. Market demand shifts have a direct relationship with price.

An increase in demand from D_1D_1 to D_2D_2 moves the point of price-quantity equilibrium from A, the initial position, to C. As can be seen moving from A to C causes an increase in price from Pa to Pc and an increase in quantity from Qa to Qc. A shift in the demand curve towards the origin will decrease price and quantity.

Finally, one more case and probably the more realistic one, and the most difficult to represent graphically, is when both curves are shifting simultaneously. The difficulty lies on the fact that the direction and the size of the shift in each curve should be known before the resulting price and quantity is determined.

For the purposes of forecasting cattle prices, attention should be given to the factors that determine price of cattle. As just explained, the market price of any commodity in a purely competitive model is determined by the forces of the supply and the demand.

In empirical situations, supply and demand schedules are not observable. However, the points related to price and quantity reflect the equilibrium situation at which the demand and supply curves have met.

Finally, price determination in the cattle sector of the economy is complicated by the fact that between the producer and consumer there are wholesalers, processors, etc. Consumers, of course, react to changes in retail beef prices while producers react to changes in live animal prices. Consequently, the demand for live cattle is probably derived from retail beef markets.

PRELIMINARY CONSIDERATIONS

The purpose of this study is to develop a price prediction model. For this reason a single instead of simultaneous equation was estimated. The classical least square method to estimate the parameters was used.

The use of a single equation implies some restrictions on the coefficients if they are to be interpreted as price flexibilities or elasticities.[1]

According to Fox[2] the single equation least square model may be used to forecast the value of dependent variables from a set of explanatory variables even when the evidence shows that a simultaneous relationship appears to be required.

No attempts have been made in the present study to estimate a simultaneous relationship. If this were used, the coefficients could have been directly interpreted as price or income elasticities.

Fox and Foote[3] point out that there are special cases where the single equation will also give an unbiased estimate of the coefficients.

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[1] Demand elasticity is defined as the percentage change in quantity associated with percentage change in price or income. The percentage change in price associated with a given percentage change in quantity is called price flexibilities and is the reciprocal of the elasticity. For a more accurate discussion about the relationship of these two coefficients, see J. P. Houck, "The Relationship of Direct Price Flexibilities to Direct Price Elasticities," Journal of Farm Economics, Vol. 47, No. 3, 1965, pp. 789-802.

[2] Karl A. Fox, The Analysis of Demand for Farm Products, (Washington: Government Print Office, 1953), United States Department of Agriculture Technical Bulletin, No. 1081, p. 5.

[3] Richard J. Foote and Karl A. Fox, Analytical Tools for Measuring Demand, (Washington: Government Print Office, 1954), United States Department of Agriculture Handbook No. 64, p. 37.

The relevant criterion to identify such special cases is the absence of interdependence between the two sets of variables.

As the primary purpose of the analysis was to predice one variable, i.e., steer price, the single equation model was judged sufficient to fulfill this requirement. Furthermore, this particular case of the monthly variation in steer price seems to meet some requirements that will allow the estimates to be interpreted as price flexibilities as long as precise estimates are not required.[1]

The following discussion gives some details about interpretation of the parameters estimated.

The supply of cattle available for slaughter in a given month is essentially predetermined by the number of animals on feed, that approach market weight at the beginning of the month. The supply curve for each month is considered to be vertical. It is known that producers can hold their animals if prices do not meet their expectations and that they also can sell the animal at lighter weight due to unexpected rise in prices. Such decisions are believed not to affect considerably the total number of cattle that go to market monthly and so a relatively inelastic supply curve seems to be a reasonable assumption.

The supplies of the closely competing commodities such as hogs, calves, and poultry are also treated as predetermined variables because they also are mainly determined by the feeding and sales patterns of the

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[1] It is important to note that even within the period of the month, the supply could react to changes in prices, but the effect of this reaction in the market should be small if compared to the total amount ready for slaughter in that month. This fact probably will cause the price flexibility coefficient to contain a small bias. Imports not accounted for in the present equation, even though in small amounts, will slightly bias the coefficients in terms of price elasticities.

producers. Since monthly steer prices do not affect the supply of beef substitutes, they were taken as a function of the substitutes.

Consumer income is an exogenous variable that is determined by the functioning of the whole economic system and as usual it can be taken as an exogenous steer price determinant.

Hayenga and Hacklander,[1] in estimating a monthly price equation for price prediction purposes, arrived at the conclusion that monthly beef production is not jointly determined with the current price; consequently, there is no need for a simultaneous equation approach.

The main focus of the above discussion is to show that the independent variables specified in the present model are predetermined. That is, steer prices at Omaha in a given month are determined by a set of explanatory variables and are not the determinant (at the same point in time) of such variables, so there is no need for a model that allows simultaneity among the variables.

One more prerequisite[2] must be met to ensure the single equation estimates to be a reasonable measure of the elasticities related to retail level,[3] and that is consideration of the effects of foreign trade and changes in stock. At the demand side, theoretically, another equation for meat export and for storage should be part of the system of equations. Since at a given time, beef supplies may be affected not only by current domestic slaughter but also by storage stocks and imports,

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[1]Hayenga and Hacklander, p. 16.

[2]Fox, p. 13.

[3]Provided that the figures used to estimate the equation are related to the retail level.

the single equation coefficient is biased as far as elasticity is concerned.

In the estimation of the present equation, storage was included as a variable but net foreign trade was not. Both figures are extremely low if compared to domestic beef production. For that reason, the bias should not be large.

Some discussion about an analysis based on time series data also is in order. Working,[1] in his pioneer article, shows that from the same data series one can estimate both the demand and the supply functions because the observed data on quantity and price are in reality the result of the intersection of a demand and a supply curve shifting over time. The specification of the shifters then is the crucial factor to estimate the demand or the supply relationships. Through the use of regression analysis it is possible to isolate the factors which cause demand and supply curves to shift over time. Depending on the objective of the analysis, one or another curve could be estimated. More important for the purpose of this study is the fact that if the main objective is to forecast the price, the true supply and demand equations need not be constructed.

As was detailed earlier, the principal purpose of constructing a single equation regression model is to predict the steer price. One can use the information contained in the model to make forecasts beyond the estimation period based on the assumption that past relationships will likely occur in the future.

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[1] E. J. Working, "What Do Statistical 'Demand Curves' Show?", Quarterly Journal of Economics, Vol. XLI, No. 2, 1927, pp. 212-235.

The set of independent variables must be forecast before the single equation regression model can be used to forecast the value of the dependent variable. This characteristic distinguishes the conditional model from the unconditional one.[1] In other words, the unconditional model is one in which the set of all explanatory variables is known with certainty. The most common cases of unconditional model is the use of explanatory variables having time lags. In the conditional forecast model one or more independent variables are not known with certainty. Their value should be forecasted in a case where the value of the dependent variable is to be forecast beyond the estimation period. In the latter case, errors of forecasting the independent variables are incorporated by the equation which will produce the forecast of the dependent variable.[2]

In this study no attempt was made to forecast a value of the dependent variable beyond the estimation period where values of the independent variables were not known with certainty.

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[1]Robert S. Pindyck and Daniel Rubenfeld, Econometrics Model and Economic Forecasts, (New York, McGraw Hill Company, 1976), pp. 155-156.

[2]The confidence interval for the predicted value of the dependent variable by using the conditional model will be wider than the interval with the same level of confidence for the value of the dependent variable by making use of the unconditional model. In other words, the forecasted nature of the values of the dependent variable increases the error of the forecast. For a formal proof, see: Ibid., p. 179.

DATA

A single equation model to explain monthly steer price variation implies the use of monthly data series.

The dependent variable in the regression model being predicted is the average steer price. Steers are sold at several markets throughout the U.S.A. and at various grades and weights. The price quotations used in this study originate from Omaha, since it is believed that the market place is a price setter and maintains a high degree of influence throughout the main beef supply area in America.

The highest percentage of slaughter cattle are choice grade, and Omaha, Nebraska, is a major market for which price quotations are available; therefore, price quotations for U.S. Choice Grade 900-110 pound steer at Omaha were used. Thus the dependent variable was:

Y = Monthly average price ($/cwt) of U.S. Choice Grade 900-1100 pound steers based on the average monthly quotations made at Omaha, published in Livestock and Meat Statistics, USDA.

Data series of prices are shown in Table 1, Appendix A.

The following variables were entered in the monthly regression model as explanatory variables.

Commercial slaughter of cattle, calves, and hogs was used as a measure of total monthly supply for each of these commodities. In respect to poultry, total production was the figure used.

X_1 = Total monthly commercial cattle slaughter in million pounds of live weight, 48 states.[1] Monthly commercial cattle slaughter figures are published in Livestock and Meat Statistics, USDA.

Table 2 in Appendix A, shows cattle slaughter data used in this study.

X_2 = Total monthly commercial cattle slaughter in million pounds of live weight, 48 states. Monthly commercial cattle slaughter data series in Livestock and Meat Statistics, USDA.

Calf slaughter data are shown in Table 3, Appendix A.

X_3 = Total monthly commercial hog slaughter in millions of pounds of live weight, 48 states. Monthly commercial hog slaughter figures are published in Livestock and Meat Statistics, USDA.

Hog slaughter data included in the monthly regression are shown in Table 4, Appendix A.

X_4 = Total monthly commercial poultry production (chicken and turkey meat), ready-to-cook weight in millions of pounds, 48 states. Commercial poultry production data is published in Poultry and Egg Situation, USDA.

Poultry production figures are shown in Table 5, Appendix A.

X_5 = Beef, frozen and cured, cold storage holdings + pork, frozen and cured, cold storage holdings + cold storage of poultry (turkey and others); United States first of the month, in millions of pounds. These figures are published in Agriculture Statistics, USDA.

These data are shown in Table 6, Appendix A.

X_6 = Per capita disposable income in current dollars, seasonally adjusted at annual rate. Quarterly data were obtained and straight line interpolated to give monthly figures. Source of the quarterly data: Economic Indicators Prepared for Joint Economic Committee by Council of Economic Advisors, U.S. Government Printing Office.

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[1] The 48 states are: Maine; N. Ham.; Ver.; Mass.; R.I.; Conn.; N.York; N. Jersey; Pa.; Ohio; Ind.; Ill.; Mich.; Wisc.; Minn.; Iowa; Mo.; N.D.; S.D.; Nebr.; Kans.; Ga.; Fla.; Ky.; Tenn.; Ala.; Miss.; Okla.; Texas; Mont.; Idaho; Wyo.; Colo.; N. Mex.; Ariz.; Utal; Nev.; Wash.; Oreg.; Cal.; Del.; Maryland; Vir.; W. Vir.; N.C.; S.C.; Ark.; La.

Per capita disposable income data are shown in Table 7, Appendix A.

Two more variables were included in the model: population and time as a trend variable. Sometimes a linear regression could lead to spurious correlation (variables moving in the same or opposite directions without implying causal relationship). To avoid such a problem, population (using data on per capita basis to account for population growth) and time (because of the general upward trend of the economy) were included in the model.

T = Time trend variable, where T + 1, 2, . . ., 240

P = Population

Population figures used in this study are shown in Table 8, Appendix A.

MODEL DESCRIPTION

Monthly steer prices were taken as a variable to be explained by relevant forces underlying the market supply and demand curves.

Forecasting steer prices through time series requires a measurement of the shifters of the supply and demand during the period under investigation. Shifts in supply or in demand curves are caused by the underlying factors that determine both curves. Variables that were assumed to be relevant supply and demand curves shifters were included in the equation and statistical test of significance were made.

An inverse impact of cattle slaughter (i.e., X_1) on steer price (i.e., Y) is the relationship that one would expect, that is an increase in the quantity slaughtered probably will be associated with a decrease in the price of steers.

$$Y = f(X_1)$$

Competing products (like calves, hogs, and poultry) that could influence the price of steers were included in the regression model. Monthly slaughter of these substitute products was hypothesized to exert an inverse effect on steer price. Statistical significance of the coefficients associated with such variables were tested at the 5 percent significant level.

Assuming substitution possibilities between beef and veal, an increase in calf slaughter should cause a decrease in the price of steers. So, the calf slaughter variable (i.e., X_2) was included in the regression equation:

$$Y = f(X_1, X_2).$$

Hog supply reflected through the number slaughtered (i.e., X_3) may influence the price of beef. Such a competitive commodity is hypothesized to have a negative sign in the associated coefficient. Thus the prediction model becomes the following:

$$Y = f(X_1, X_2, X_3)$$

The impact of positive changes in poultry production (i.e., X_4) is expected to depress steer prices. In this case, as in the case of hogs, the hypothesis formulates that such products are, to a certain degree, beef substitutes. The single equation incorporating this variable is:

$$Y = f(X_1, X_2, X_3, X_4)$$

Meats in cold storage (i.e., X_5) are hypothesized to have an impact on steer price because they are components of the total meat supply. The placement of meat in storage reduces the quantity available for consumption at that time, and logically would appear to exert a positive effect on steer prices. However, the accumulation of stocks may at the same time be viewed by the trade as available supplies which can be dumped on the market, and if so storage stocks may have an inverse impact on steer prices. All meats were aggregated because stored meat, regardless of the kind, is a potential supply competing with the fresh market. The availability of such meat and substitution possibilities are the contingencies upon which the inclusion of such variables in the model were based.

$$Y = f(X_1, X_2, X_3, X_4, X_5)$$

While it is not difficult to give an economic explanation of the effect of income on the quantity of beef demanded and on the resulting price level, some questions still remain concerning the use of deflated or undeflated income.

According to the consumer-oriented or psychological approach, if consumers have demonstrated money illusion, expenditures on meat should correspond to current income. On the other hand, if consumers' attitude towards income expenditure is based on real prices of goods and serivces, deflated income should be the variable to be included in the model. There is no clear answer to this question because the consumer's budget may be expended based on many decisions (taking into account both real and current income); also, some consumers have the real income criteria to make expenditure decisions and some do not. The use of either of the two in applied economic research is a matter of judgment.

The use of deflated income in the present model would require a forecast of the deflator, which in turn would generate one more source of error. Thus, undeflated per capita personal disposable income (i.e., X_6) and undeflated prices were utilized in the regression equation.

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6)$$

Thus, the steer price is assumed to be equal to the sum of the estimated relationship times the value of the respective variables (quantity slaughtered, meat storage, and income) plus the unexplained variation. The estimated steer price would be equivalent to the observed price less the respective error term.

STATISTICAL PROCEDURE

A multiple regression model estimated through ordinary least square method was used. In general terms, the following model was applied to the data:

$$Y_t = b_o + b_1X_{1t} + b_2X_{2t} + \dots + b_kX_{kt} + U_t$$

$$t = 1, 2, \dots n.$$

where,

Y_t = The t^{th} observation on the dependent variable

X_{it} = The t^{th} observation on the i^{th} independent variable, $i = 1, 2, \dots k$ if we have k independent variable

b_i = Unknown coefficient of the i^{th} independent variable

U_t = The t^{th} value of the disturbance term.

The least square method is based on the following assumptions:[1]

$E(U_t) = 0$

$E(U_t^2) = \sigma^2$

$E(U_tU_s) = 0$, where $t \neq s$

$E(U_tX_{it}) = 0$

X_i's, fixed in advance or not correlated with each other.

Variables in the present study were included in the regression model based on economic reasoning. Statistical tests of significance

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[1]For further information, see Harry H. Keleijan and Wallace E. Oates, Introduction to Econometrics, (New York: N.Y.: Harper & Row, Publishers, Inc.), 1974, pp. 121.122.

were performed to test the regression coefficients associated with each economic variable included in the model.

After having estimated the coefficients, summary statistics were computed to measure the explanation power of the regression.

Since the residuals show the extent of the movement in the dependent variable not explained by the independent variables, some measure relating the residuals to total variation in the dependent variable should be used. Such a measure is the square of the multiple correlation coefficient, also called coefficient of determination:

$$R^2 = 1 - \frac{\Sigma \hat{e}^2}{\Sigma (y-\bar{y})^2} \text{ or;}$$

$$R^2 = 1 - \frac{ESS}{TSS} = \frac{RSS}{TSS} \text{ where,}$$

$\hat{e}$ = unexplained residual.

ESS = Error Sum of Square (variation in the dependent variable not explained by the regression model)

RSS = Regression Sum of Square (variation in the dependent variable explained by the regression model)

TSS = Total Sum of Square (total variation of the dependent variable)

TSS = RSS + ESS

Thus, R^2 is the explanatory power of the regression model. The more of the variation in the independent variable the regression model explains, the closer R^2 will be to 1; the weaker the relationship between dependent and independent variables, the nearer R^2 will be to zero.

Even though the summary statistic, R^2 is widely used in applied research and will be used in the present paper, some comments about its misuse are necessary.

Briefly, R^2 from different specified regression equations should not be used as a measure that will select a best fitted equation in the following cases:

- Equations that are specified as having different functional forms;
- Different definitions of dependent variables related to the same set of independent variables;
- Equations with different numbers of explanatory variables.

Since it will be necessary to compare equations with different numbers of independent variables, some adjustments on R^2 should be made.

Due to the mathematical property of R^2, any time an additional variable is added to the equation, R^2 increases (or at least remains unchanged). This does not necessarily mean that the variable included expresses a causal relationship with the dependent variable. In other words, the residual sum of squares decreases (or at least remains unchanged) with any added variable, so the equation with the largest number of variables should yield the least residual sum of squares and hence the highest R^2.

To take care of this problem $\bar{R}^2$ was calculated and used. $\bar{R}^2$ is also called adjusted R^2 because it takes into account the degrees of freedom associated with the residual sum of squares (residual variance) and the degrees of freedom associated with the variation in the dependent variable. $\bar{R}^2$ is defined as follows:

$$\bar{R}^2 = 1 - \frac{VAR(\hat{e})}{VAR(y)} \quad \text{where,}$$

$$VAR(\hat{e}) = \frac{\Sigma \hat{e}^2}{N - K}$$

$$VAR(y) = \frac{\Sigma (Y - \bar{Y})^2}{N - 1}$$

N = Number of observations, and

K = Number of independent variables.

The reduction in the error sum of squares due to inclusion of one more variable could increase, decrease, or leave $\bar{R}^2$ unchanged, simply because the residual variance could probably move in any direction causing the change in $\bar{R}^2$ to be unpredictable. Thus, $\bar{R}^2$ will be reported with the estimated regression equations to show the sensitivity of the model to a decrease in the number of independent variables whenever this procedure is necessary.

Often variables were included or excluded from the equation based on the respective t-statistics. Whenever such a test was performed at given significance levels, it was hypothesized that, according to the null hypothesis, the coefficient is equal to zero. The t-statistic is defined as:

$$t = \frac{\text{Estimated coefficient of the varible Xt}}{\text{Standard error of the estimate of the coefficient of Xt}}$$

Usually a rule of thumb is used to test hypotheses about the estimated coefficient. If the absolute value of the t-statistic is greater than or equal to two, then the estimated coefficient is said to be statistically different from zero at 5 percent significant level. This means that there is a significant relationship between the tested explanatory variable and the one to be explained.

Finally, we should consider one more "statistic" used in the present study as a tool to understand the empirical results. The Durbin-Watson statistic is a test developed with the objective to determine whether or not the error terms are successively correlated with each other.

The basic assumption for computing the standard errors of regression coefficients is that the successive observations in the error terms are independent. Such an assumption does not quite hold whenever time series is used in estimating regression equations. Thus, the residual for successive months may be significantly positively correlated. In this case, the calculated standard error will be underestimated or, in other words, the t-statistics will be over-estimated.

The existence of correlation between successive residuals can be tested by the Durbin-Watson statistic.[1]

The formula used to calculate this statistic is the following:

$$d = \frac{\Sigma(\hat{e}_t - \hat{e}_{t-1})^2}{\Sigma\hat{e}_t^2}$$

Where $\hat{e}_t$ is the unexplained residual for the t^{th} observation.

If the following assumption of the regression model holds, $E(U_s U_t) = 0$ for $s \neq t$, we have no auto-correlation.

By using a table given by Durbin and Watson, we can test whether or not there is auto-correlation. In order to use these tables we need the total number of observations (n), the number of parameters (k) in the equation (excluding the constant term), and the level of significance. Associated with (n), (k), and given level of significance, the table gives us the lower limit (dl) and upper limit (du). If d is either greater than (4 - dl) or less than dl, there may be significant serial correlation. If d has a value between (4 - du) and du the auto-correlation is absent. But if d value lies between dl and du or between (4 - du) and (4 - dl), the test is inconclusive.

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[1]Durbin, J. and G. S. Watson, "Testing for Serial Correlation in Least Square Regression," Biometrika, Vol. 38, 1951, pp. 159-177.

One other problem that arises from a model of the type used in this paper is the presence of multicolinearity (violation of the assumption that x's are not correlated with each other).

Whenever one explanatory variable is highly correlated with another explanatory variable multicolinearity is present.

There is no formal test[1] to check the presence or absence of multicolinearity. The problem that the researcher faces is the various degrees of multicolinearity. The presence of multicolinearity increases the standard error of the coefficients, thereby lowering the value of the t-test.

In cases where the regression equation is used to predict the future value of the dependent variable, the accuracy of the prediction probably will not be affected by the presence of multicolinearity if it is expected to occur in the future.

Finally, other problems in empirical studies involve the choice of the true mathematical functional form. Seldom is the economic relationship explicit about the functional form. Linear and logarithmic equations are often used in economic analysis.

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[1] Some text books suggest that a high R^2 associated with a low t ratio could be one symptom of the presence of multicolinearity. Some others indicate that an inspection in the correlation matrix should give some insight about the degree at which independent variables are intercorrelated. Another rule of thumb says whenever one or more suspect multicolinear variables are deleted from the model the size of the t-test associated with the remaining variables should substantially increase.

EMPIRICAL RESULTS

NON-LAGGED MODEL

The economic relationship among variables specified in the original regression equation is discussed in order to determine the most adequate model. Various models will be presented along with each estimated regression equation. The absolute value of the t-statistics will be reported under each respective coefficient. The value of R^2 as well as $\bar{R}^2$ and Durbin-Watson statistic (d) will be shown for each corresponding equation.

Firstly, the regression equation corresponding to the original model as it was specified in earlier chapters will be described. Based on economic reasoning and statistical considerations, variables will be dropped from or added to the original model.

Data Unadjusted for Population Effects

At first, all specified variables enter the model at the same time period. The hypothesis is that the price of steers will change at the same point in time as changes occur in the independent variables. This equation does not allow for lag adjustments in the market mechanism. Thus, the estimated prediction equation is:

$$\begin{aligned} Y = 24.31 &- \underset{(12.91)}{.00836X_1} + \underset{(1.24)}{.00593X_2} + \underset{(1.81)}{.001515X_3} + \underset{(.338)}{.00043X_4} \\ &- \underset{(8.21)}{.00964X_5} + \underset{(27.57)}{.01149X_6} \qquad (1) \end{aligned}$$

$R^2 = .897$ $\bar{R}^2 = .894$ d = 1.1681

Where: Y, X_1, . . ., X_6 are as defined under the Chapter entitled Data.

Equation (1) shows that about 90 percent of the variation in monthly steer prices is explained by the six explanatory variables. In terms of economic relationship, some coefficients have unexpected signs in this first model. Veal, pountry and pork are traditionally taken as competing products for beef at the consumer level and would be expected to carry negative coefficients.

A rise in the quantity slaughtered of any of them should cause a drop in their prices and consequently, a rise in their consumption. An increase in the consumption of any beef substitutes would normally reduce beef consumption. As beef consumption decreases, so does demand for cattle and cattle prices. Therefore, calves, hogs and poultry would be expected to have an inverse impact on beef prices.

The statistical analysis revealed that no significant substitute relationships were present in equation (1). On examining the statistical results for each unusual-sign-variable their respective t-ratios were found to be statistically non-significant. In other words, at the 5 percent significance level one would accept the null hypothesis that these coefficients are equal to zero and no relationship is present between this subset of independent variables and the dependent variable.

From the economic point of view it is concluded tentatively that only a weak (if any) substitute relationship existed between cattle and the set of substitute products (calf, hog, and poultry) at the live animal market level from 1955 to 1974.

The coefficients associated with cattle slaughter, per capita disposable income, and meat storage, show signs consistent with economic expectations. For example, an increase in per capita disposable income is expected to shift demand to the right. Other things being equal, both price and tonnage of cattle slaughter should increase. The inverse relationship expressed by meat storage is also consistent with economic postulates. An increase in the quantity of meat stored might be construed as a decrease in supply available for immediate consumption, but the expectation of its being dumped on the market apparently has a negative effect on steer prices.

Before any sound conclusions are taken from the first equation some weakness of the model should be pointed out. A time series analysis like the one performed in this paper presents problems with respect to estimation procedure.

A high degree of interdependence among explanatory variables (multicolinearity), as mentioned in earlier chapters will make the t-ratio less reliable but still will give unbiased estimates. Some variables used in the model exhibited a markedly upward or downward trend during the period studied. Cattle slaughter trended steadily upward as well as per capita disposable income. This indicates the possible presence of multicolinearity.

A simple correlation matrix is presented on the next page, and shows simple correlation among the explanatory variables as one possible indication of the existence of multicolinearity.

Another uncomfortable situation that arises when the least square method is applied to time series data, as was pointed out earlier, is

	Y	X_1	X_2	X_3	X_4	X_5	X_6
X_1	0.59103	1					
X_2	-0.61280	-0.61639	1				
X_3	-0.02260	0.30138	-0.33112	1			
X_4	0.61001	0.82862	-0.64528	0.30226	1		
X_5	0.41695	0.63106	-0.61745	0.49224	0.45261	1	
X_6	0.88429	0.84927	-0.72896	0.15421	0.76191	0.66754	1

the possibility of auto-correlation among the non-explained portion of the dependent variable (steer price). The Durbin-Watson test statistic shows the existence of auto-correlation in the model.[1]

Another estimation problem is the risk of using an inadequate functional form to analyze the process underlying the determination of steer prices.[2]

$$Y = 24.78 - \underset{(5.22)}{.00500X_1} - \underset{(3.25)}{.02867X_2} + \underset{(1.40)}{.00113712X_3} + \underset{(1.04)}{.00135X_4} -$$

$$\underset{(8.82)}{.00996X_5} + \underset{(24.49)}{.01315X_6} - \underset{(4.59)}{.06833T} \qquad (1.1)$$

$R^2 = .906$ $\qquad \bar{R}^2 = .903$ $\qquad d = .944$

Equation (1.1) adds a time variable to the previous six independent variables. This variable is expected to work in such a way as

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[1]Various authors suggest the use of "first difference," because of certain technical reasons which would result in a reduction of the correlation between the independent variables, and of serial correlation in residuals. Those options were explored and the results are shown in Appendix B.

[2]Multiplicative relationship of the form: $\hat{Y} = \hat{b}_o X_1^{\hat{b}1} X_2^{\hat{b}2} X_3^{\hat{b}3} X_4^{\hat{b}4} X_5^{\hat{b}5} X_6^{\hat{b}6}$ was explored. An equation in log form as follows: $\log\hat{Y} = \log \hat{b}_o + \hat{b}_1 \log X_1 + \hat{b}_2 \log X_2 + \hat{b}_3 \log X_3 + \hat{b}_4 \log X_4 + \hat{b}_5 \log X_5 + \hat{b}_6 \log X_6$ was also explored. (See Appendix B.)

to account for the effect of linear trend. The inclusion of the time variable would probably avoid some strong spurious relations in the regression equation. In the period under investigation, calf slaughter presented a decreasing trend over the period investigated. Per capita disposable income and price of steers seem to contain an upward trend component.

Equation (1.1) has an $\bar{R}^2$ of .903, slightly higher than the $\bar{R}^2$ of equation (1) due to the fact that a time variable entered the model with a significant t-ratio showing that "time" is statistically an important variable. Including "time" in the model, increases the possibility of interdependence between this variable and income since both are moving steadily upwards. The auto-correlation is again present and d dropped from 1.17 to 0.944.

The advantage of equation (1.1) over equation (1) is the fact that the calf slaughter coefficient now has the correct sign (negative) in accordance with the postulated economic relationship between steer prices and calf slaughter.

It is noted in equation (1) that the variables--calf, hog and poultry--which do not have the anticipated depressing effect on steer price are also those whose t-statistics are less than two. If all assumptions related to the least square method hold, this would suggest that there does not, in fact, exist an inverse relation between steer price and calf slaughter, hog slaughter or poultry production. Thus, the lack of logical explanation for the behavior of beef competing products as well as the statistical non-significance of these variables cause them to be deleted from equation (1) with little loss in explanatory power. R^2 decreased only by .002.

Equation (1.1) has the same pattern as the first model, in that variables not consistent with economic logic are also those whose standard errors do not exceed twice the size of their respective coefficients, i.e. their t-ratios are less than two. On deleting these variables from equation (1.1), results seem improved as far as theoretical economic relationship is concerned.

The following equations were generated by the first two models discussed above:

$$Y = 27.19 - .00813X_1 - .00874X_5 + .01099X_6 \qquad (2)$$
$$(15.50) \quad (9.24) \quad (37.3)$$
$$R^2 = .895 \qquad \bar{R}^2 = .893 \qquad d = 1.27$$

$$Y = 25.07 - .00461X_1 - .02827X_2 - .00958X_5 + .01298X_6 - .06429T \qquad (2.1)$$
$$(4.89) \quad (3.26) \quad (10.18) \quad (24.45) \quad (4.51)$$
$$R^2 = .904 \qquad \bar{R}^2 = .901 \qquad d = .991$$

From model (1) to model (2), $\bar{R}^2$ decreased by .001, which indicates that a small variation in steer price was accounted for by calf slaughter, hog slaughter and poultry production--the deleted variables. All the coefficients show a strong relationship with the price of steers; this can be seen by the high values of the t-ratios.

Cattle slaughter, per capita disposable income, and meat storage, all together explained almost ninety percent of the variation in the choice slaughter steer price over the period January 1955 to December 1974.

To illustrate the potential uses and pitfalls of this model, 1975 data were used to test how accurately the more appropriate equation would predict steer price beyond the estimation period.[1]

[1] The expost forecast in this study is provided only as a means of evaluating the model.

To use this equation (or any equation presented so far) for prediction purpose, one must predict the values of the independent variables.

The results in the table below show the comparison between actual and predicted steer prices. The difference between each actual and predicted price is reported as the prediction error. The directions of changes for each actual and predicted steer price are reported under the direction of changes columns. These, combined with the graph, show how well the model predicted the turning points.

The errors in Table 1 show that predictions beyond the estimation period using the model (2) are not as reliable as the predictions within the estimation period--1955-74. Abnormally low prices at the beginning of the year made the model overestimate the price, giving rise to two of the largest errors (in absolute value) over the evaluation period. If the direction of changes is taken as another measure of evaluation, Table 1 shows that model (2) predicted changes in wrong directions only four times out of twelve. This fact does not obscure the inability of the equation to predict the magnitude of steer prices. From the turning point evaluation, the arrows in the direction of changes columns and Figure 4 provide the necessary elements for the analysis. If we look at the direction of changes columns from top to bottom (or vice-versa), whenever the arrows point in opposite directions, they constitute a turning point. The turning point is correctly predicted when the actual data turning point is recorded, and the model predicts this turning point. The only time that model (2) correctly predicted the turning point was in the month of June. Equation (2) failed to predict turning point in February, August and September. Also there is a case (October) where a turning point is incorrectly

TABLE 1

COMPARISON BETWEEN ACTUAL AND PREDICTED STEER PRICE, 1975

Month	Actual	Predicted Equation (2)	Error* (2)	Directions of Changes: Actual	Directions of Changes: Predicted	Predicted Equation (2.1)	Error (2.1)	Directions of Changes: Actual	Directions of Changes: Predicted
	(Dollars per hundredweight)								
January	36.34	39.72	-3.38			40.21	-3.87		
February	34.74	44.45	-9.71			43.95	-9.21		
March	36.08	46.05	-9.97			45.62	-9.54		
April	42.80	46.43	-3.63			46.02	-3.22		
May	49.48	48.13	1.35			47.61	1.87		
June	51.82	49.73	2.09			49.09	2.73		
July	50.21	48.11	2.10			47.20	3.01		
August	46.80	47.65	- .85			47.25	- .55		
September	48.91	47.01	1.90			46.79	2.12		
October	47.90	43.43	4.47			43.65	4.25		
November	45.23	46.68	-1.45			46.00	- .77		
December	45.01	47.16	-2.15			47.32	-2.31		

*Error = Actual - predicted

predicted. This situation arises when there is no actual turning point, but one is predicted. The model performed favorably in the months of March, April, May, July and December when the actual data did not exhibit turning points and model (2) correctly did not predict any turning points.

In general, from the turning point criteria as well as from the magnitude of the prediction error, the model did not predict accurately.

Table 1 also shows the results of prediction when equation (2.1) is evaluated. As one can see, in both equations the results are similar.

The results discussed up to this point suggest several additional generalizations. The coefficient of per capita disposable income was significant in all cases related and in some earlier statistical explorations. Also, the economic relationship between steer prices and income, in all cases, was the expected one. The price of steers appears to have been highly sensitive to changes in cattle slaughter. In all estimated regression equations, this variable was highly significant. Another important factor affecting the live animal market price in the period under investigation was the quantity of meat in storage at the beginning of the month. In all cases this variable was consistent with economic expectations and highly significant from a statistical standpoint. These three variables together accounted for about 90 percent of the variation in the price of steers during the period 1955 to 1974. Thus, cattle slaughter, per capita disposable income and meat storage inventories were the main factors determining steer prices during that period.

The regression coefficients for the variables that entered the equation as beef substitutes, were statistically significant only in some of the equations. Also in some cases they did not have the expected inverse relationship with steer price.

In view of this result, some considerations about the prediction ability of the model and the interpretation of the coefficients will be based on the equation that includes only those highly significant factors just mentioned above.

For purposes of interpretation of the estimate coefficient equation (2) will be used. Any other equation seems to underestimate the effect of cattle slaughter on its own price when compared with previous studies.[1] As mentioned in previous chapters the single equation least square is not the most adequate method to estimate price flexibility because the assumptions imposed by the method would probably not hold in the short-run for the beef sector of the economy.

As expected, monthly cattle slaughter had an inverse relationship with monthly average steer prices. An increase in cattle slaughter of one million pounds live weight was associated with a decrease in the price of steers by \$0.0083 per hundredweight. At an average (1955-74) steer price of \$28.13 per hundredweight and a monthly average cattle slaughter of 2554.2 million pounds, the price flexibility coefficient for beef was -.74.[2] That is a ten percent increase in the

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[1]For a comparison among several estimates of price flexibilities published by several authors, see Langemeier and Thompson, Table 2, p. 177.

[2]This price flexibility coefficient is calculated as follows: $\frac{\partial Y}{\partial X_1} \cdot \frac{\bar{X}_1}{\bar{Y}}$, where the derivative of Y with respect to X_1 is -.00813 (according to equation (2)) and the ratio $\frac{\bar{X}_1}{\bar{Y}}$ is $\frac{2554.2}{28.13}$, so the resulting price flexibility is: $-.00813 \cdot \frac{2554.2}{28.13} = -.74$.

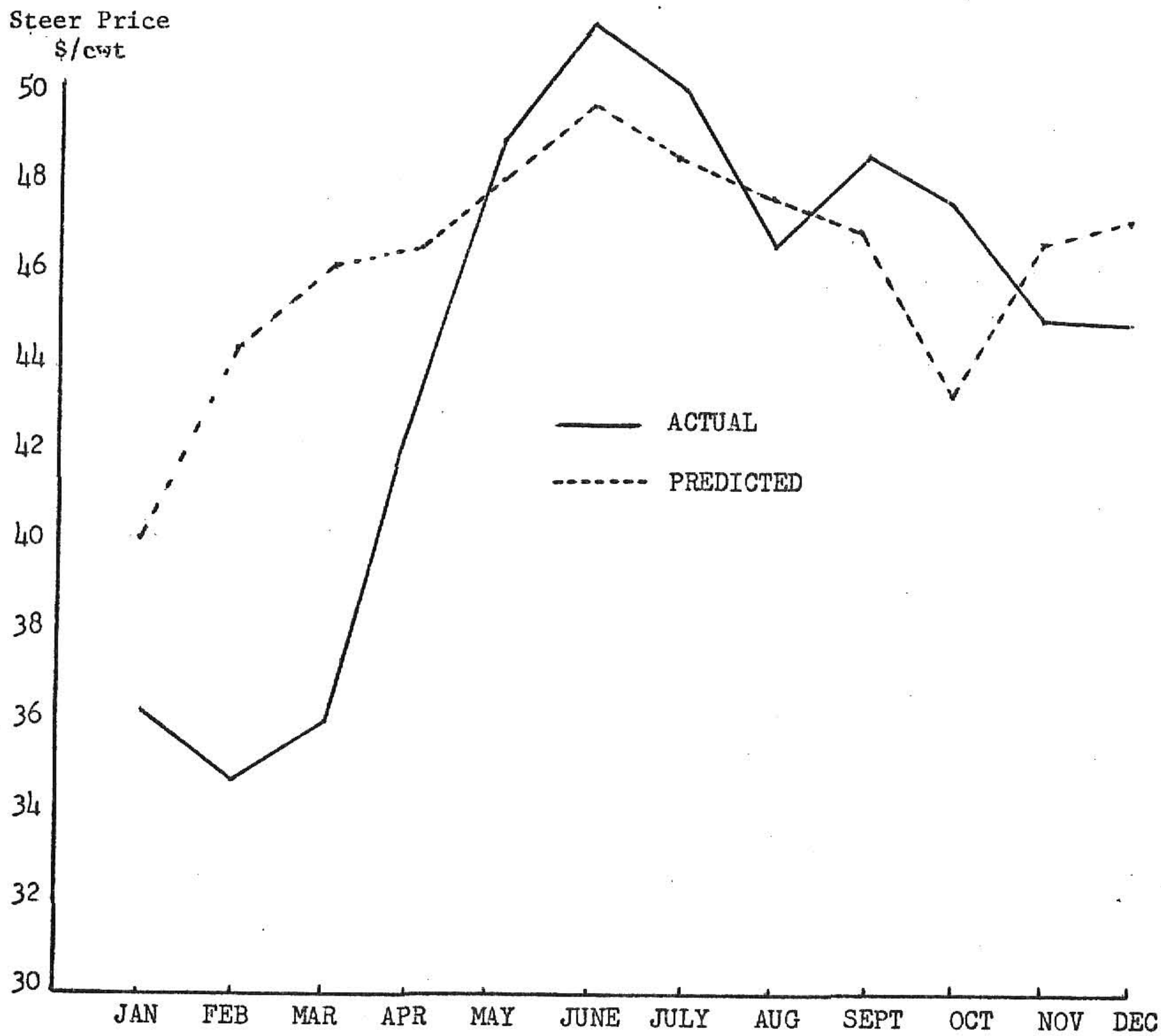

Figure 4. Comparison Between Actual and Predicted Steer Price--Equation (2)--1975[1]

[1] For a comparison between actual and estimated steer prices during the estimation period see Appendix C.

live weight of cattle slaughtered was associated with a decrease in the price of steers of 7.4 percent.[1]

By definition, price flexibility is sensitive to higher or lower quantity--price ratios employed in its computation.[2] If we take the price and quantity related to the month of January 1975, the price flexibility turns to be -.80 because steer price is equal to $36.34, and quantity slaughtered reached the amount of 3.590 million pounds causing a different quantity-price ratio.

Another datum that could be obtained from equation (2) is the relationship between income and price of beef. An increase in per capita disposable income is associated with an increase in demand for beef and beef products causing also an increase in live cattle prices. Thus, the positive sign associated with per capita disposable income is the expected one. One dollar increase in per capita disposable income is associated with an average increase of $0.0109 per hundred-weight in the price of steers. An increase of one million pounds of meat storage was associated with a decrease of $0.00874 per hundred-weight in steer prices.

In terms of prediction, all equations performed quite similarly. The innacuracy of the model in predicting steer prices is probably the result of its failure in capturing the unusual circumstances in the

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[1]This coefficient is low if compared with -1.338 reported by Hayenga and Hacklander, p. 19. Although both models are quite similar, different time periods were used to estimate the coefficients and different definitions for some variables were used.

[2]This is valid whenever a linear relationship is estimated. If a rectangular hyperbola were the estimated equation, the price flexibility would remain constant throughout the entire period. The coefficients of the logarithmic equations in Appendix B yield a constant price flexibility.

market of the live cattle during 1975. For instance, in February and March the price of slaughter steers reached the lowest point since autumn of 1972.

Until 1974, the beef sector showed a trend toward increasing slaughter of grain fed cattle but in 1975 cows and non-fed steers and heifers occupied a larger proportion in the slaughter mix than the preceding years. Furthermore, in the recent past, cattle prices have remained relatively stable compared with the fluctuations which occurred in 1973-1975. In 1975 steer prices ranged from $34.74 per hundredweight in February to $51.82 in June and to $45.01 in December.

These factors apparently suggest that some structural change is taking place in the beef market and simple past market performance will not be able to reflect accurately the recent apparent changes in the beef market.

The inability of the model to capture these apparent changes is reflected through large errors of predictions and inaccuracy in prediction of turning points. In some cases the direction of the changes was predicted correctly, but more often than not the size of the changes turned out to be larger or smaller than predicted.

Data Adjusted for Population Effects

The next step was to correct the variables for the effect of the trend to population growth during the period 1955-1974. Thus, to avoid confusing the trend due to population growth with the trend due to general economic growth, monthly cattle slaughter, calf slaughter, hog slaughter and poultry production in the price equation were put on a per capita basis by dividing by monthly population figures.

The two following equations were estimated:

$$Y = 25.54 - \underset{(4.92)}{.93658X_1} - \underset{(3.15)}{5.08550X_2} + \underset{(1.38)}{.20732X_3} + \underset{(.73)}{.18292X_4} - \qquad (3)$$

$$\underset{(8.69)}{1.87919X_5} + \underset{(23.01)}{.01374X_6} - \underset{(6.28)}{.09789T}$$

$R^2 = .905$ $\bar{R}^2 = .902$ $d = .927$

$$Y = 26.89 - \underset{(4.64)}{.87036X_1} - \underset{(3.21)}{5.10468X_2} - \underset{(10.11)}{1.80513X_5} + \underset{(22.91)}{.01363X_6} - \qquad (3.1)$$

$$\underset{(6.51)}{.09685T}$$

$R^2 = .904$ $\bar{R}^2 = .902$ $d = .972$

Where the variables used in these equations are as previously described, but are now on a per capita basis.

It is observed from equation (3) that again the non-significant variables had the non-expected economic relationship with the price of steers. As was previously noticed, including time as a variable, the calf slaughter coefficient became negative and statistically significant. Again, hog and poultry supply variables in equation (3) had coefficients with illogical signs. However, the coefficients were non-significant at the 5 percent level.[1] Consequently, those variables were dropped in equation (3.1).

The model represented by equation (3.1) shows an $\bar{R}^2$ identical to the one yielded by equation (3). This means that the inclusion of the two variables (X_3 and X_4) does not reduce enough the residual variance to account for the loss in the degrees of freedom. In terms of explanatory

[1]The sign of the coefficient for hogs does not agree with Hayenga and Hacklander, p. 18.

power, both equations contributed the same amount to reduce the unexplained variation in the price of steers.

The use of the equation with a smaller number of explanatory variables has an advantage. Stemming from the fact that any conditional model requires a forecast of the predetermnned variables before steer price can be predicted. Thus, the amount of error due to forecast predetermined variables should be smaller in equation (3.1).

Table 2 shows the comparison between actual and predicted steer prices. The difference between actual and predicted is the error reported with the associated sign. The direction of changes in the actual and predicted price of steers is also reported in that table.

No detailed discussion is necessary since this model has the same degree of accuracy as the previous ones.

It is probable that the rigidity of the model and "some rather drastic changes"[1] in the beef industry during 1975 made the conceptual model fail in its predictive power.

DEVIATION FROM THE TREND MODEL

This model is conceptually similar to equation (1.1) and equation (3). In the present case, each individual variable has the trend component eliminated before entering the causal relationship.

The model is the following:

$$\Delta Y = f(\Delta X_1, \Delta X_2, \Delta X_3, \Delta X_4, \Delta X_5, \Delta X_6)$$

where Δ's stand for deviation from linear trend and is defined as:

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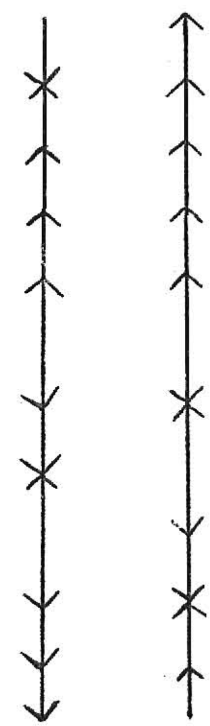
[1] James E. Nix, Grain-fed Versus Grass-fed Beef Production. Livestock and Meat Situation (Washington: Government Printing Office, 1975) April 2, p. 37.

TABLE 2

COMPARISON BETWEEN ACTUAL AND PREDICTED STEER PRICE--1975

Month	Actual	Predicted Equation (3.1)	Error Equation (3.1)	Direction of Changes Actual	Direction of Changes Predicted
	(Dollars per hundredweight)				
January	36.34	40.79	-4.45		
February	34.74	44.25	-9.51		
March	36.08	45.90	-9.82		
April	42.80	46.41	-3.61		
May	49.48	47.99	1.48		
June	51.82	49.29	2.52		
July	50.21	47.63	2.57		
August	46.80	47.66	- .87		
September	48.91	47.33	1.58		
October	47.90	44.65	3.24		
November	45.23	46.75	-1.52		
December	45.01	47.97	-2.96		



$\Delta Y = Y - \hat{Y}$ where $\hat{Y} = \hat{a} + \hat{b}T$

$\Delta X_i = X_i - \hat{X}_i$ where $\hat{X}_i = \hat{a} + \hat{b}T$

where T is month and T = 1, 2, . . . 240, and

X's are dependent variables and i = 1, 2, . . . 6.

The empirical estimated model corresponding to equation (1.1) is:

$$Y = .00002 - \underset{(5.23}{.0050\ X_1} - \underset{(3.25)}{.0287\ X_2} + \underset{(1.24)}{.0010\ X_3} + \underset{(1.17)}{.0015\ X_4} - \underset{(8.6)}{.0097\ X_5} + \underset{(24.3)}{.0131\ X_6} \quad (4)$$

$R^2 = .793$ $\bar{R}^2 = .787$ $d = 1.16$

Except for some rounding error, equation (1.1) and the one above give essentially the same information. The coefficients are extremely close to the first model. R^2 is not comparable since the "absolute" model (i.e. equation (1.1)) has one more variable than the "deviation from the trend model" (i.e. equation (4)).

Since these regression coefficients present the same relationship with price of steer as equation (1.1), there is no need for extensive discussion. However, it is worthwhile to comment that by fitting a more appropriate trend curve (i.e. more appropriate than the linear trend used) to individual variables one could probably obtain better results. No attempt in the present study was made in this direction. But, if a different functional form were applied to different individual variables, the similarity between equation (4) and equation (1.1) probably would not hold. In equation (1.1) the linear trend was isloated by use of "time" as a variable. In case (4) the linear trend was purged and its effect entered the equation through the "trend adjusted varibles."

LAGGED MODEL

In attempting to incorporate all specified variables in one linear regression equation several hypotheses were tested concerning the responsiveness of steer prices to changes in lagged dependent variables.

Introducing the dynamic element in the equation through the use of time lag, the model assumed no immediate adjustment in the market mechanism that determines the price of steers.

There is no clear evidence about the length of the time period during which adjustments take place in the beef market. Some statistical exploration was performed and the most promising result will be discussed in this chapter.

Since the objective of this study is neither to determine the leading price in the meat marketing channel nor to analyze the timing relationship between price and quantity, further discussion with respect to this subject will not be made. For a study of that nature, a more appropriate technique such as spectral[1] and harmonic[2] analysis should be used. As was mentioned before, the main purpose of this paper is to find a sound economic quantitative relationship between steer price and a set of independent variables.

The models discussed in earlier chapters differs from the one discussed in the present, due to the fact that the latter allows for

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[1]Hiram C. Barksdale, Jimmy E. Hilliard and Mikael C. Ahlund, "A Cross-Spectral Analysis of Beef Prices," American Journal of Agricultural Economics, Vol. 57, No. 2, 1975, pp. 309-315.

[2]John R. Franzman and Rodney L. Walker, "Trend Models of Feeder, Slaughter and Wholesale Beef Cattle Prices," American Journal of Agricultural Economics, Vol. 54, No. 3, 1972, pp. 507-512.

a period of time during which the explanatory variables affect steer prices.

Both sets of models--nonlagged and lagged--are similar as far as the functional form and the specified variables are concerned.

The traditional assumption in meat marketing is that the demand for live animals is directly dependent upon the demand for meat, which implies that retail price level is the leading one.[1] In other words, this study has accepted that, "according to economic theory, the demand for resources is derived from the final consumer demand which finds its first market expression at the retail level."[2] So, any changes in the retail market are passed through the marketing channels until they reach the live animal market.

After some tentative exploration the model assumed the following relationship:

$$Y_t = f(X_{1t}, X_{2(t-1)}, X_{3(t-1)}, X_{4(t-1)}, X_{5(t-1)}, X_{6(t-1)})^3$$

This is still a conditional model since cattle slaughter is related to steer price at the same point in time. Also in this model cattle slaughter is assumed to be a predetermined supply variable.

The remaining explanatory variables were lagged behind by one month. In other words, the effects of those variables are hypothesized to be felt on steer prices after one month. The period of time that

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[1]For a different approach see, Hiram C. Barksdale, Jimmy E. Hilliard and Mikael C. Ahlund. p. 315.

[2]John R. Franzman and Rodney L. Walker. p. 510.

[3]Where t is the current month and t-1 is the month before. For example, if t is for February, t-1 is January.

allows for the market adjustment was assumed to be the shortest possible--one month.[1]

The empirical estimated relationships were as follows:

$$Y_t = 33.26 - \underset{(13.75)}{.00776X_{1t}} - \underset{(2.58)}{.01175X_{2(t-1)}} - \underset{(3.47)}{.002853X_{3(t-1)}} - \qquad (5)$$

$$\underset{(2.50)}{.002976X_{4(t-1)}} - \underset{(6.106)}{.007049X_{5(t-1)}} + \underset{(27.83}{.01088X_{6(t-1)}}$$

$R^2 = .905$ $\bar{R}^2 = .902$ $d = 1.12$

Thus, equation (5)--the lagged version of model(1)--is the only model up to this point that contains all specified variables with two distinguishing characteristics: all the explanatory variables are statistically significant, and for the first time the sign of each coefficient conforms with economic expectations.

Estimates show that the lagged model resulted in a slight improvement over previous ones as far as R^2 and d statistics are concerned. But like the earlier regression equations the present one did not show any improvement in the predictive power beyond the period in which the original parameters were obtained.

The market relationship between steer prices and a set of lagged explanatory variables is shown in the above equation. Cattle slaughter was the only independent variable in the model without time lag involved. This suggests that steer prices react in the same period as changes occur in number of cattle slaughter. Activities in the cattle market are, perhaps, performed faster than activities

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[1]In the present study the shortest lag period that can be used is one month lag, since monthly figures are used in the analysis.

in the market of the cattle competing products. Also the translation of the consumer's decision into the live animal market level for cattle is performed quickly enough to allow response in the same time period. Thus, there are no lags between the time decisions are made and the time they are carried out through the cattle marketing channels.

As expected, cattle slaughter had an inverse relationship with steer prices. A one million pound increase in liveweight of cattle slaughter in time t will generate enough increase in beef supply to cause steer prices to drop by $0.00776 per hundredweight at the same point in time.

The time required for marketing activities to be carried out combined with the delay in consumer's reaction suggest that beef competing products have a time lag in their relationship with steer price at the live animal market level.

An increase of one million pounds liveweight in calf slaughter in the previous month (t-1) would depress steer price in month (t) by $0.01175 per hundredweight.

A negative sign was expected on the hog slaughter variable. An increase in commercial hog slaughter in time (t-1) will cause a decrease in hog prices in time (t-1) which in turn causes an increase in pork consumption in t. When pork consumption increases in t, beef consumption will probably decrease in t. The decrease in beef consumption will affect negatively the demand for cattle slaughter, and both demand and prices in the live animal market will probably decrease in the month t. Thus, one million pound increase in liveweight of hog slaughter in time (t-1) was associated with a decrease in beef price of \$0.002853 per hundredweight in time t.

For the first time poultry production appears in the model with a negative sign associated with its coefficient and with a t- ratio greater than 2 or statistically significant at the 5 percent significance level. A poultry production increase of one million pounds were associated with a steer price decrease of \$0.002976 per hundredweight. Here again, the increase in poultry production in time (t-1) affected steer prices in time t.

Meat storage is again an important variable that helped to explain variation in steer prices. This variable has an inverse relationship with price as theory would suggest. A meat storage increase of one million pounds in time (t-1) was associated with a steer price decrease of \$0.007049 in t, holding other factors constant.

It seems reasonable that income earned in month (t-1) will likely be expended on month t. Since it could be assumed that per capita disposable income is not related to the same point in time with beef consumption, we would therefore have a sequence over time in which steer price in one month is related to per capita disposable income in the previous month.

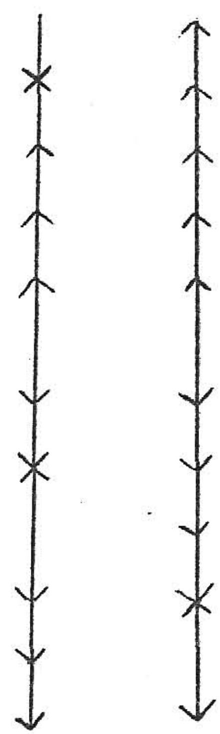
The theoretically expected sign associated with per capita disposable income was again found. An increase of \$1 in per capita disposable in time (t-1) was associated with an increase of \$0.01088 per hundredweight in the price of steer in t.

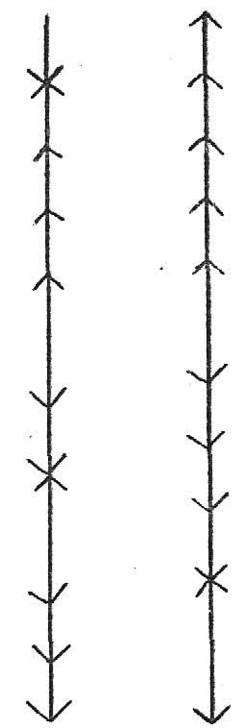
Table 3 shows again large prediction errors when the lagged model is evaluated beyond the estimation period.

TABLE 3

COMPARISON BETWEEN ACTUAL AND PREDICTED STEER PRICE, 1975

Month	Actual	Predicted Equation (5)	Error Equation (5)	Direction of Changes: Actual	Direction of Changes: Predicted	Predicted Equation (5.1)	Error Equation (5.1)	Direction of Changes: Actual	Direction of Changes: Predicted
				(Dollars per hundredweight)					
January	36.34	40.61	-4.27			43.11	-6.77		
February	34.74	43.75	-9.01			43.47	-8.73		
March	36.08	45.62	-9.54			45.97	-9.87		
April	42.80	46.77	-3.97			46.94	-4.14		
May	49.48	47.22	7.26			47.64	1.84		
June	51.82	49.04	2.78			49.60	2.22		
July	50.21	48.99	1.22			49.17	1.04		
August	46.80	47.78	- .98			48.07	-1.90		
September	48.91	46.94	1.97			47.05	1.86		
October	47.90	44.26	3.64			45.13	2.77		
November	45.23	46.88	-1.65			47.48	-2.25		
December	45.01	46.03	-1.02			46.93	-1.92		





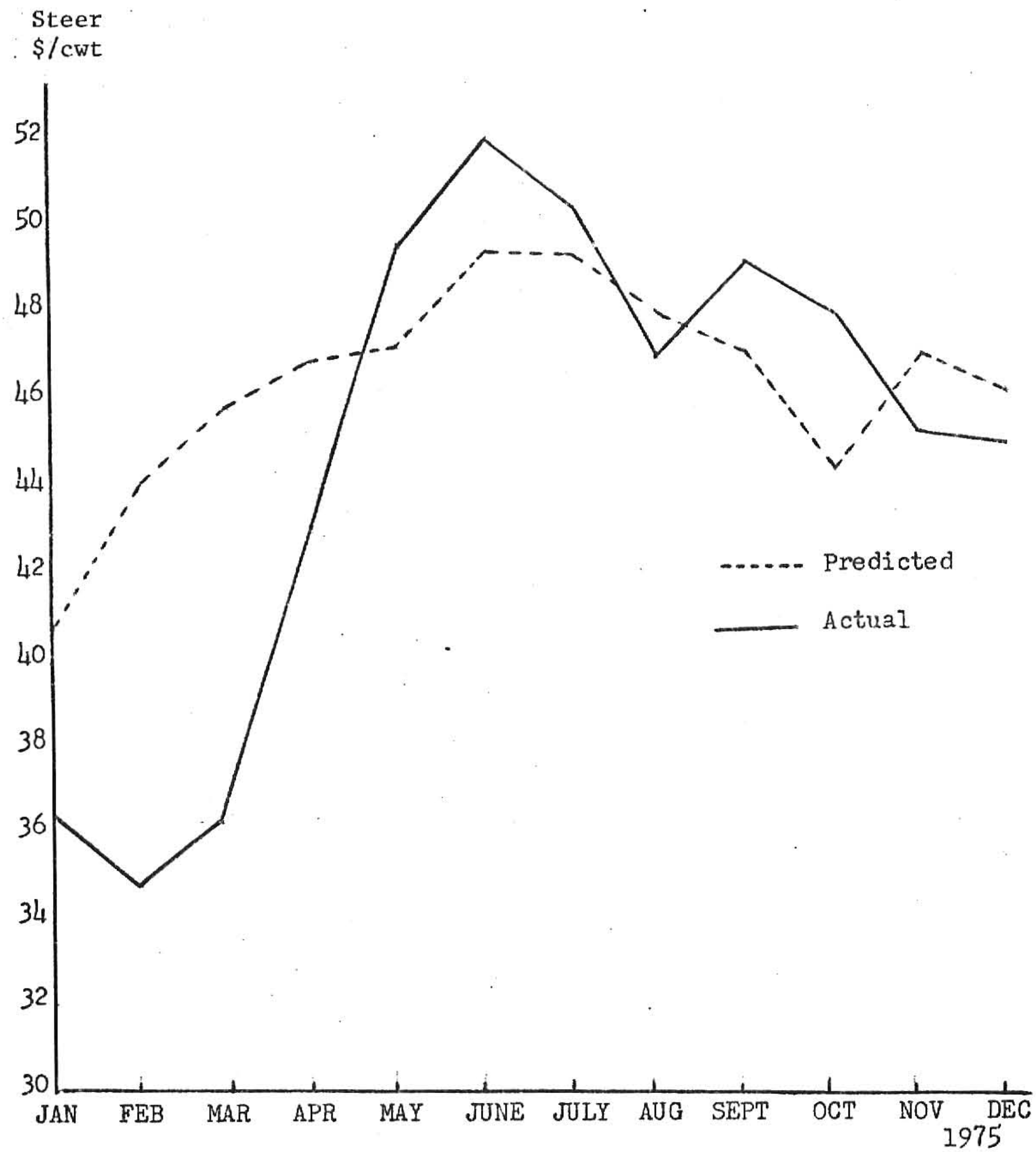


Figure 5. Comparison Between Actual and Predicted Steer Price--Equation (5)--1975[1]

[1]For a comparison between actual and predicted steer price during the estimation period see Appendix C.

Analysis of the turning point is important because trends once started usually continue some time in the same direction. The lagged model in a few cases predicted correctly the turning points, but more often than not the predicted price was larger or smaller than the observed. In two out of twelve cases, (October and November) the turning points were incorrectly predicted; in one case (June) the turning point was correctly predicted. Turning points which occurred were not predicted in three months (February, August and September). Finally, in four cases (March, April, May and July), the turning points were neither predicted nor recorded.

It is believed that for the same reasons both sets of models--lagged and non-lagged--did not perform quite as well as it did from 1955-74 as can be interpreted by the relatively high R^2. Discussion of this subject in the earlier part of this chapter is applied to the present situation and there is no need for repetition.

In order to allow for non-measurable factors, dummy variables were included in lagged model equation (5.1).

$$Y_t = f(X_{1t}, X_{2(t-1)}, X_{3(t-1)}, X_{4(t-1)}, X_{6(t-1)}, D_1, \ldots D_{11})$$

Not all the steer price determinants are direct measurable factors. Tastes, preferences, religion and weather, are good examples of demand determinants for which direct measurement if not impossible is rather difficult.

To account for those factors and possible seasonal movements in the production side, dummy variables were included in the model. Thus, monthly dummy variables may account for non-measurable monthly variation in steer prices.

To avoid perfect multicolinearity and consequently the possibility of having an insoluble equation the monthly dummy variable for December was omitted. Thus, the month of December should be thought of as the base month. The coefficients associated with other monthly dummy variables should be interpreted as price deviation from this base month--December--due to non-measurable factors.

$$Y_t = 37.01 - \underset{(13.53)}{.008594X_{1t}} - \underset{(2.19)}{.01310X_{2(t-1)}} - \underset{(4.05)}{.004253X_{3(t-1)}} -$$

$$\underset{(1.29)}{.003080X_{4(t-1)}} - \underset{(5.74)}{.006837X_{5(t-1)}} + \underset{(28.82)}{.01127X_{6(t-1)}} + 2.113 \text{ Jan} -$$

$$1.003 \text{ Feb} - .7077 \text{ March} - .7878 \text{ April} - .3918 \text{ May} - .6226 \text{ June} -$$

$$.9083 \text{ July} - .8456 \text{ Aug} - .9320 \text{ Sept} + .3239 \text{ Oct} - .2814 \text{ Nov} \quad (5.1)$$

$R^2 = .919$ $\quad\bar{R}^2 = .912$ $\quad d = 1.028$

At first, it can be seen that dummy variables did not add much to the explanatory power of the regression equation. The Durbin-Watson statistic shows again the presence of serial correlation. All the variables had the expected economic relationship with steer prices.

The use of dummy variables did not prove to be a factor that increased the prediction characteristics of the model. In some months they increased and in others they decreased the forecast error. The patterns of prediction are quite similar to the earlier models. Thus, it is believed that no further discussion is necessary.

Extending the evaluation period would probably give better indication of the accuracy of all models discussed in this study. This, beyond any doubt, would help clarify whether the inaccuracy of the model is due to unusual circumstances that took place in the beef market, rigidity in the conceptual framework of the model, or, if structural change is taking place in the beef industry. This will be possible only when additional observations are available, the actual can be compared with the forecasted steer price, and conclusions can be drawn.

SUMMARY AND CONCLUSIONS

The models discussed in this study represent an attempt to explain and predict short-run fluctuations in the average monthly price of choice 900-1000 pound steers at Omaha.

The results reported in this paper are based on equations in which the variables are in the arithmetic form. In developing the models, several transformations of the variables, including logarithms and first differences were tried. The choice of the best alternative is in part subjective. The magnitude of the R^2, the Durbin-Watson statistics and the statistical significance of the parameters were considered. In estimating the equations multicolinearity and autocorrelation in the residuals proved to be a problem.

The price of steers was related, at first, to a set of non-lagged explanatory variables. The non-lagged relationship shows that cattle slaughter, meat storage, and per capita disposable personal income were the most relevant factors in explaining the price of steers over the period of 1955-74 on a monthly basis. These variables not only entered the equation with a logical economic sign associated with their coefficients, but also presented high level significance from the statistical standpoint. All three together account for 90 percent of the variation in steer prices.

The lagged model indicated that all the explanatory variables except cattle slaughter would influence steer prices one month in in the future. All variables in this model have a consistent economic relationship with steer prices.

To be predictive, a model should be accurate. The variables included in the model should be theoretically sound and the prediction error should not be large.

All versions of both types of models--lagged and non-lagged--indicate they are not accurate in predicting prices in time periods other than the period in which the estimated coefficients were obtained.

According to the size of the forecasting error and the inability to predict turning points both types of models proved to be not useful for short-run predictions. It is worthwhile to mention that this conclusion is based on the performance of the model only during the year of 1975 when the behavioral pattern of steer prices was quite different from the preceding years.

APPENDIX A

TABLE 4

MONTHLY AVERAGE PRICE OF CHOICE 900-1100 POUNDS, SLAUGHTER STEERS, OMAHA, 1955-1975*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1955	27.36	26.06	25.65	24.32	22.20	21.82	22.20	21.99	22.49	21.51	20.32	19.54
1956	20.16	19.54	19.99	20.25	20.24	20.33	21.87	24.80	26.16	25.07	23.36	21.41
1957	10.94	20.12	21.44	22.28	22.79	22.74	24.60	24.95	24.15	23.94	24.42	25.53
1958	26.47	27.55	29.31	28.90	28.46	27.40	26.50	25.68	26.21	26.13	26.52	27.28
1959	28.19	28.02	28.83	29.98	29.08	27.99	27.89	27.41	27.24	26.36	25.62	25.43
1960	26.26	26.58	27.75	27.88	27.19	25.85	25.02	24.41	24.06	24.24	25.40	26.13
1961	26.74	26.15	25.52	24.87	23.22	22.42	22.34	23.87	23.78	23.96	24.83	25.51
1962	25.76	25.95	26.36	26.81	25.50	25.07	25.68	27.41	28.83	28.46	29.12	28.12
1963	26.49	24.47	22.88	23.10	22.27	22.52	24.57	24.40	23.98	23.74	22.92	21.64
1964	22.20	21.36	21.38	20.28	20.28	21.25	22.69	24.23	24.75	23.66	23.45	22.79
1965	22.98	22.53	23.17	24.38	26.00	26.69	26.05	26.28	26.19	25.33	24.93	25.38
1966	25.92	27.16	28.25	26.94	25.94	25.25	25.27	25.76	25.54	24.70	23.92	23.92
1967	24.94	24.32	23.92	23.89	24.75	25.45	26.28	26.57	26.63	25.98	25.34	25.48
1968	25.69	26.37	26.60	26.50	26.30	26.39	27.37	27.54	27.27	27.05	27.38	27.94
1969	27.74	27.50	28.81	30.14	32.79	33.63	31.29	30.04	28.66	27.60	27.44	27.73
1970	28.38	29.30	30.99	30.79	29.57	30.36	31.12	30.09	29.21	28.47	27.22	26.82
1971	29.10	32.18	21.89	32.41	32.86	32.35	32.44	33.10	32.58	32.22	33.30	34.28
1972	35.63	36.32	35.17	34.52	35.70	37.91	38.38	35.70	34.69	34.92	33.59	36.85
1973	40.65	43.54	45.65	45.03	45.74	46.76	47.66	52.94	45.12	41.92	40.14	39.36
1974	47.13	46.37	42.85	41.54	40.52	37.98	43.72	46.62	41.38	39.64	37.72	37.20
1975	36.34	34.74	36.08	42.80	49.48	51.82	50.21	46.80	48.91	47.90	45.23	45.01

SOURCE: U.S. Department of Agriculture, Economic Research Service, Statistical Reporting Service and Agricultural Marketing Service, Livestock and Meat Statistics (Washington: Government Printing Office) Statistical Supplement for 1975.

*Monthly average price per hundredweight, Omaha, 1955-75. Monthly averages are based on the mean of daily quotations.

TABLE 5

COMMERCIAL CATTLE SLAUGHTER: TOTAL LIVE WEIGHT, BY MONTHS, 48 STATES, 1955-75*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1,000,000 pounds											
1955	1,975	1,701	1,971	1,840	1,954	2,077	1,903	2,245	2,214	2,157	2,115	2,049
1956	2,223	1,960	2,024	2,007	2,129	2,112	2,164	2,202	2,042	2,445	2,258	2,117
1957	2,414	1,950	1,976	1,951	2,160	1,958	2,210	2,172	2,090	2,322	1,975	1,948
1958	2,193	1,740	1,800	1,836	1,902	1,926	2,033	1,907	2,033	2,170	1,755	1,944
1959	1,987	1,673	1,806	1,926	1,872	1,943	2,044	1,891	2,058	2,090	1,922	2,043
1960	2,105	1,914	2,110	1,972	2,103	2,189	2,044	2,289	2,292	2,236	2,126	2,051
1961	2,181	1,906	2,167	1,985	2,282	2,305	2,119	2,328	2,198	2,341	2,187	2,061
1962	2,339	1,940	2,150	1,990	2,289	2,215	2,239	2,365	2,106	2,402	2,163	2,022
1963	2,364	2,042	2,211	2,248	2,416	2,262	2,371	2,410	2,327	2,647	2,282	2,313
1964	2,623	2,235	2,411	2,614	2,602	2,742	2,674	2,590	2,692	2,867	2,587	2,773
1965	2,698	2,390	2,747	2,493	2,503	2,680	2,677	2,769	2,869	2,850	2,812	2,828
1966	2,936	2,597	2,826	2,634	2,793	2,953	2,712	3,023	2,969	2,896	2,886	2,860
1967	3,006	2,669	2,935	2,737	3,020	2,989	2,740	2,993	2,849	2,999	2,826	2,773
1968	3,117	2,816	2,787	2,811	3,069	2,802	3,065	3,072	2,962	3,304	2,867	2,843
1969	3,206	2,796	2,850	2,859	2,876	2,847	3,005	2,967	3,152	3,362	2,809	3,076
1970	3,194	2,789	2,966	3,015	2,924	3,050	3,051	2,918	3,144	3,216	2,874	3,119
1971	3,057	2,729	3,166	2,979	2,958	3,224	3,111	3,098	3,166	3,065	3,024	3,010
1972	3,026	2,894	3,162	2,870	3,219	3,203	2,826	2,299	3,121	3,331	3,149	3,026
1973	3,256	2,798	2,989	2,482	3,046	2,899	2,812	2,771	2,728	3,303	3,116	2,937
1974	3,278	2,702	3,060	3,065	3,246	3,043	3,228	3,256	3,125	3,605	3,298	3,310
1975	3,590	3,150	3,207	3,237	3,165	3,153	3,306	3,401	3,576	3,917	3,419	3,611

SOURCE: U.S. Department of Agriculture, Economic Research Service, Statistical Reporting Service and Agricultural Marketing Service, Livestock and Meat Statistics (Washington: Government Printing Office) Statistical Supplement for 1975.

*Includes slaughter under Federal inspection and other commercial slaughter. Excludes farm slaughter.

TABLE 6

COMMERCIAL CALF SLAUGHTER: TOTAL LIVE WEIGHT, BY MONTHS, 48 STATES, 1955-75*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1,000,000 pounds											
1955	207	182	214	197	213	234	220	257	265	256	236	208
1956	209	196	204	203	220	223	240	273	256	307	256	204
1957	231	191	200	202	211	205	235	244	234	253	19	179
1958	192	156	163	162	162	163	171	166	168	183	146	147
1959	135	120	129	130	124	133	142	133	152	161	142	142
1960	139	127	247	131	137	154	149	178	179	176	164	144
1961	145	130	147	130	142	141	132	158	151	163	149	127
1962	147	123	139	126	140	129	135	153	145	166	141	124
1963	139	116	121	115	117	106	125	133	135	148	126	121
1964	136	114	123	121	118	129	147	150	164	174	149	140
1965	142	124	143	131	120	134	138	152	162	159	150	131
1966	136	124	145	124	119	127	124	142	137	137	131	116
1967	123	107	117	102	108	108	106	122	119	128	116	99
1968	114	98	101	99	100	93	101	107	107	121	110	98
1969	108	95	96	92	90	89	96	94	102	109	88	88
1670	89	78	87	83	80	81	82	83	87	88	78	78
1971	77	73	86	78	75	77	75	75	80	77	75	71
1972	71	67	73	59	63	63	59	68	62	66	62	56
1973	63	53	54	43	48	43	42	44	43	50	49	43
1974	51	44	48	48	52	45	58	71	82	104	84	83
1975	104	89	101	107	106	111	137	130	147	170	136	136

SOURCE: U.S. Department of Agriculture, Economic Research Service, Statistical Reporting Service and Agricultural Marketing Service, Livestock and Meat Statistics (Washington: Government Printing Office) Statistical Supplement for 1975.

*Includes slaughter under Federal inspection and other commercial slaughter. Excludes farm slaughter.

TABLE 7

COMMERCIAL HOG SLAUGHTER: TOTAL LIVE WEIGHT, BY MONTHS, 48 STATES, 1955-75*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1,000,000 pounds											
1955	1,646	1,352	1,579	1,307	1,256	1,180	1,049	1,272	1,401	1,638	1,889	2,035
1956	1,888	1,636	1,716	1,447	1,385	1,268	1,218	1,269	1,338	1,694	1,784	1,587
1957	1,606	1,384	1,479	1,404	1,413	1,187	1,209	1,206	1,323	1,627	1,516	1,551
1958	1,567	1,236	1,334	1,396	1,284	1,234	1,242	1,230	1,408	1,613	1,489	1,661
1959	1,671	1,564	1,590	1,598	1,439	1,437	1,475	1,373	1,593	1,830	1,779	1,960
1960	1,822	1,609	1,687	1,557	1,554	1,478	1,253	1,469	1,452	1,512	1,630	1,635
1961	1,619	1,406	1,671	1,417	1,598	1,490	1,253	1,436	1,429	1,696	1,755	1,617
1962	1,708	1,471	1,693	1,574	1,636	1,462	1,357	1,470	1,314	1,836	1,785	1,678
1963	1,779	1,547	1,757	1,734	1,656	1,395	1,431	1,435	1,592	1,848	1,779	1,873
1964	1,936	1,616	1,749	1,782	1,549	1,468	1,423	1,367	1,550	1,882	1,823	1,857
1965	1,675	1,439	1,756	1,588	1,327	1,340	1,231	1,032	1,485	1,494	1,535	1,411
1966	1,338	1,285	1,603	1,493	1,418	1,369	1,208	1,415	1,592	1,658	1,755	1,772
1967	1,774	1,561	1,809	1,616	1,510	1,481	1,348	1,608	1,666	1,847	1,821	1,739
1968	1,813	1,558	1,671	1,765	1,773	1,434	1,500	1,580	1,674	1,979	1,803	1,819
1969	1,837	1,632	1,755	1,781	1,607	1,512	1,529	1,478	1,699	1,866	1,577	1,728
1970	1,646	1,441	1,663	1,761	1,565	1,533	1,538	1,567	1,804	1,997	1,969	2,133
1971	1,964	1,645	2,109	2,009	1,820	1,860	1,631	1,769	1,890	1,852	1,989	1,999
1972	1,671	1,601	1,993	1,724	1,765	1,663	1,363	1,634	1,615	1,790	1,824	1,606
1973	1,694	1,442	1,665	1,516	1,702	1,480	1,302	1,411	1,353	1,689	1,707	1,558
1974	1,775	1,447	1,695	1,783	1,833	1,552	1,501	1,637	1,666	1,801	1,657	1,632
1975	1,631	1,389	1,435	1,596	1,363	1,307	1,187	1,154	1,301	1,351	1,310	1,433

SOURCE: U.S. Department of Agriculture, Economic Research Service, Statistical Reporting Service and Agricultural Marketing Service, Livestock and Meat Statistics (Washington: Government Printing Office) Statistical Supplement for 1975.

*Includes slaughter under Federal inspection and other commercial slaughter. Excludes farm slaughter.

TABLE 8

COMMERCIAL PRODUCTION OF POULTRY,* READY TO COOK WEIGHT, BY MONTH, 48 STATES

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	-------	-------	-------	-------	-------	1,000,000 pounds	-------	-------	-------	-------	-------	-------
1953	208	201	228	243	294	304	322	362	419	449	468	362
1954	239	229	247	257	309	300	309	345	429	519	536	436
1955	240	203	209	248	291	295	314	356	410	512	491	392
1956	274	254	278	292	336	366	379	479	542	626	581	485
1957	342	280	316	351	376	386	408	441	514	606	571	464
1958	360	304	330	371	409	433	476	547	602	689	604	528
1959	394	346	393	432	497	482	488	545	600	699	514	456
1960	387	361	392	403	460	481	508	623	656	718	638	518
1961	442	349	454	486	595	632	618	725	734	827	736	523
1962	458	374	456	481	580	573	572	663	652	833	734	562
1963	530	411	448	500	571	555	641	701	735	833	688	636
1964	557	464	494	541	569	611	635	699	778	838	725	640
1965	560	469	526	541	563	645	683	773	847	877	819	695
1966	582	522	562	602	617	724	717	893	931	958	888	790
1967	655	544	624	605	733	791	764	978	913	986	884	741
1968	687	566	582	620	694	671	805	880	858	984	803	764
1969	726	579	631	661	724	783	842	897	949	1,048	812	840
1970	749	655	726	763	755	895	956	958	1,001	1,063	875	846
1971	762	676	791	757	749	894	909	1,020	1,003	1,009	935	870
1972	799	754	821	754	881	961	918	1,113	981	1,091	977	833
1973	855	721	781	725	886	949	920	1,070	910	1,120	999	859
1974	933	766	806	832	944	920	1,002	1,023	898	1,015	800	768
1975	781	676	736	825	831	884	967	942	978	1,067	834	914

SOURCE: U.S. Department of Agriculture, Economic Research Service, Poultry And Egg Situation (Washington: Government Printing Office).

*Includes chicken and turkey.

TABLE 9

MEAT COLD STORAGE, HOLDINGS FIRST OF MONTH*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	----	----	----	----	----	1,000,000 pounds	----	----	----	----	----	----
1955	927	946	912	861	811	715	590	515	459	462	600	743
1956	874	927	919	875	831	746	662	574	499	529	693	837
1957	876	869	845	806	730	666	591	506	470	509	634	668
1958	657	667	610	557	549	496	466	439	471	539	692	733
1959	743	762	796	772	781	749	687	618	581	619	740	763
1960	793	815	798	732	734	702	654	600	583	622	741	688
1961	654	675	659	626	642	621	619	602	630	723	869	894
1962	843	808	753	753	740	707	630	572	575	620	766	778
1963	766	754	755	786	781	735	697	667	685	802	944	956
1964	928	989	984	969	991	973	925	844	805	817	984	997
1965	969	959	889	847	784	684	564	530	560	671	809	776
1966	736	701	688	654	666	632	593	614	645	792	969	956
1967	986	1,010	1,012	982	997	920	887	872	930	1,056	1,226	1,153
1968	1,101	1,090	1,003	931	921	893	821	792	841	931	1,095	1,019
1969	970	924	885	832	829	753	676	683	759	901	1,075	944
1970	870	851	861	871	904	916	872	884	914	1,031	1,175	1,107
1971	1,065	1,047	982	985	1,018	1,031	1,061	1,069	1,125	1,206	1,293	1,119
1972	1,074	994	914	877	916	874	824	836	909	1,111	1,125	1,007
1973	905	882	823	803	789	768	803	789	787	900	1,115	1,135
1974	1,177	1,203	1,161	1,240	1,280	1,294	1,259	1,231	1,264	1,325	1,384	1,129
1975	1,164	1,141	1,015	1,054	1,036	872	919	887	846	986	1,125	940

SOURCE: U.S. Department of Agriculture, Economic Research Service, Statistical Reporting Service and Agricultural Marketing Service, Livestock and Meat Statistics (Washington: Government Printing Office) Statistical Supplement for 1975.

*Includes beef, pork and poultry storage.

TABLE 10

PER CAPITA DISPOSABLE INCOME, CURRENT DOLLARS, SEASONALLY ADJUSTED AT ANNUAL RATES, BY MONTH, 1955-75.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1955	1,572	1,586	1,600	1,614	1,628	1,636	1,644	1,653	1,660	1,667	1,673	1,673
1956	1,673	1,673	1,683	1,693	1,703	1,706	1,709	1,713	1,720	1,727	1,735	1,744
1957	1,753	1,762	1,772	1,781	1,789	1,792	1,795	1,799	1,793	1,787	1,780	1,784
1958	1,788	1,793	1,796	1,801	1,813	1,825	1,837	1,839	1,841	1,843	1,843	1,853
1959	1,863	1,874	1,888	1,902	1,916	1,914	1,912	1,909	1,913	1,917	1,922	1,923
1960	1,923	1,924	1,935	1,946	1,956	1,957	1,957	1,957	1,955	1,953	1,951	1,947
1961	1,943	1,940	1,950	1,950	1,969	1,976	1,983	1,989	1,998	2,007	2,015	2,021
1962	2,027	2,033	2,040	2,047	2,055	2,059	2,063	2,067	2,073	2,079	2,085	2,089
1963	2,093	2,097	2,102	2,107	2,111	2,118	2,125	2,131	2,140	2,149	2,159	2,176
1964	2,193	2,211	2,229	2,245	2,261	2,270	2,279	2,288	2,296	2,304	2,311	2,320
1965	2,329	2,339	2,350	2,361	2,373	2,396	2,419	2,443	2,457	2,471	2,486	2,503
1966	2,520	2,537	2,545	2,553	2,560	2,573	2,586	2,598	2,612	2,626	2,639	2,657
1967	2,675	2,693	2,703	2,713	2,723	2,735	2,747	2,758	2,771	2,784	2,798	2,822
1968	2,846	2,869	2,887	2,905	2,924	2,931	2,938	2,946	2,961	2,976	2,991	3,002
1969	3,013	3,023	3,039	3,055	3,070	3,099	3,128	3,157	3,170	3,183	3,197	3,222
1970	3,247	3,272	3,299	3,324	3,353	3,367	3,381	3,395	3,400	3,405	3,410	3,446
1971	3,482	3,517	3,542	3,567	3,592	3,601	3,610	3,620	3,630	3,640	3,649	3,670
1972	3,691	3,711	3,728	3,747	3,765	3,787	3,809	3,831	3,872	3,913	3,955	4,018
1973	4,081	4,143	4,177	4,211	4,244	4,276	4,308	4,339	4,377	4,415	4,452	4,467
1974	4,482	4,497	4,520	4,543	4,565	4,604	4,643	4,681	4,702	4,723	4,745	4,753
1975	4,721	4,808	4,895	4,983	5,070	5,074	5,079	5,083	4,121	5,159	5,197	5,235

SOURCE: Economic Indicator, Prepared for Joint Economic Committee by Council of Economic Advisors (Washington, Government Printing Office).

*Quarterly data were obtained and straight line interpolated to give monthly figures.

TABLE 11

ESTIMATES OF THE POPULATION OF U.S., RESIDENT POPULATION, AT FIRST OF THE MONTH, 1955-1975

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1,000 persons											
1955	163654	163844	164051	164339	164574	164843	165069	165338	165649	165934	166198	166464
1956	166725	166924	167145	167405	167634	167855	168088	168386	168704	169000	169288	169516
1957	169817	170025	170242	170487	170691	170960	171187	171466	171765	171990	172307	172549
1958	172809	172988	173187	173452	173683	173927	174149	174400	174712	174972	175263	175510
1959	175775	175997	176205	176458	176653	176894	177135	177403	177686	177953	178239	178495
1960	178729	178902	179112	179323	179540	179780	179979	180257	180571	180848	181123	181364
1961	181629	181848	182031	182298	182517	182771	182992	183266	183552	183822	184058	184265
1962	184508	184684	184872	185104	185284	185551	185771	186016	186326	186561	186761	187016
1963	187284	187456	187656	187837	188046	188271	188483	188762	189026	189301	189544	189760
1964	189973	190124	190304	190507	190738	190925	191141	191401	191655	191899	192119	192347
1965	192529	192680	192781	192983	193158	193329	193526	193750	193924	194164	194319	194506
1966	194649	194759	194881	195045	195209	195371	195576	195727	195957	196147	196206	196406
1967	196596	196696	196834	196976	197124	197283	197457	197675	197852	198175	198275	198428
1968	198578	198679	198788	198923	199070	199238	199399	199593	199809	200011	200183	200342
1969	200498	200589	200720	200887	201048	201210	201385	201581	201826	202050	202279	202494
1970	202717	202865	203032	203235	203407	203618	203810	204035	204255	204476	204701	204919
1971	205156	205308	205462	205677	205837	206058	206219	206427	206641	206930	207039	207209
1972	207396	207508	207621	207802	207940	208100	208234	208377	208559	208703	208848	208982
1973	209136	209213	209337	209468	209593	209733	209859	210013	210179	210332	210436	210574
1974	210692	210800	210902	211018	211131	211267	211389	212549	211716	211883	212019	212136
1975	212245	212345	212433	212538	212657	212868	213032	213230	213394	213553	213703	213819

SOURCE: U.S. Department of Commerce, Bureau of the Census, Population Estimates and Projections (Washington: Government Printing Office) Current Population Reports Series P-25, 1976.

APPENDIX B

I. The estimated equations, using "first difference" were the following:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6)$$

where;

a) $Y = Y_t - Y_{(t-1)}$

$X_i = X_{it} - X_{i(t-1)}$ $\quad t = 1, \ldots 240$

$i = 1, \ldots 6$

The best[1] result was as follows:

$$Y = .120 - \underset{(3.60)}{.004668X_5} + \underset{(.0012)}{.012407X_6} \qquad R^2 = .06$$

b) $Y = Y_t - Y_{(t-12)}$

$X_i = X_{it} - Y_{(t-12)}$ $\quad t = 1, \ldots 240$

$i = 1, \ldots 6$

The best[1] result was:

$$Y = .5619 - \underset{(1.30)}{.0020X_1} - \underset{(4.16)}{.046392X_2} - \underset{(1.44)}{.00605X_4} - \underset{(3.54)}{.00575X_5} + \underset{(7.49)}{.01422X_6}$$

$$R^2 = .28$$

II. The estimated equation using log variables is of the following form:

$$\log \hat{Y} = \log \hat{a} + \hat{b}_1 \log X_1 + \hat{b}_2 \log X_2 + \hat{b}_3 \log X_3 + \hat{b}_4 \log X_4 + \hat{b}_5 \log X_5 + \hat{b}_6 \log X_6$$

The best[1] estimated log equation was:

$$\log Y = 1.277 - \underset{(15.23)}{.8111 \log X_1} - \underset{(8.62)}{.2392 \log X_5} + \underset{(33.41)}{1.0639 \log X_6}$$

$$R^2 = .86$$

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[1]"Best" is determined by stepwise regression procedure.

APPENDIX C

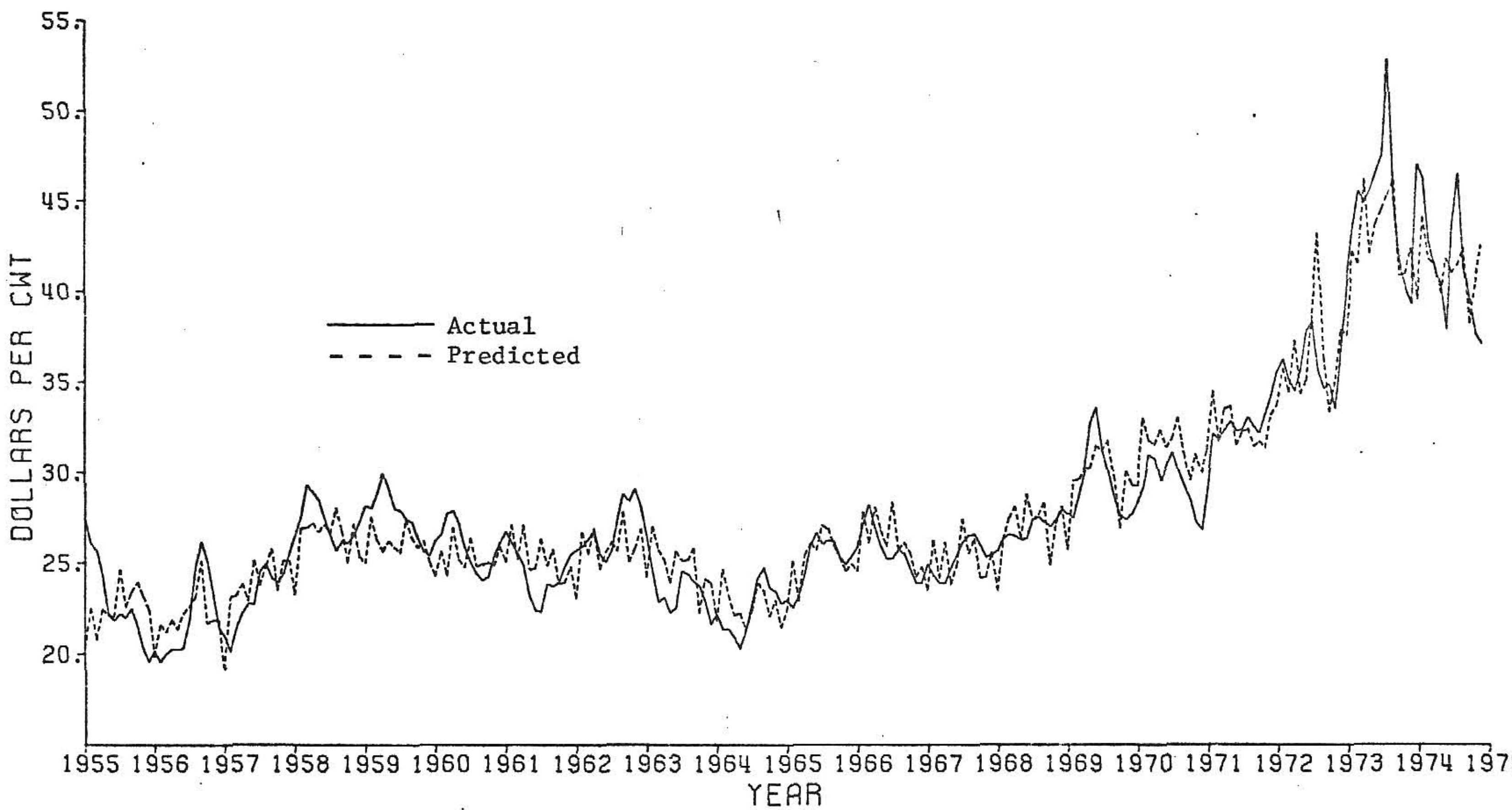

Figure 6. Comparison Between Actual and Predicted Steer Price--Equation (2)--1955-74.

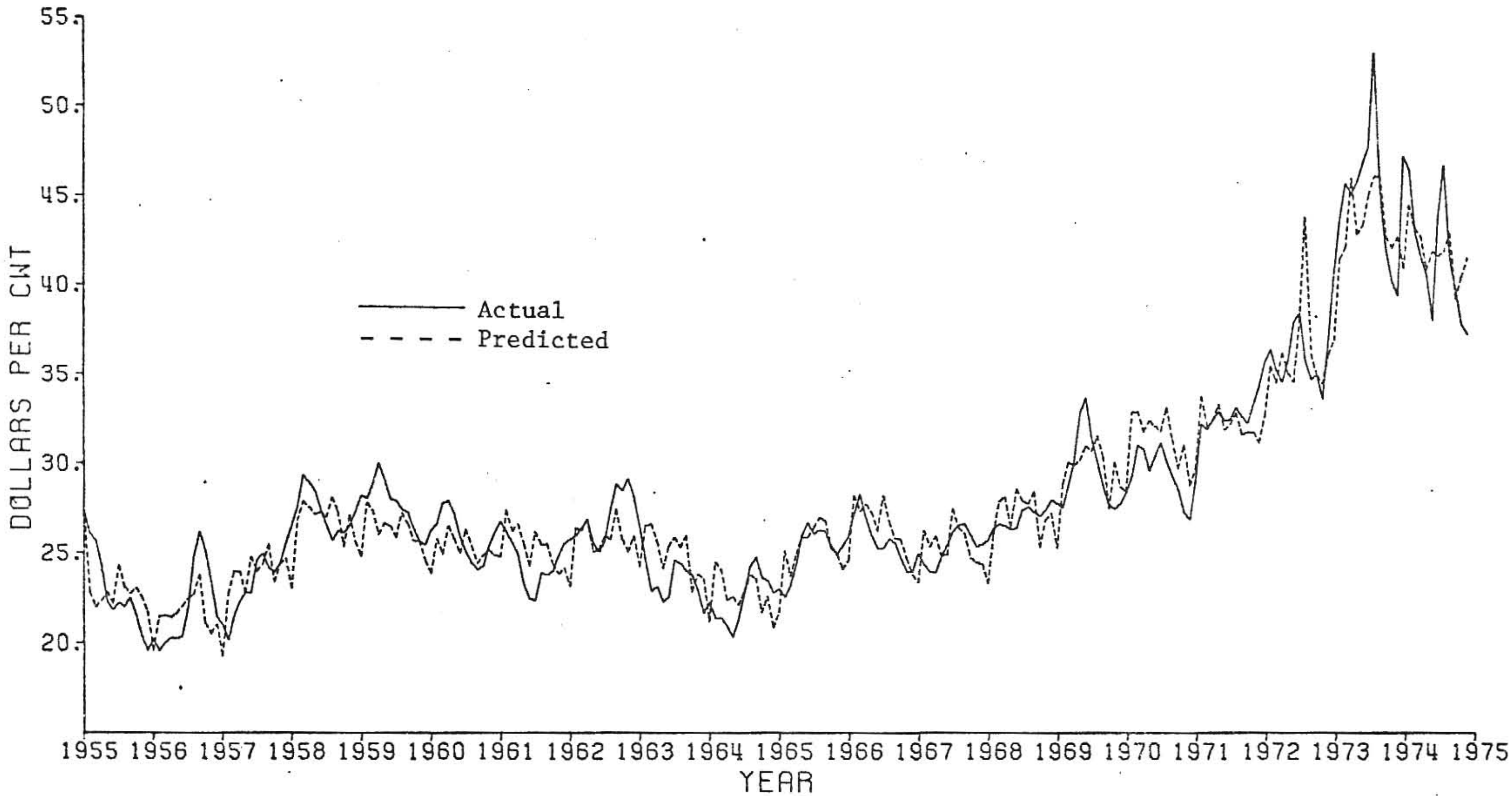

Figure 7. Comparison Between Actual and Predicted Steer Price--Equation (5)--1955-74.

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FACTORS ASSOCIATED WITH
STEER PRICES

by

JOÃO FERNANDO MARQUES

B.S., Pontificia Universidade Catolica De Campinas, Brasil, 1970

AN ABSTRACT OF A MASTER'S THESIS

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Department of Economics

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1976

In order to find adequate models that explain fluctuations in steer prices during the period 1955-74 and could also be used for prediction purposes, several equations were developed and discussed in this study.

The postulated relationship is that steer prices are a function of cattle slaughter, calf slaughter, hog slaughter, poultry production, and meat storage. Such variables were expected to have an inverse relationship with steer prices. In addition per capita personal disposable income, as a demand shifter, also was included in the original equation and, as suggested by economic theory, it was thought to have a positive impact on steer prices.

Based upon economic reasoning and statistical criteria, variables were added to or deleted from the original model.

Multicolinearity and serial correlation were present in most of the estimated equations.

In all of the non-lagged equations, cattle slaughter, meat storage and per capita disposable personal income were statistically significant and had a consistent economic relationship in all cases. Those variables accounted for 90 percent of the variation in steer prices over the period under investigation. The remaining explanatory variables, in most of the cases, entered the equation with a sign not suggested by economic theory. However, if all assumptions related to the least square method hold, this would suggest that there does not exist an inverse relationship between steer price and calf slaughter, hog slaughter or poultry production. But in most cases their coefficients were associated with a relatively large standard error.

Of the models tested the lagged version was the only one in which all explanatory variables exhibited a consistent economic relationship at a statistically significant level. In this model all steer price determinants, except cattle slaughtered, were lagged one month.

Price predictions from all versions of both types of models--lagged or non-lagged--were evaluated over a one-year period, beginning in January and ending in December of 1975. These predictions were found to be relatively inaccurate. However cattle price trends during 1975 may have been somewhat abnormal.