SHORT-RUN BEEF PRICE FORECASTING MODELS

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

The live-animal price variability that has characterized the beef industry in recent years introduces a significant degree of uncertainty into the decision making process of most livestock feeders. In the 1962-68 period, the variance of the monthly live-animal price of choice slaughter steers was $4.34 per hundredweight.[1] In May of 1964, the market price was $20.67 per hundredweight, while the price one year later was $26.56. This price variation makes it difficult for farm firms and/or other market participants to plan their farm operations so that their economic goals can be achieved. The fluctuating profitability of a cattle feeding operation introduces a barrier to firms attempting to achieve a constant or optimal rate of growth from internal financing to take advantage of economies of scale as they develop. Tight external credit arising from the price uncertainty can also make it difficult for firms to take advantage of these economies.

A portion of the price variability, which does not result in a large degree of uncertainty, is a result of regular cycles of a seasonal and/or long-term nature.

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[1]This is based on the price of 900-1100 pound steers at the Chicago market. In this case, the variance refers to the measured degree of dispersion, and not to the range of prices.

Over tha past 45 years, the deflated price of beef has
increased at an average rate of 0.5 per cent per year.
In addition to this long-term trend, there has been an
upward movement in cattle prices as a result of the
inflationary trend. Seasonal fluctuations are readily
evident in the past, although these have been disappearing
with the advent of large central feedlot operations.

The per capita consumption of beef has increased
steadily from 88.8 pounds per year in 1962 to 109.4
pounds in 1968.[1] Consumption of other meat substitutes
has remained fairly constant in this period; thus
establishing beef as a relatively superior meat product
for this time period. Because the change in consumption
patterns appear to have remained relatively stable in this
period, most of the price uncertainty in the beef industry
is probably a result of factors on the supply side.
Factors usch as weather, feed conditions, average slaughter
weight, and the number of cattle on feed exert a significant
influence on price, particularly in the short-run.

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[1]U. S., Department of Agriculture, Livestock and Meat
Statistics, July 1969, (Washington: Government Printing
Office, 1969), Table 209, p. 147.

OBJECTIVES

Livestock producers are in need of an objective fore-
casting model to combine with their own subjective judge-
ments as a means of formulating future choice slaughter
steer price predictions.[1] Thus, the primary purpose of
this study was to formulate a quantitative model that
could be used to forecast slaughter steer prices in the
short-run. To be consistent with the above objective,
the model needs to be computationally easy so that users
will find it practical. Also, input data necessary for
calculating the price predictions needs to be readily
available to potential users of the model.

To maintain simplicity, all exogenous variables in
the model were lagged at least the length of the fore-
casting period.[2] Thus, an unconditional market price
forecast can be calculated on the basis of expost infor-
mation available to a producer.[3] This formulation has an

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[1]The choice price was selected as the most important
grade to forecast since the largest percentage of slaughter
cattle grade choice. In general, an indication of the price
of other grades will be given by a prediction of the price
of choice cattle. For convenience, the price of choice
slaughter cattle will sometimes be referred to as the beef
cattle price.

[2]The forecast period refers to the length of time
between the current period and the period forecasted.

[3]The forecast will be unconditional in the sense that
it is not necessary to make provisions concerning the values
of the exogenous variables used for calculating the forecast.
Provisions are not necessary since the actual values of the
exogenous variables are used in calculating the forecasts.

added advantage in that it eliminates the necessity of developing supplementary models for forecasting the exogenous variables.

A two equation model for forecasting the deflated price of choice slaughter cattle was developed as an alternate. The reason for developing such a model is that a certain degree of imprecision can be introduced into market price models during periods of changing rates of inflation. This imprecision results from the changing portion of the observed price variability that is due to the inflationary forces rather than from absolute forces. For a producer to obtain a market price forecast from this model, the price deflator will need to be forecasted.

Models of each type were specified for forecast periods of both three and six months. Producers, especially cattle feeders, consider forecasts of this length the most useful in their short-run decision making. Hence, the primary objective of this study can be restated as being to develop two simple models for forecasting beef cattle price. The construction of a model that meets this objective will probably involve a loss of precision.[1] Yet, the benefits

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[1]The relative forecasting precision of large and simple models has not been established. Primarily, this precision depends on the empirical situation being dealt with and the length of the forecasting period. Currently, considerable discussion of model size has occurred in relation to models for forecasting macro-economic variables. For example, see I. Friend, and R. C. Jones, "Short-Run Forecasting Models Incorporating Anticipatory Data." Studies in Income and Wealth, Vol. 28, (Princeton, N. J.: Princeton University Press, 1964), pp. 279-326.

accruing to a producer from a model that can be used for
quantitative prediction may outweigh such a loss.

REVIEW OF LITERATURE

Forecasting models can be subdivided into the following two types:

    (1) Models that have all exogenous variables lagged at least the length of the forecasting period.

    (2) Models that use non-lagged values for some or all of the exogenous variables in the equation or system. With models of the first type, the values of the endogenous variables can be forecasted unconditionally. Forecasts of the second type will be conditional in the sense that the prediction will be accurate only if the values of the exogenous variables used actually occur in the future. With a model of this type, the exogenous variables that are used in the forecasting equation must be predicted by other means.

Forecasting errors arising from a model of the first type will result only from model specification errors, provided that structural changes in the industry and other related factors remain the same as they were in the observation period. Errors arising from a model of the second type can result from the procedure used to predict the exogenous variables, the specification of the model, or both.

A number of estimated structural models of the beef sector of the economy have been used for price forecasting. These models can be categorized as of the second type. For

example, a simple structural model would be the following

demand equation:

$$P_t = a_0 + a_1 C_t + a_2 P_{p,t} + a_3 Y_t$$

where

P_t = Price at time (t)

C_t = Consumption

$P_{p,t}$ = Price of a meat substitute

Y_t = Income

To forecast price in some future time period, say (t+1),

supplementary relations would be required to forecast

C_{t+1}, $P_{p,t+1}$, and Y_{t+1}.[1]

Hayenga and Hacklander in a recent study developed the

following two equation model of the first type:[2]

$$P_{t+6} = a_0 + a_1 P_t + a_2 \Delta Q_t + \sum_{i=3}^{14} a_i D_i + u_{1,t+6} \qquad (1)$$

$$Q_{t+6} = b_0 + b_1 F_{st} + b_2 F_{s't} + b_3 F_{ht} + \sum_{i=1}^{15} b_i D_i + u_{2,t+6} \qquad (2)$$

where

$$\Delta Q_t = \frac{Q_{t+6}/W_{t+6} - Q_t/W_t}{Q_t/W_t} \cdot 100$$

P_t = Price in month (t)

Q_t = Total beef production

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[1] For an example of a more complicated structural model,
see: W. R. Maki, "Forecasting Livestock Supplies and Prices
with an Econometric Model," Journal of Farm Economics, XXXXV,
No. 3 (1963), pp. 612-624.

[2] M. Hayenga, and D. Hacklander, Short-Run Livestock
Price Prediction Models, Michigian State University Agri-
cultural Experiment Station Research Bulletin No. 25, 1970.

W_t = Workdays in month (t)

F_{st} = Number of 500-700# steers on feed

$F_{s't}$ = Number of 700-900# steers on feed

F_{ht} = Number of heifers on feed weighing less than 500#

D_i = (0, 1) monthly dummy variables

Price predictions are obtained by predicting (Q_{t+6}) from equation (1) and substituting the quantity prediction into equation (2) to obtain the predicted (P_{t+6}). The basic difficulty with their estimated model is the unsatisfactorily low squared multiple correlation coefficient (R^2 = 0.50) for equation (2). That is, this model as well as other fore-casting models using lagged variables--models of the first type--have been characterized by low multiple correlation coefficients. Thus, a high degree of statistical unreliability is transferred to the predictions.

In 1968, Franzmann developed a derived demand equation forecasting model which included all exogenous variables lagged three months.[1] Exogenous variables used in this model were the number of cattle slaughtered, average live weight of slaughter cattle, dressing yield, end of month cold storage holdings of cured and frozen beef, wholesale value of carcass and by-products, and the average weekly earnings of packing plant workers. For this model, Franzmann

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[1] J. R. Franzmann, "Slaughter Cattle Prices: Up or Down?" Oklahoma Current Farm Economics, XXXXI, No. 1 (1968), pp. 24-31.

used two Koyck geometric lag forms for the exogenous variables. One lag parameter was associated with the first three variables above, while the second was associated with the last three.

The estimated model has an extremely good fit over the observation period, which probably arises from the lagged variables included to estimate the lag parameters. In general, forecasts from the model for 1968 were inaccurate by most criteria.

PRELIMINARY CONSIDERATIONS

For the development of a price forecasting model,
consideration must be given to the forces which determine
the price of the commodity in question. According to
economic theory, the market price of a good in a purely
competitive market is determined by the forces of supply
and demand. In market equilibrium, this price is given
by the intersection of the market supply and demand curves.

In empirical situations, only points in the price and
quantity plane are observed, and not the actual supply and
demand schedules. For purposes of explanation or predic-
tion of price in a market supply and demand context,
estimation of these curves is necessary from time series
observations on these points. That is, the problem is one
of estimating exante relationships from expost observations.

One problem resulting from this type of estimation
procedure is that of identification of each of the curves.
Working, in his classic article, pointed out that the slopes
of the two curves must be separated from the shifts in the
position of these curves before meaningful regression
results can be obtained.[1] In essence, because a line
fitted to observations has a negative slope does not
necessairly mean that it is a demand curve, and similarly

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[1] E. J. Working, "What Do Statistical Demand Curves
Show?," Quarterly Journal of Economics, XLI (1927), pp. 212-
235.

for a supply curve. With the exception of special cases, identification of both curves is possible if these curves have been shifting as a result of different factors and these factors can be quantitatively measured. It should be noted that this is only a necessary condition for identification.[1]

Another problem that arises in an empirical study of this type is the specification of the true mathematical functional forms of the curves. Specification of the wrong form can result in invalid statistical results. Some of the model specification problems related to this analysis will be covered in a later chapter.

Other estimation and conceptual problems arise when consideration is given to the fact that lags in adjustment to price changes usually occur in the real world. These lags can arise from uncertainty, costs of adjustment, or from factors of an institutional, psychological, or technological nature.[2] Thus, expost observations may reflect

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[1]The necessary condition for identification of an equation in a system is that it omit (G-1) or more variables, where (G) equals the number of endogenous variables contained in the system. The sufficient condition is that the matrix of coefficients of variables not contained in the equation under consideration, but contained in the other equations of the system have rank equal to (G-1). Since the true parameters are not known this condition is inapplicable in empirical situations.

[2]Marc Nerlove, "Distributed Lags and Demand Analysis," Agriculture Handbook No. 141, U. S. Dept. of Agriculture, (Washington: Government Printing Office, 1958).
R. Eisner, and R. Strotz, "Determinants of Business Investment," C.M.C., Impacts of Monetary Policy. (Englewood Cliffs, N. J.: Prentice Hall, 1963).

either short-run or long-run equilibrium situations, or both.

Lags in adjustment to price changes has led Economists' to make a distinction between long-run and short-run demand and supply concepts in empirical analysis. Considerable discussion currently exists as to the appropriate definition of long-run market demand. For the purposes of this analysis, long-run demand will be loosely defined as a schedule showing the quantity that consumers demand at all possible prices, provided that one and only one quantity will be demanded at a given price. i.e. consumers have sufficient time to adjust to the long-run equilibrium quantity demanded.

As an illustration of the differences between the short-run and long-run demand concepts, consider the hypothetical curves in Figure 1. $D_1 D_1$ respresents the long-run schedule, while $D_s D_s$ and $D_s' D_s'$ represent two of the infinitely many short-run demand schedules. Assume that there is a lag in adjustment to price changes and that consumers expect these changes to be permanent. Also assume that consumers are in long-run equilibrium at price P_0, consuming X_0^*. If price decreases to P_1 and there is a rigidity in the behavior of consumers, they will react to this price change by moving down the short-run demand curve $D_s D_s$ and consuming X_1 rather than moving down $D_1 D_1$ and consuming the long-run equilibrium quantity X_1^*. Analygously, if consumers are

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NUMEROUS PAGES
WITH DIAGRAMS
THAT ARE CROOKED
COMPARED TO THE
REST OF THE
INFORMATION ON
THE PAGE.

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Fig. 1.--Long-Run and Short-Run Demand Curves
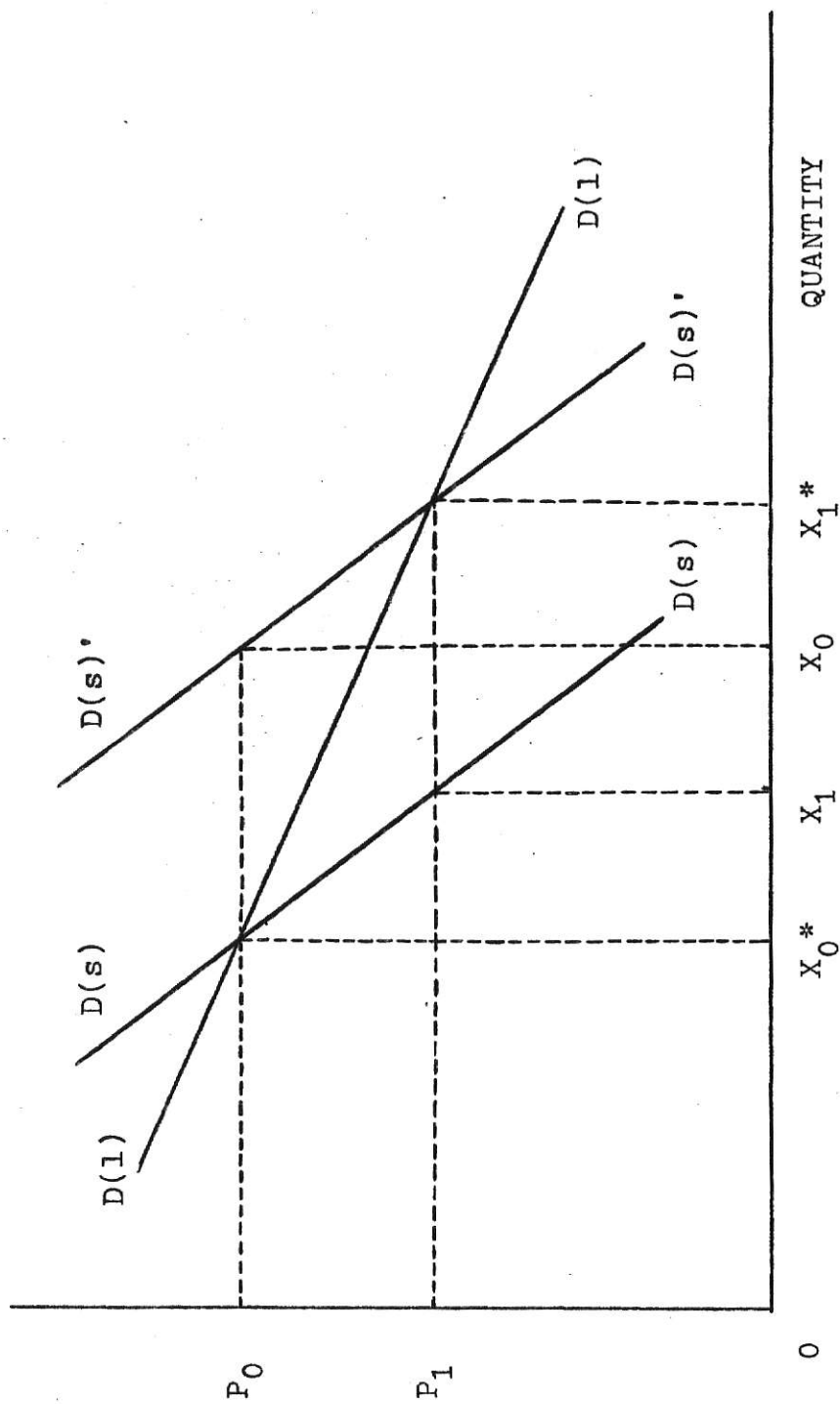
Source: Marc Nerlove, "Distributed Lags and Demand Analysis," p. 16.

in long-run equilibrium at price P_1, consuming X_1^*, and price increases to P_0, they will react by moving up the short-run demand curve $D_s'D_s'$ and consuming X_0. The short-run curve that consumers follow will depend on the point they are on when the price change occurs.

Lags in adjustment to price changes imply the presence of the short-run and long-run demand concepts presented above. If the presnece of lags in the beef industry is accepted, then the methodological difficult of the short-run fore-casting of price on the basis of expost information can be visualized in the context of these curves. To illustrate this, consider Figure 2 and the following specific assumptions:

(1) Let (t) = current time, and (t+1) = time period forecasted.

(2) Actions in the market are continuous between (t) and (t+1).

(3) Short-run and long-run demand curves exist. The short-run supply curves are perfectly vertical, and the quantity supplied in period (t+1) can be precisely predicted at time (t).

(4) Lags in adjustment result primarily from the force of habit of consumers.

(5) Consumers are in short-run equilibrium at time (t), consuming $Q(t)$, and paying a price of (P_a).

Fig. 2.--Forecasting Illustration in the Context of Long-Run and Short-Run
Demand Curves
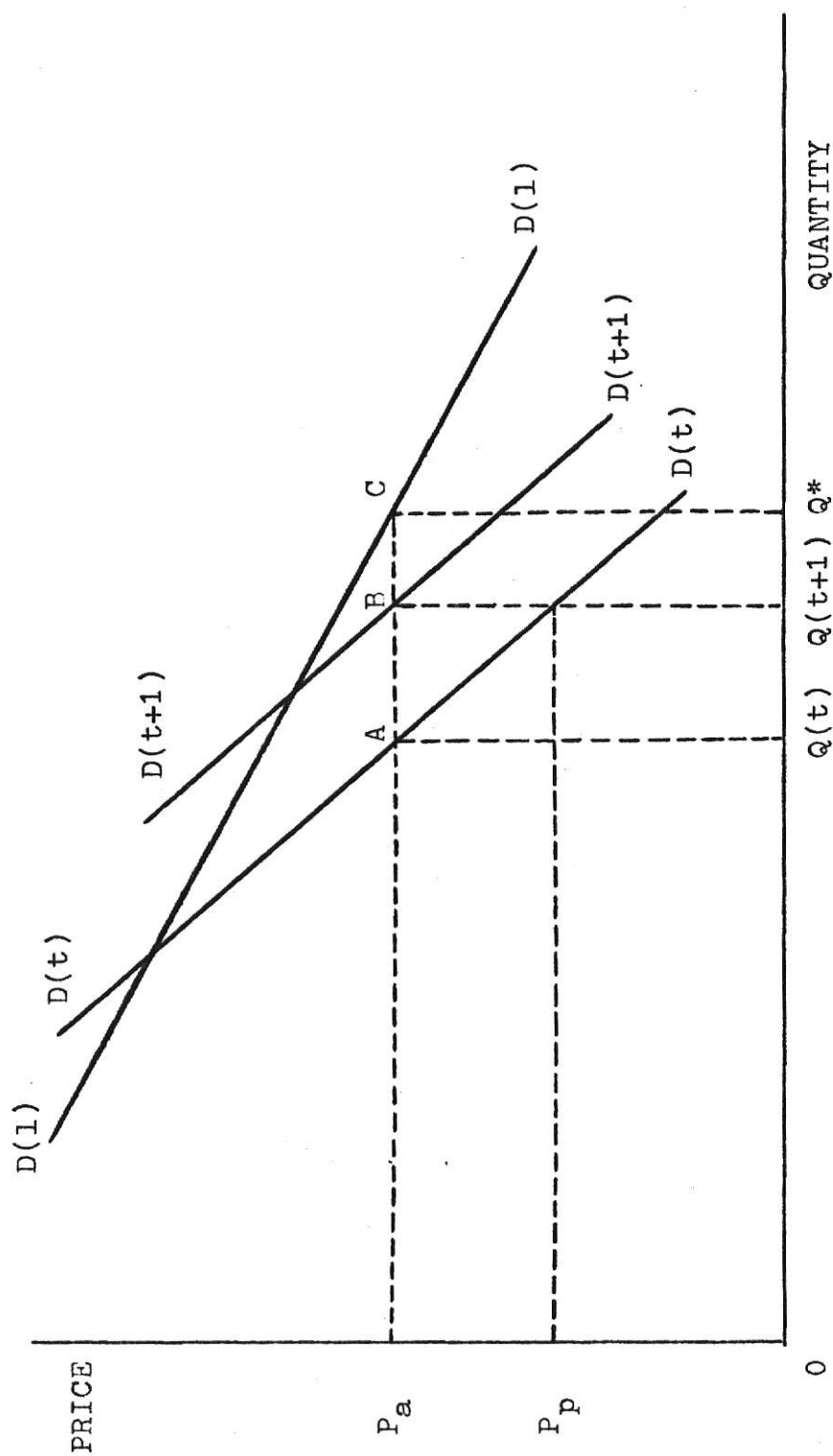
(6)   Price does not change from (P_a), although this is not known to the forecaster. Between (t) and (t+1) consumers are altering their habits, moving along the line segment AB approaching their long-run equilibrium quantity demanded (Q*) at this price. The line segment AC represents very short-run equilibrium positions during the interim period.

(7)   Ceteris paribus conditions hold except for quantity and habits.

On the basis of the above assumptions and the current short-run demand curve D(t), the forecasted price will be given by the intersection of D(t) and Q(t+1). This price will be (P_p), while actual price has remained at (P_a). This difference in forecasted and actual price results because consumers will be at point C in their adjustment process at the instant of time (t+1) and will thus react on the basis of the short-run demand curve through that point D(t+1). This extreme example, which can be expanded to many more possibilities, gives an indication of the basic difficulty of forecasting on the basis of expost information.

The short-run supply curve depends on which factors are permitted to vary, and which are fixed in this time period. This supply concept might best be related to the beef industry by letting the short-run to be a period during which producers cannot alter the number of cattle, with the only variable factor in this period being the amount and type of feed fed.

Thus, producers can alter total pounds of beef only to a limited extent. Hence, the short-run market supply curve in the beef industry will be steeply sloping, but not vertical. The long-run supply curve is derived by letting all factors of production to be variable. Thus, the long-run curve will be less steeply sloping than the short-run curve.

Price determination in the beef industry is complicated by the presence of intermediate processes between production and consumption. Consumers react to the retail price of meat, while producers react to the live-animal price. Hence, the retail demand for beef in terms of live-animal price is a derived demand based on retail market considerations.

Figure 3 provides a simple diagrammatical representation of the demand and supply structure for the beef cattle industry. Price variables are shown within circles, and other variables are shown within rectangles. Heavy arrows indicate less important influential variables. As shown in the diagram, the total beef production in any given year is to a large extent predetermined by the number of cattle and calves on farms January 1 of that year. Even though the number of marketable cattle is fixed at any given time, producers can send beef to market early or hold off to a certain extent. Thus, producers can adjust to a limited extent to economic conditions in the short-run by altering the weight of the beef cattle marketed. Also, they can

Fig. 3.--The Demand and Supply Structure for the Beef Industry

THE DEMAND AND SUPPLY STRUCTURE FOR BEEF
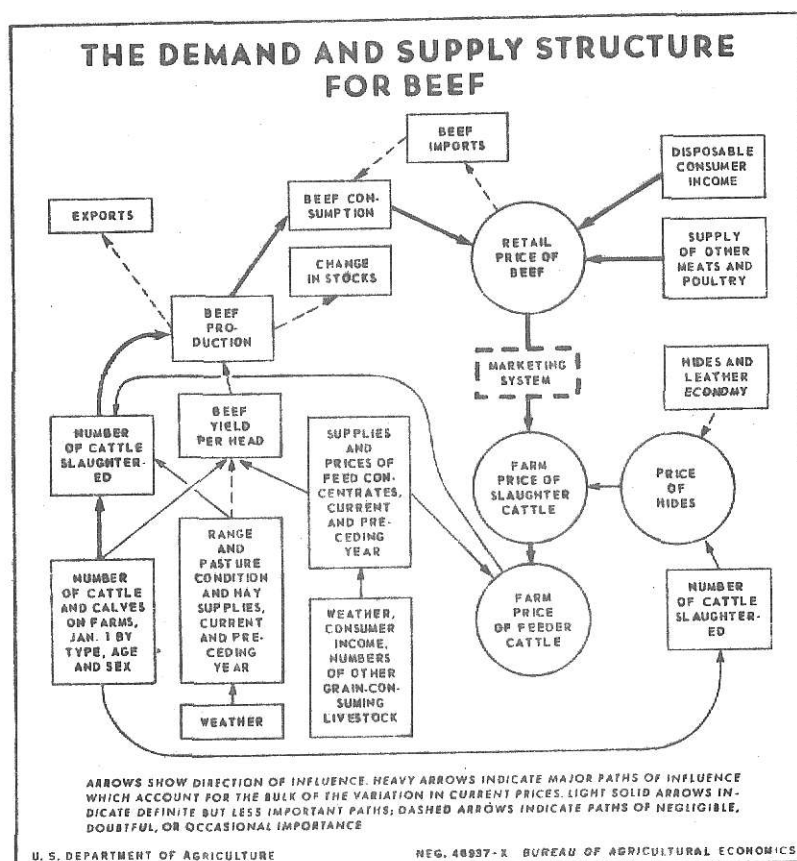
Source: Karl A. Fox, Econometric Analysis for Public Policy, (Ames, Iowa: Iowa State College Press, 1958), p. 79.

change the length of time necessary to achieve a given weight through the amount and type of feed rations used. These decisions are usually based on future price expectations by producers as well as the possible profits at these expected prices, as compared with the current price and profit that could be realized at this price.

The operation of the beef production cycle is illustrated by Figure 4. This production cycle should not be confused with cyclical variations in price, although the production cycle can and usually is one of the causal factors of this variation. Commercial cattle slaughter from steers in year (t+1) depends on the number of calves in year (t), which depends on the number of cows in year (t-1). Total commercial cattle slaughter in year (t+1) is thus dependent on the number of calves the previous year plus the changes in the inventories of cows and heifers.

On the basis of producer expectations regarding future conditions, it seems logical that the feeder cattle price would lead the slaughter cattle price, but this lead effect does not tend to hold in the real world. Empirically, the feeder market coincides with the slaughter market.[1] Thus, the feeder market does not seem to offer any exante information concerning the future slaughter cattle market conditions. This empirical fact is illustrated in Figure 4

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[1]W. R. Maki, "Forecasting Livestock Supplies and Prices with an Econometric Model," Journal of Farm Economics, XXXXV, No. 3 (1963), p. 614. Unpublished research indicates that this concept does not entirely hold.

Fig. 4.--The Internal Mechanism of the Beef Cycle

Market or Production variable	Year				
	T-2	T-1	T	T+1	T+2
Feeder Calf Price					
Cattle on Farms (Jan. 1)					
Calves					
Heifers					
Steers					
Cows					
Commercial Cattle Slaughter					
Slaughter Cattle Price					
Feeder Calf Price					

Source: W. R. Maki, "Decomposition of the Beef and Pork Cycles," Journal of Farm Economics, XLIV, No. 3 (1962), p. 739.

by the slaughter cattle price in a given year being
transferred to the feeder cattle price in the same year.

Over tha past, beef cattle prices have exhibited a
degree of regular variability of seasonal, cyclical, and
long-term trend nature. Seasonal fluctuations are those
variations of a regular nature that occur during a given
calendar year, while cyclical fluctuations are those that
regularly occur over a period of years. A long-term trend
is a regular movement of prices in the same direction over
time.

Seasonal fluctuations usually arise from the seasonality
of production and consumption, although these fluctuations
have seemed to disappear from the beef industry in the
recent past possibly because of expanded feedlot operations.

Figure 5 illustrates the pattern of yearly deflated
price over the past 40 years.[1] A rough cycle of approxi-
mately ten years duration is evident, although the magnitude
of this pattern has diminished over the past ten years. A
slow upward trend is also evident. Results of a trend line
fitted to the 1921-67 data by Franzmann indicates that the
deflated price increased at an average rate of $0.0063 per
hundredweight each month.[2]

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[1] Yearly average price of slaughter steers deflated by
the W.P.I. (1957-59 = 100). This same price deflated by the
C.P.I. exhibits approximately the same pattern.

[2] J. R. Franzmann, "Trend in Slaughter Cattle Prices,"
Oklahoma Current Farm Economics, XXXX, No. 4 (1957),
pp. 96-101.

Fig. 5.--Deflated Price of Slaughter Steers: 1929-69

Fig. 5.--Continued

Price
$/c.w.t.
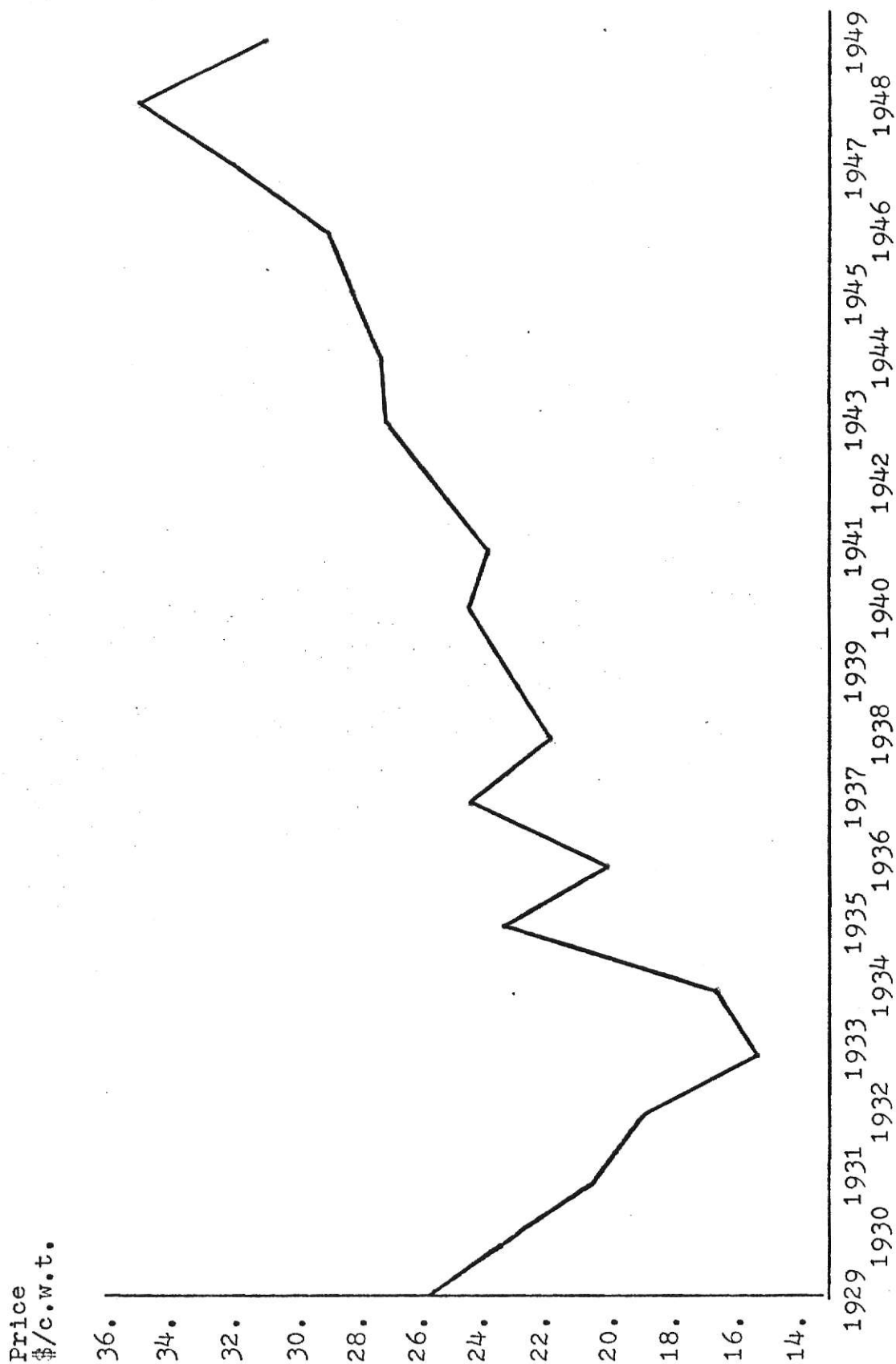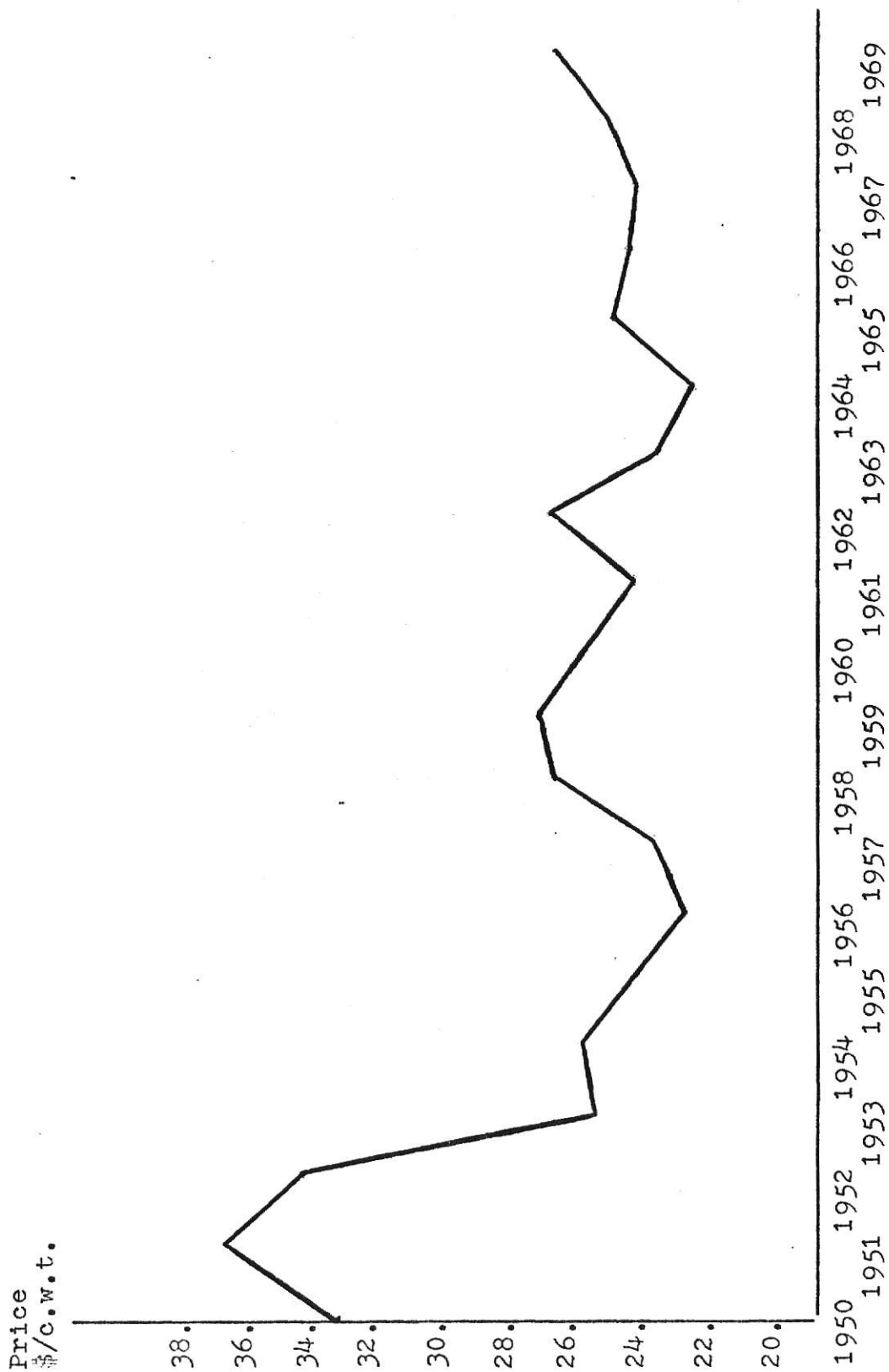
Consideration of the beef production cycle warrants an analysis of how producers plans are formulated. Figure 6 provides an illustration of the basic factors that are usually considered as influencing these plans. Expectations are formed on the basis of predetermined variables such as the number of calves, price of feed, and price of slaughter steers. Judgements are formed by consideration of expectations and predetermined variables. These three factors are then combined to form plans. Thus, in general, production and marketing plans are formed on the basis of past and current values of variables and the judgements of producers.

Fig. 6.--Causal Hierarchy among Plans, Judgements, and
Expectations
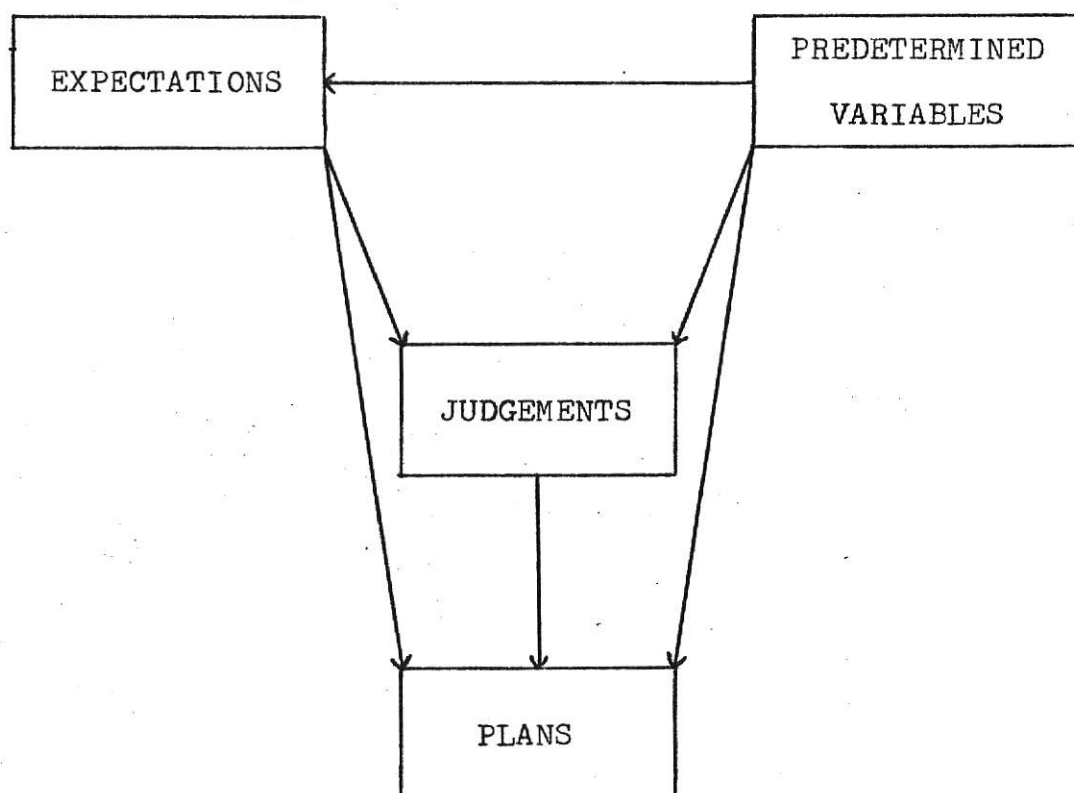
METHODS OF ANALYSIS

Concepts presented in the Chapter on preliminary considerations allow for some insight into the theoretical determination of beef prices. These concepts combined with the factors related to the structure of the beef industry provide the underlying basis for the development of a short-run forecasting model.

Two different models were formulated in this study. The first is a single equation model with all exogenous variables lagged the length of the forecast period. The second is a two equation simultaneous system with all explanatory variables lagged. Price and quantity are the endogenous variables in the system. Estimation of the two equation model was based on quarterly observations, while monthly observations were used for the single equation model.

Single Equation Approach

The basic rationale behind the development of this model is that the true supply and demand curves need not be constructed if the objective of the model is only to forecast prices.[1] Thus, variables considered important in influencing decisions and expectations on both sides of the market were used, even though the substantiation of some of

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[1] E. J. Working, "What Do Statistical Demand Curves Show?" pp. 212-235.

these in a structural sense may be doubtful. One serious
shortcoming of this approach is the ease with which
spurious correlations can result, even though the variables
might subjectively be considered important in the forming
of the market participants plans.

The model used in this approach is:

$$P = XB + U \tag{1}$$

where

P = (n x 1) vector of (n) observations on price

n = number of observations

X = (n x r) matrix of observations on the (r) exogenous
and endogenous variables, with each variable lagged
(i) periods or more.

i = length of the forecast period in months

U = (n x 1) vector of error terms

B = (r x 1) vector of coefficients to be estimated

To allow for quarterly changes in the slopes and intercept
of the forecasting relation, the model was divided into one
equation for each quarter. The rationale behind this
procedure is the same as using quarterly dummy variables
to allow for slope and intercept changes and dropping
insignificant variables. One gain achieved by using this
type of model formulation is the dimunition of the multi-
collinearity problem caused by the presence of a large number
of intercorrelated variables in the equation. In addition,
variables which are significant in only one quarter, but

not in others, can be included in the equation for that
quarter.

One problem that arises from a model of this type is
the presence of serially correlated errors. If this type
of correlation occurs, then the classical least squares
estimator of the parameters will be unbiased, but inefficient.
Serially correlated errors could result from any of the
following four reasons:

(1) Omission of relevant variables.

(2) Incorrect specification of the functional form of
the relationship.

(3) Measurement errors.

(4) Lagged dependent variables.

Because of the nature of the model used in this study,
autocorrelation can be expected for all four reasons given
above. Prediction of an endogenous variable in a model with
autocorrelated errors which has been estimated without
considering the information in regard to autocorrelation will
be biased. However, for the model given by equation (1), this
bias will be small if not totally absent if the autocorrelation
is weak.[1]

In this analysis the presence of a high degree of
multicollinearity was an additional source of model estim-
ation problems. The presence of multicollinearity leads

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[1]The theoretical bias for a model of this type is
derived in Appendix A.

to biased and inefficient estimates of the parameters in the model. However, this problem should not affect the accuracy of the price forecasts, provided the intercorrelation of the variables may reasonably be expected to continue in the future.[1]

Multiequation Approach

The model developed under this approach was used to forecast the quarterly average deflated price of beef. Two equations were used in an effort to take advantage of the correlation between the deflated price and the per capita quantity produced in a given period. Thus, price and quantity produced were treated as endogenous variables. The explanatory variables in the model were lagged at least the length of the forecast period.

The basic form of the model developed is:[2]

$$P_{t+i} = a_0 + a_1 Q_{t+i} + a_2 Q_t + a_3 P_t + u_{1,t+i}$$
$$Q_{t+i} = b_0 + b_1 F_{1,t} + b_2 F_{2,t} + \cdot \cdot \cdot \cdot + u_{2,t+i}$$

where

i = Forecast period in quarters.

P_t = Price in quarter (t).

Q_t = Quantity in quarter (t).

$F_{1,t}$; $F_{2,t}$ = Variables relating to the number of calves on feed at time (t).

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[1] J. Johnson, Econometric Methods, (New York: McGraw Hill, 1963), p. 197.

[2] The basic similarity between this model and the one used by Hayenga and Hacklander (presented on page 7) should be noted, especially with respect to the quantity equation.

Classical least squares was used to estimate the above
equations since the system was black-recursive. Model
estimation problems related to autocorrelated residuals and
multicollinearity that were discussed for the single equation
model also apply to this model.

Evaluation of Forecasting Models

Evaluation of the accuracy of a forecasting model which
is based on time series data is extremely difficult. The
method used to evaluate the models developed in this study
was to estimate the parameters of the model from observations
through 1968, and forecast prices for the following year.
Price forecasts were then compared with the actual prices
during this period.

The three criteria used to evaluate the forecasting
models and the derived price forecasts were:

(1) The accuracy with which the model explained beef
prices over the observation period on which the model
was based.

(2) Forecasting errors.

(3) The accuracy of forecasting turning points.
The multiple correlation coefficient was used to measure
the accuracy with which the model explained prices over the
observation period. Forecasting errors are calculated by
taking the difference between the actual and predicted values.
The turning point concept can best be illustrated with the aid

of Figure 7, which shows four possible situations. These
possibilities are:[1]

(1) A turning point is correctly predicted. _i.e._
A turning point is predicted, and an actual turning
point in the same period is recorded afterwards.

(2) A turning point is incorrectly not predicted. _i.e._
A turning point is recorded, but it was not predicted
before.

(3) A turning point is incorrectly predicted. _i.e._ A
turning point is predicted, but there is no actual turning
point.

(4) A turning point is not predicted. _i.e._ A turning
point is neither predicted nor recorded.

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[1]H. Theil, _Economic Forecasts and Policy_, (Amsterdam:
North-Holland Publishing Company, 1961), p. 28.

Fig. 7.--Four Possibilities in Turning Point Forecasting.[a]

CASE(1)

CASE(2)

CASE(3)

CASE(4)
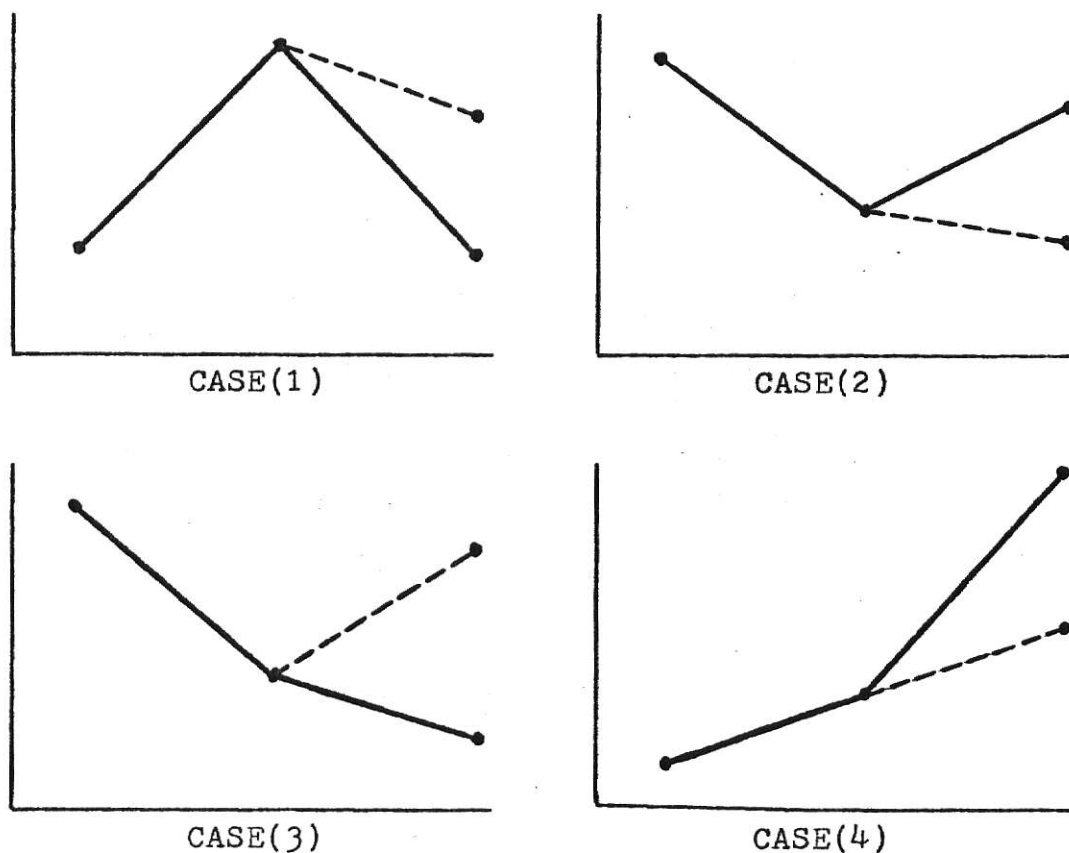
[a]The broken lines represent predictions, the solid ones actual development. Horizontal; time: Vertical; the variable analyzed.

DATA

The three basic criteria that were followed in selecting the data sources to be used in this analysis were:

(1) That the sources be readily available to potential users of the models.

(2) Sources that publish the data within a reasonable length of time after the actual enent has occurred.

(3) The data for each variable be standardized over the time period on which estimation of the models is based. The first two of these criteria are necessary for the model to be useful and applicable for forecasting, while the third is necessary so that measurement errors will be minimized as much as possible.

Estimation of the models was based on observations over the years 1962-68. This period was used for the analysis primarily for two reasons. First, the length of the period under analysis needed to be relatively short in order to be certain that no significant structural changes in the beef industry had occurred. Second, standardized quarterly and monthly data relating to some of the supply variables were not available prior to 1962. Observations for 1969 were dropped from the analysis so that the models could be evaluated over this period.

The variables used in this study are:

$P_{1,t}$ = Monthly average price of choice 900-1100 pound slaughter steers at the Chicago market.

$P_{2,t}$ = Quarterly average price of choice 900-1100 pound slaughter steers at the Chicago market.

CPI_t = Consumer price index for all commodities, expressed in percentage terms. (1957-59 = 100)

$p_{1,t} = (P_{2,t} * 100)/(CPI_t)$ = Quarterly average deflated price of choice 900-1100 pound slaughter steers.

$X_{1,t}$ = Hog-corn ratio. (Chicago Basis)

$X_{2,t}$ = Steer-corn ratio. (Chicago Basis)

$X_{3,t}$ = Range conditons measured as:

Over 100; excellent	60-69; poor
90-99; very good	50-59; bad
80-89; good	Below 50; very bad
70-79; fair	

$X_{4,t}$ = Quarterly number of steers on feed weighing less than 500 pounds. (32 State total).[1]

$X_{5,t}$ = Number of 500-699 pound steers on feed.

$X_{6,t}$ = Number of 700-899 pound steers on feed.

$X_{7,t}$ = Number of 900-1099 pound steers on feed.

$X_{8,t}$ = Number of steers on feed weighing more than 1100 pounds.

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[1]States compromising this total are: 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.; Utah; Nev.; Wash.; Oreg.; and Calif.

$X_{9,t}$ = Number of heifers on feed weighing less than
500 pounds.

$X_{10,t}$ = Number of 500-699 pound heifers on feed.

$X_{11,t}$ = Number of 700-899 pound heifers on feed.

$X_{12,t}$ = Number of 900-1099 pound heifers on feed.

$X_{13,t}$ = Total U. S. population including military forces.

$q_{1,t}$ = Quarterly average commercial beef production
measured in millions of pounds.

$Q_{1,t} = (q_{1,t})/(3)(X_{13,t})$ = Quarterly per capita
commercial beef production.

AN ANALYSIS OF THE PRICE FORECASTING MODELS

Statistical analysis of the various specifications of
the two price forecasting models developed in this study
were derived for the following four cases:

(1) Equations for a forecast period of six months.

(2) Logarithmic form equations for a six month forecast
period.

(3) Equations for a forecast period of three months.

(4) Two equation analysis.

The first three cases refer to the single equation model for
forecasting the market price of beef. The last case refers
to the simultaneous equation model that was developed to
forecast the deflated price of beef.

Equations for a Forecast Period of Six Months

The estimated quarterly equations for a forecast period
of six months are presented in Table 1. The relationships
shown are those that resulted from a concentrated analysis
to determine what combination of variables and the various
lags of these variables yielded the best statistical fit
over the 1962-68 observation period. Variables were removed
from an equation if their coefficients were larger than their
standard deviations: i.e. A (t) value of at least one.[1]

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[1]See, for example, H. S. Houthakker, and L. D. Taylor,
Consumer Demand in the U. S. 1929-1970, (Cambridge: Harvard
University Press, 1966), p. 7.

TABLE 1

ESTIMATED QUARTERLY EQUATIONS FOR A FORECAST
PERIOD OF SIX MONTHS

VARIABLE	QUARTER			
	FIRST	SECOND	THIRD	FOURTH
CONSTANT	15.5692	49.3500	39.5100	31.0500
HOG-CORN $X_1(t-6)$	1.1494 (.1581)			0.2028 (.1585)
HOG-CORN $X_1(t-9)$		0.5122 (.1755)		
STEER-CORN $X_2(t-6)$			0.3494 (.0985)	0.8034 (.1248)
RANGE $X_3(t-6)$				-0.1109 (.1001)
RANGE $X_3(t-12)$			-0.2889 (.0672)	
RANGE $X_3(t-18)$	-0.1924 (.0800)			
STEERS <500# $X_4(t-6)$				-0.0497 (.0114)
500-699 STEERS $X_5(t-9)$		-0.0584 (.0121)	0.0052 (.0021)	
STEERS >1100# $X_8(t-6)$	0.0165 (.0081)		-0.0039 (.0039)	0.0069 (.0044)
HEIFERS <500# $X_9(t-6)$		-0.0872 (.0212)		
HEIFERS <500# $X_9(t-9)$		0.0321 (.0611)		
R^2	0.80	0.88	0.76	0.83
D.W.	1.71	1.46	1.69	1.78

TABLE 1

Continued.

Notes:
Market price at time (t) is the dependent variable for each respective quarter. First quarter; Jan., Feb., March: Second quarter; April, May, June: Third quarter; July, Aug., Sept.: Fourth quarter; Oct., Nov., Dec. The Durbin-Watson statistic is denoted by D.W.

The presence of an extremely high degree of multi-collinearity between a number of the variables considered adversely affected the results. Consequently, only a few of the potential economic variables effecting beef cattle prices could be included in any one equation and yet maintain significant coefficients. In many cases, relations with higher multiple correlation coefficients were obtained. These relationships were rejected because the coefficients of one or more of the variables were insignificant which resulted from the influence of multicollinearity.

The hog-corn ratio, steer-corn ratio, range condition, and the number of calves on feed for various weight groups were found to be the most significant variables in explaining the quarterly variations in price. The steer-corn ratio had a significant coefficient only in the third and fourth quarters. This variable was significantly correlated with price in the first and second quarters, but was insignificant when combined with the other variables. This lack of significance probably resulted from the high degree of multicollinearity among the variables.

The hog-corn ratio was found to be significant in all the equations except for the third quarter. In the second quarter, a lag of nine months instead of six resulted in the best statistical fit. A lag for this variable between six and nine months would more than likely give the best results in all the equations. That is, the supply factors which contribute to price determination in period (t) are

influenced primarily by the hog-corn ratio at some time between (t-6) and (t-9). However, variables lagged between six and nine months were not used in this analysis because of the large number of possible combinations.

The range condition variable was used in the model to reflect weather conditions and hence to serve as a proxy for changes in cattle and calves not on feed. This variable also served as a method of reflecting current cattle conditions which influence future prices. Range condition was a significant variable in all equations except for the second quarter relationship. This insignificance in the second quarter would be expected since range conditions are less influential on supply during the winter months and therefore on future price.

In general, this variable was found to be positively correlated with price for lags shorter than six months in length, while negatively correlated with price for longer lags.[1] The cattle reproduction cycle undoubtedly has an effect on this correlation. For example, if range conditions in period (t) are excellent, then less cattle will be marketed in the short-run because of the incentive to keep a large number of cattle on grass. Thus, price will tend to increase in the short-run because of the depressed supply. Over a longer time period, price will probably decrease

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[1]This pattern of correlation was also found to hold for the deflated price of beef.

because the number of cattle as well as the total pounds of beef marketed will increase from the previous witholding action.

The number of steers on feed weighing more than 1100 pounds had a significant positive coefficient in the relationships for the first and fourth quarters. If this variable reflects producers expectations of price in the immediate future and these expectations are realized, then the positive sign would be expected. However, the sign of this variable in the equation for the third quarter contradicts this intrepretation, although the coefficient was less significant. In addition, the negative sign may have resulted from a spurious correlation or a multi-collinearity bias.

The number of steers on feed weighing less than 500 pounds was significant in the equation for the fourth quarter. The coefficient for this variable was negative, which would be expected. That is, an increase in the number on feed, operating through supply and demand in the future, would tend to lower price.

The coefficient's sign for the variable 500-699 pound steers lagged nine months differed for the second and third quarter relationships. As with the lighter weight animals, a negative sign would be expected. Thus, the positive sign for the third quarter could have resulted from either a multicollinearity bias or a spurious correlation. If multi-

collinearity was the cause and Johnson's claim is accepted, then the price forecasts from this equation should not be affected.[1]

The number of heifers less than 500 pounds on feed was significant with a lag of both six and nine months in the second quarter. The number of heifers on feed in this weight group at time (t-9) has the most significant effect on price within the period (t-3) to (t). This result is consistent with a normal rate of gain for these animals. The difference in the signs of the two coefficients was more than likely a bias which resulted from the serial correlation of this variable (0.88 in this case).

In all the estimated relations shown in Table 1, the Durbin-Watson test for autocorrelated error terms was inconclusive. Hence, the potential bias of a forecast resulting from error terms will be small if not totally absent.[2]

Logarithmic Form Equations for a Six Month Forecast Period

The relationships shown in Table 1 were placed in logarithmic form and reestimated to give the equations

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[1] Johnson, op. cit., p. 197.

[2] The Durbin-Watson test is for first order auto-correlation only. Therefore, this conjecture holds only for bias due to such a scheme. More complicated schemes could be present and thus bias the forecasts, but this is unlikely. The theoretical bias for a first order scheme for the models used in this analysis is derived in Appendix A.

shown in Table 2. The objective of this analysis was to determine if the results could be substantially improved with the variables in logarithmic form. That is, the gain in model precision would outweigh any loss in practicality of the logarithmic form. However, only two of the equations were improved as measured by the multiple correlation coefficient, and this improvement was very small. Thus, the potential gain appears to be small, although other sets of variables in this form might give substantially better results than the ones shown.

Equations for a Forecast Period of Three Months

Estimated quarterly equations for forecasting price three months into the future are presented in Table 3. For all quarters except the third, the statistical results were improved with a shorter lag for the exogenous variables. The relationship with the best statistical fit found for the third quarter was identical to the one shown in Table 1 for a six month forecasting period. Thus, for both three and six month forecasting periods, the third quarter was the one with the most insignificant fit, and hence the most difficult quarter to forecast.

The variables used for the three month forecasting period were almost identical to those in the six month relationships and thus would have the same basic economic

TABLE 2

LOGARITHMIC FORM EQUATIONS FOR A FORECAST PERIOD OF SIX
MONTHS

VARIABLE	QUARTER			
	FIRST	SECOND	THIRD	FOURTH
CONSTANT	2.4650	7.3720	-0.4009	6.1970
HOG-CORN $LOG(X_1(t-6))$	0.7118 (.0959)			0.1636 (.0888)
HOG-CORN $LOG(X_1(t-9))$		0.2242 (.1347)		
STEER-CORN $LOG(X_2(t-6))$			0.2700 (.0768)	0.6237 (.0954)
RANGE $LOG(X_3(t-6))$				-0.4431 (.2874)
RANGE $LOG(X_3(t-12))$			-0.5418 (.1205)	
RANGE $LOG(X_3(t-18))$	-0.6203 (.2470)			
STEERS <500# $LOG(X_4(t-6))$				-0.7314 (.1549)
500-699# STRS $LOG(X_5(t-9))$		-1.2530 (.4353)	0.2511 (.0672)	
STEERS >1100# $LOG(X_8(t-6))$	0.2520 (.1202)		-0.0394 (.0726)	0.1668 (.0746)
HEIFERS <500# $LOG(X_9(t-6))$		-0.4615 (.2190)		
HEIFERS <500# $LOG(X_9(t-9))$		1.2930 (.3727)		
R^2	0.81	0.78	0.78	0.84
D.W.	1.69	0.62	1.70	2.00

TABLE 3

ESTIMATED QUARTERLY EQUATIONS FOR A FORECAST
PERIOD OF THREE MONTHS

VARIABLE	QUARTER			
	FIRST	SECOND	THIRD	FOURTH
CONSTANT	9.0590	50.4500	39.5100	25.8900
PRICE $P_1(t-3)$	0.4210 (.2239)	-0.2876 (.2132)		-0.4465 (.2617)
HOG-CORN $X_1(t-6)$	0.0493 (.2880)	0.2427 (.1126)		
STEER-CORN $X_1(t-3)$				0.6613 (.1181)
STEER-CORN $X_2(t-6)$			0.3494 (.0985)	
RANGE $X_3(t-3)$				0.078 (.0544)
RANGE $X_3(t-9)$		-0.1019 (.0811)		
RANGE $X_3(t-12)$			-0.2889 (.0672)	
STEERS <500# $X_4(t-3)$	-0.0169 (.0153)			
500-699# STEER $X_5(t-9)$			0.0052 (.0021)	
STEERS >1100# $X_8(t-3)$		-0.0307 (.0053)		-0.0210 (.0054)
STEERS >1100# $X_8(t-6)$			-0.0039 (.0039)	
500-699# HEIF. $X_{10}(t-3)$	0.0142 (.0052)			
R^2	0.83	0.87	0.76	0.92
D.W.	1.50	1.67	1.69	1.62

intrepretation. The price of market cattle in the previous quarter was the only variable appearing in these equations that was insignificant in the six month relationships. In two of the equations shown in Table 3, the coefficient of this variable was negative. The negative sign on the lagged price variable would indicate that a quarterly cyclical behavior of price was present over the 1962-68 observation period.

The coefficients of steers on feed greater than 1100 pounds in both the second and fourth quarters had a negative sign, which would be expected if these steers were marketed within three months. That is, an increase in the number of steers of this size at time (t-3) will tend to lower price at time (t). The negative sign on the coefficient of this variable does not necessairly contradict the expectational intrepretation given to this variable for the six month model. The previous model specification involves a six month lag, while a three month lag was involved in this case.

As in the equations for a six month forecasting period, the Durbin-Watson test was inconclusive as to the presence of autocorrelated residuals.

Two Equation Models

The results of the regression analysis for the two equation model for a forecast period of one quarter are shown in Table 4. In both equations (0, 1) dummy variables were

TABLE 4

ESTIMATED PARAMETERS FOR THE TWO EQUATION MODEL WITH A
FORECAST PERIOD OF ONE QUARTER

VARIABLE	EQUATION	
	PRICE	QUANTITY
CONSTANT	8.5351	0.8602
DEFLATED PRICE $P_2(t)$	DEPENDENT	
DEFLATED PRICE $P_2(t-1)$	0.6944 (.1463)	
QUANTITY $Q_1(t)$	-2.7646 (.9932)	DEPENDENT
QUANTITY $Q_1(t-1)$	2.6158 (.9649)	0.6148 (.1677)
DUMMY D(1)	-0.5106 (.3975)	0.0249 (.1222)
DUMMY D(3)	0.7551 (.4431)	0.1332 (.0855)
DUMMY D(4)	-0.6477 (.4007)	-0.1982 (.1821)
700-899# STEERS $X_6(t-1)/X_{13}(t-1)$		0.1358 (.0839)
900-1099# STEERS $X_7(t-1)/X_{13}(t-1)$		0.0794 (.1017)
R^2	0.67	0.92

used to allow for changes in the intercept of these relations. As in the previous model, variables were considered significant if the estimated coefficients exceeded their respective standard deviations.[1]

The per capita number of 700-899 pound steers on feed, 900-1099 pound steers on feed, and the per capita quantity produced in a given quarter were found to be the most significant variables in explaining the variations in per capita quantity produced the next quarter. Variables relating to the per capita number of heifers on feed were not included in the forecasting equation because of their insignificance when combined with the other variables. In addition, range condition was considered as a proxy variable in the model to reflect weather conditions and changes in the number of calves not on feed, but was found to be insignificant. More than likely, these two variables would be significant if the appropriate lag was found or a lag distribution used. The quantity equation shown in Table 4 explained the variation in per capita quantity over the observation period very well considering that the percentage of cattle not on feed as well as the average weight of slaughter cattle varies.

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[1] In these equations, the significance of the variables cannot arise from seasonality in the data because seasonal dummy variables were used in estimating the relations. The coefficients of variables estimated with seasonal dummy variables included in the equation are identical to those that would be obtained by first removing seasonality from each variable separately and then regressing on the adjusted variables.

The percentage of explained variation of deflated price was relatively low which would contribute to the inaccuracy of future price forecasts. The deflated retail and wholesale prices of pork, and deflated per capita income were found to be insignificant in this relation when lagged three months. i.e. the length of the forecast period.

Results of the analysis for the two equation model with a two quarter forecast period are shown in Table 5. The same basic relationships were used for this forecast period as for the shorter period. In addition to the two steers on feed variables, the number of 700-899 pound heifers on feed was a significant variable in the quantity relation. The range condition variable was again found to be insignificant.

The quarterly average deflated price of pork at both the retail and wholesale level, and deflated per capita income were insignificant in the price equation. In the price equations for both the three and six month forecasting periods, the coefficient for lagged quantity had a positive sign, while the current quantity had the expected negative sign. Since these coefficients were of about the same magnitude, this difference in signs was more than likely caused by a bias resulting from the serial correlation of the quantity variable.[1]

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[1]The serial correlation of this variable in the two time period combinations is: $CORR(Q(t), Q(t+1)) = 0.94$; $CORR(Q(t), Q(t+2)) = 0.89$.

TABLE 5

ESTIMATED PARAMETERS FOR THE TWO EQUATION MODEL WITH A
FORECAST PERIOD OF TWO QUARTERS

VARIABLE	EQUATION	
	PRICE	QUANTITY
CONSTANT	15.7963	2.7752
DEFLATED PRICE $P_2(t)$	DEPENDENT	
DEFLATED PRICE $P_2(t-2)$	0.4079 (.1953)	
QUANTITY $Q_1(t)$	-3.4315 (1.051)	DEPENDENT
QUANTITY $Q_1(t-2)$	3.0879 (.9765)	
DUMMY $D(1)$	0.0897 (.5337)	-0.2910 (.2507)
DUMMY $D(2)$	0.6701 (.5619)	0.1422 (.1680)
DUMMY $D(4)$	1.1234 (.5700)	0.3854 (.2622)
700-899# HEIFERS $X_{11}(t-2)/X_{13}(t-2)$		0.2795 (.2055)
700-899# STEERS $X_6(t-2)/X_{13}(t-2)$		0.1532 (.1255)
900-1099# STEERS $X_7(t-2)/X_{13}(t-2)$		0.2143 (.1253)
R^2	0.45	0.83

Evaluation of the Forecasting Models

Price predictions from the quarterly equations shown in Table 1 for a forecast period of six months are shown in Table 6. Corresponding to each predicted price is the actual market price and the forecasting error for each respective time period. The largest forecasting errors occurred during the second and third quarters. These large errors probably resulted from the rapid upward movement in price in these two periods, the specification of the model, and/or from other factors. The most significant factor was that the actual price for the months of May, June, and July of 1969 where the error was the largest was significantly greater than any price in the 1962-68 period on which the model estimation was based.[1] That is, from an econometric viewpoint, the coefficients in Table 1 would be valid only for values of the variables that were used to estimate the coefficients. Thus, some inaccuracy of forecasts would be expected on theoretical grounds alone.

Another basic factor which could have contributed to the forecasting errors was the increase in the rate of inflation over the 1968-69 period. The Consumer Price Index increased 2.1 per cent in the first two quarters of 1969. This general price increase was larger than that

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[1]The highest price in the 1962-68 period was $30.13 per hundredweight, while the price in June of 1969 was $34.22 per hundredweight.

TABLE 6

SIX MONTH FORECASTS BASED ON QUARTERLY EQUATIONS

MONTH	ACTUAL	PRED.	ERROR[a]
Oct. 1968	28.21	28.52	-0.31
Nov.	28.46	27.51	0.95
Dec.	28.88	27.79	1.09
Jan. 1969	29.23	29.04	0.19
Feb.	29.11	28.70	0.41
March	30.19	29.04	1.15
April	30.98	31.09	-0.11
May	33.85	30.94	2.91
June	34.22	30.84	3.38
July	31.49	28.45	3.04
Aug.	30.94	29.42	1.52
Sept.	29.75	29.74	0.01

[a](ERROR) = (ACTUAL) - (PREDICTED)

observed for any period within the 1962-68 period on which
the model was based. Unless inflation increases at approx-
imately the same rate as it progressed over the observation
period, the prices predicted from the model would tend to
be less than the actual prices.

Predictions from the quarterly equations shown in Table 2
for a forecast period of three months are shown in Table 7.
The forecasting errors for the three months in the second
quarter were extremely large. The low forecast values in
that quarter were primarily a result of the large increase in
the first quarter of the number of steers on feed weighing
more than 1100 pounds. Although the number of steers on
feed in the first quarter indicated that quantity would
increase in the next quarter, the actual quantity marketed
decreased. Total commercial beef production in the second
quarter was 5,016 million pounds, while quantity produced
the first and third quarters was 5,148 and 5,325 million
pounds, respectively. More than likely the steers on feed
in this period were fed out to a higher than normal weight,
and thus the major effect of this production on price was
not felt until six months later. In addition, the percentage
of steers not on feed in the first quarter was much lower
than normal; thus causing the number on feed to give a false
indication of future quantity. Hence, the large price
prediction errors for the second quarter were probably a
result of the increase in actual price from the low quantity

TABLE 7

THREE MONTH FORECASTS BASED ON QUARTERLY EQUATIONS

MONTH	ACTUAL	PRED.	ERROR[a]
Oct. 1968	28.21	28.27	-0.06
Nov.	28.46	28.66	-0.20
Dec.	28.88	28.78	0.10
Jan. 1969	29.23	30.06	-0.83
Feb.	29.11	30.15	-1.04
March	30.19	30.32	-0.13
April	30.98	23.14	7.84
May	33.85	23.67	10.18
June	34.22	23.43	10.79
July	31.49	28.45	3.04
Aug.	30.94	29.42	1.52
Sept.	29.75	29.74	0.01

[a](ERROR) = (ACTUAL) - (PREDICTED)

marketed and a greater than normal rate of inflation, with the forecasted prices being pushed down by the large number of steers on feed.

An extension of the evaluation period into 1970 and 1971 would give a better indication of the forecasting precision of the model. This analysis would help ascertain whether the large forecasting errors for the second quarter of 1969 were a result of the equations, the apparent unusual circumstances in that quarter, or to a change in the structure of the beef industry. Lengthening the period might also indicate whether the accurate price predictions for other months would continue in the future. In general, a longer evaluation period would permit more substantive conclusions concerning the model. However, there is a basic shortcoming in lengthening the evaluation period. The shortcoming is that when observations are added to update the estimated model, the significance of the variables may change; thus altering the forecasting ability of the model.

A graphical comparison of the actual and predicted values of price for the quarterly equations with a forecast period of six months are shown in Figure 8. In four cases out of the twelve, the turning points were incorrectly predicted, in four cases turning points were correctly predicted, and in the other four cases turning points were correctly not predicted. Thus, one-third of the forecasts in the evaluation period were undesirable from the point of view of turning points.

Fig. 8.--A Graphical Comparison of the Actual and Forecasted Prices for the Quarterly Equations with a Forecast Period of Six Months.[a]

PRICE
$/c.w.t.
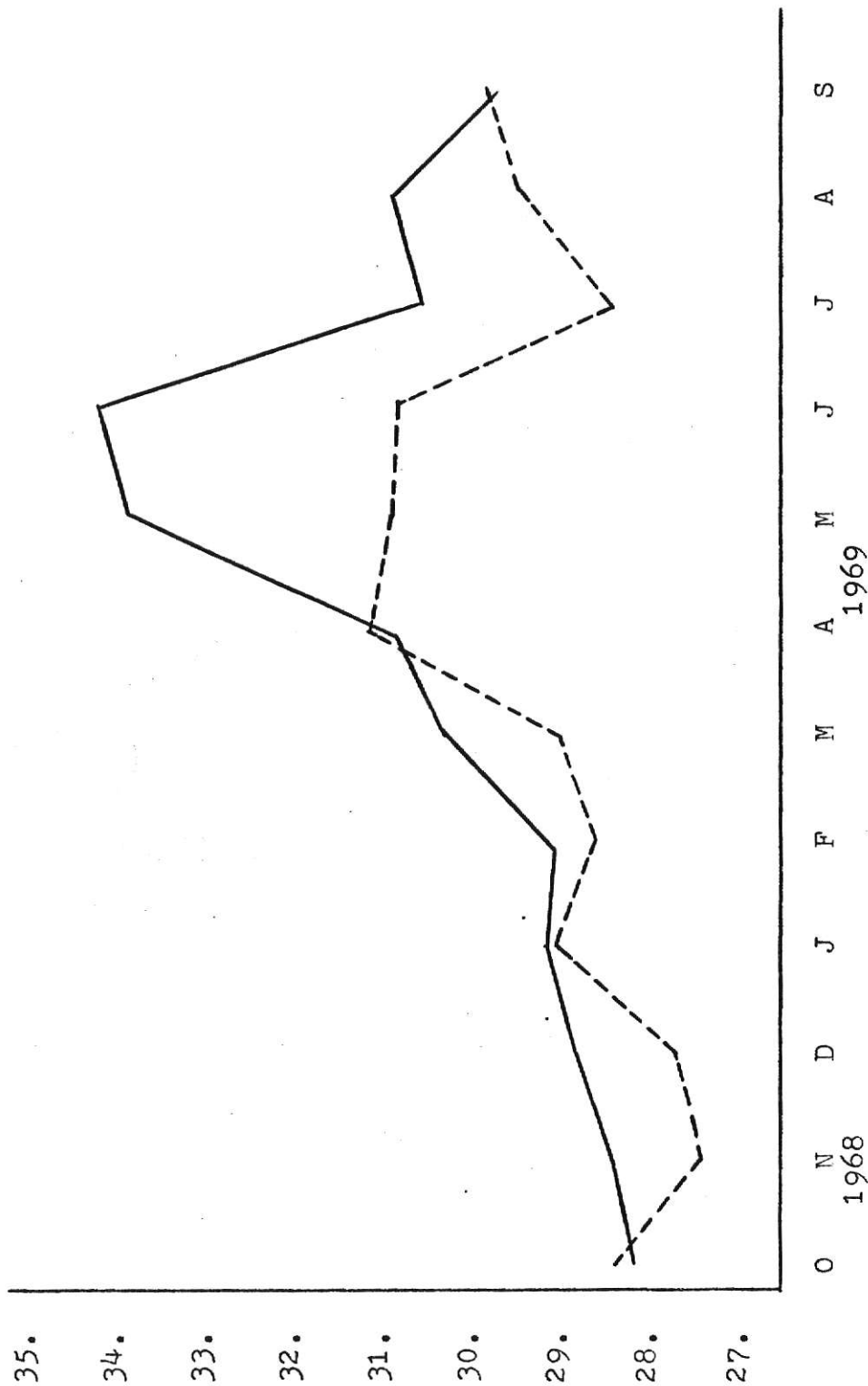
[a]Solid line; actual price: Dashed line; forecasted price.

The same analysis for the quarterly equations with a forecast period of three months is shown in Figure 9. In six cases out of twelve the turning points were incorrectly predicted, in one case a turning point was correctly predicted, and in five cases a turning point was correctly not predicted.

A comparison of actual and forecasted deflated prices from the two equation model are shown in Tables 8 and 9 for forecast periods of one and two quarters, respectively. As with the previous models, the largest errors occurred during the second quarter. Again, this model inaccuracy was the result of the number of steers on feed giving an indication that the quantity would increase, while the actual quantity marketed decreased. Predictions were undesirable from a turning point view in two out of four cases for both of the forecasting periods. Undoubtedly, any conclusions based on the turning point and forecasting error analysis can be substantially biased from only four observations. Also, the forecasts for the fourth quarter of 1968 were in the observation period for this model.

Fig. 9.--A Graphical Comparison of the Actual and Forecasted Prices for the Quarterly Equations with a Forecast Period of Three Months.a
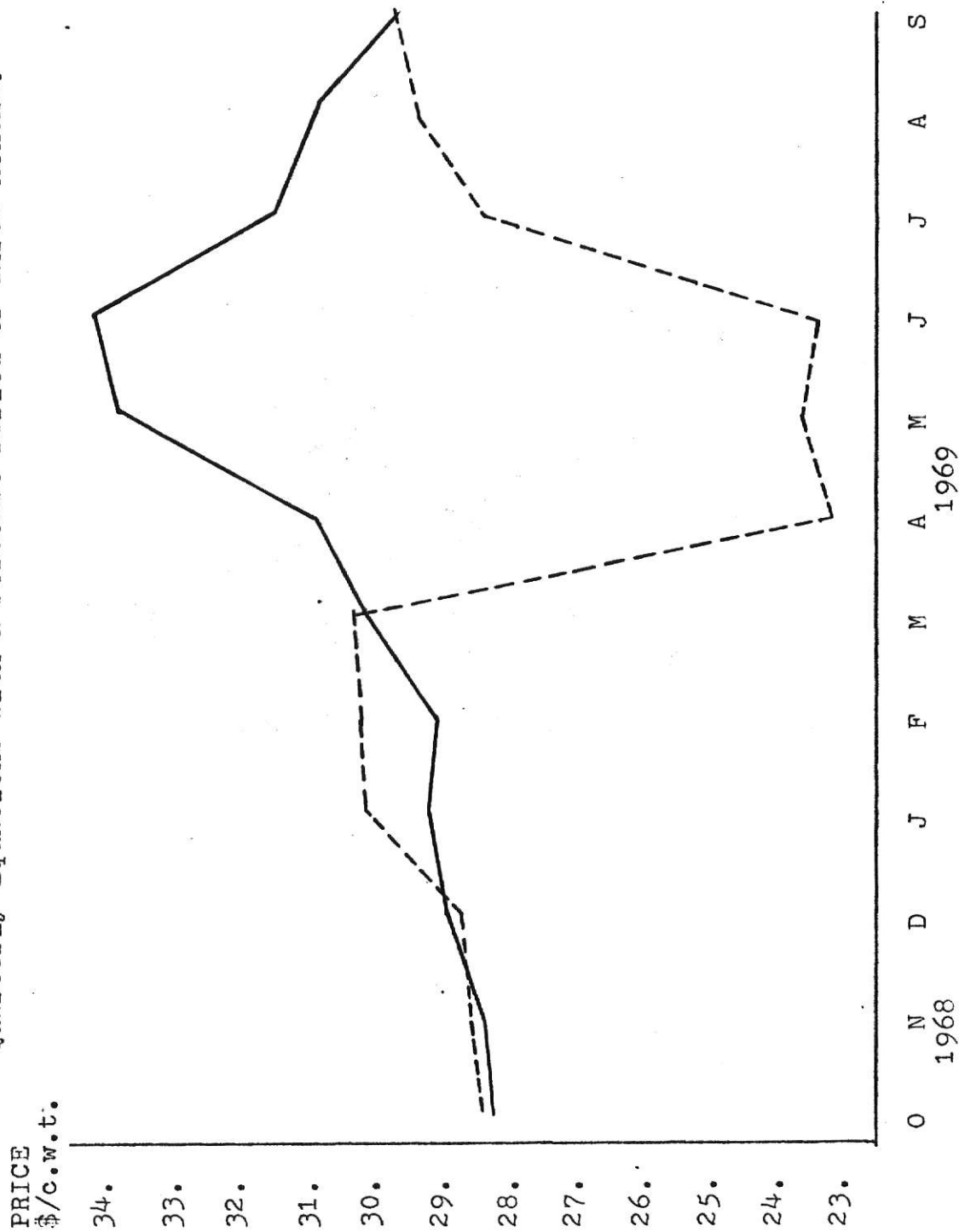
aSolid line; actual price: Dashed line; forecasted price.

TABLE 8

DEFLATED PRICE PREDICTIONS FROM THE TWO EQUATION MODEL WITH
A FORECAST PERIOD OF ONE QUARTER

QUARTER	ACTUAL	PRED.	ERROR[a]
1968 (4)	23.13	22.39	0.74
1969 (1)	23.65	22.74	0.91
(2)	26.02	22.73	-3.27
(3)	23.88	25.05	-1.17

TABLE 9

DEFLATED PRICE PREDICTIONS FROM THE TWO EQUATION MODEL WITH
A FORECAST PERIOD OF TWO QUARTERS

QUARTER	ACTUAL	PRED.	ERROR[a]
1968 (4)	23.13	22.96	0.17
1969 (1)	23.65	21.87	1.78
(2)	26.02	22.91	3.11
(3)	23.88	21.08	2.80

[a](ERROR) = (ACTUAL) - (PREDICTED)

SUMMARY AND CONCLUSIONS

Two quantitative models for the short-run forecasting
of slaughter cattle price were developed in this study.
Both models were developed with the objective of providing
livestock producers a simple quantitative model for fore-
casting that would be helpful in reducing price uncertainty.

The first model developed provides unconditional
forecasts of the average monthly market price. The second
is a two equation simultaneous system that provides uncondi-
tional forecasts of the deflated price and per capita quantity
produced in a given quarter. The simultaneous model for
forecasting deflated price was developed because a large
degree of imprecision can be introduced into a market price
model by changing rates of inflation. The quarterly equation
model could be formulated in terms of deflated price and
would possibly give better results than the simultaneous
model, but a single equation model based on deflated prices
was not formulated in this study.

Forecasts from the two types of models were evaluated
over a one year period. The average forecasting error for
the quarterly equation model with a forecasting period of
six months was $1.26 per hundredweight.[1] The forecasting
error for the same model with a forecasting period of three

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[1]The average forecasting error is the average of the
absolute value of the individual errors.

months was $2.98 per hundredweight. The relatively large error for the shorter forecasting period resulted from the large prediction errors for the second quarter equation.

The large prediction errors for the second quarter resulted from an unusual set of circumstances that were not encountered in the period on which estimation of the model was based. Also, price movements in the evaluation period were rather extreme as compared with past price movements.

The quarterly equation models were also evaluated on their ability to predict turning points. The model with a forecast period of six months made undesirable turning point predictions in four cases out of the twelve, while the model for a three month forecast period made undesirable predictions in six cases out of the twelve. Again, the relative inaccuracy of the model with a three month forecast period resulted from the euqation for the second quarter.

The two models for forecasting the quarterly deflated price made undesirable turning point predictions in two out of four cases. The average deflated price forecasting error for the model with a one quarter forecast period was $1.52 per hundredweight. For the model with a two quarter forecast period the average error was $1.96 per hundredweight. The forecasting analysis for the two equation model was based on only four forecasts; thus any conclusions would be biased from the small number of observations.

Factors on the supply side of the industry were

emphasized as those variables that would give the best
indication of future price. Hence, a portion of the fore-
casting imprecision could have resulted from factors on the
demand side of the industry which were not accounted for.
Another factor that was not incorporated into the models,
which is related to demand, is the general economic situation.
However, a variable which gives a short-run exante indication
of the future economic condition would be difficult to
determine.

In general, the forecasts were found to be fairly
accurate considering the unusual circumstances that prevailed
in the 1968-69 evaluation period. Hence, the models may be
useful to livestock producers as an aid in forming predictions
of future prices. More substantive conclusions concerning
the accuracy of the estimated models could be made by
extendind the evaluation period through 1970 and 1971.

APPENDIX A

The following discussion is an illustration of the forecasting bias that can result from autocorrelated residuals in a model similar to the one used in this study. The single equation model is of the following form:

$$P_t = AX_{t-6} + u_t \qquad (1)$$

where (u_t) conforms to a first order Markov process;

$$u_t = pu_{t-1} + w_t \qquad (2)$$

where

p = autoregressive parameter

$E(w_t) = 0$ for all t

$V(w_t) = \sigma_w^2$

$COV(w_i, w_j) = 0$ for all $(i \neq j)$.

The expected value of (P_{t+6}) given the values $(u_1, \ldots, u_n)$ that have generated the sample will be the predicted value of (P_{t+6}).[1] This expected value will be:

$$E(P_{t+6}/u_1 \ldots u_n) = AX_t + E(u_{t+6}/u_1 \ldots u_n) \qquad (3)$$
$$= AX_t + pu_{t+5} \qquad (4)$$

If least squares had been applied to equation (1), then the prediction would be:

$$\hat{P}_{t+6} = \hat{A}X_t$$

Hence, the predicted value of (P_{t+6}) will be biased

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[1] J. Johnson, Econometric Methods (New York: McGraw Hill, 1963), p. 196.

unless the information about the error term was utilized.

A number of statistical problems arise when this analysis is extended to the model used in this study where (P_{t+6}) is predicted on the basis of information at time (t). That is, information about ($u_{t+5}, \dots u_{t+1}$) is not known. Using equation (2) to place equation (4) in terms of (u_t) gives:

$$E(P_{t+6}/u_1 \dots u_n) = AX_t + p^6 u_t \qquad (5)$$

Thus, if errors followed a first order autoregressive scheme and this autocorrelation was weak, the bias that resulted from not using the information about the error terms would be small. If the autocorrelation was strong (i.e. / p / $\doteq$ 1), then the bias can be large. Specifically, the bias depends on the value of (p), the size of the error (u_t), and the number of periods between the forecast period and the last period information about the error term is available.

In a prediction problem of this type using a first order autoregressive transformation to eliminate the problem will not help since the model becomes:

$$(P_{t+6} - pP_{t+5}) = a(X_t - pX_{t-1}) + w_t \qquad (6)$$

and the value for (P_{t+5}) would be needed to forecast (P_{t+6}). The only time an autoregressive transformation would be useful in this case would be when a correlation between (u_t) and (u_{t+6}) existed.

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SHORT-RUN BEEF PRICE FORECASTING MODELS

by

CHARLES ROBERT TAYLOR

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

In this paper two statistical models for the short-run forecasting of choice slaughter steer price were developed. The models were developed in an effort to provide livestock producers a practical quantitative prediction model that could be used as an aid in reducing the price uncertainty that currently exists in the beef industry. One model, which provides forecasts of the monthly market price, was formulated with an equation for each quarter of the year. The second is a two equation simultaneous system for forecasting the deflated quarterly average price. Both models were specified to provide forecasts three and six months in the future, since producers should find these the most useful in their short-run decision making.

All exogenous variables in the models were lagged so that price forecasts could be calculated on the basis of expost information available to producers. Hence, no structural significance can be placed in either of the models

The models were estimated by classical least squares regression techniques from observations in the 1962-68

time period. Price predictions from the models were
evaluated over a one year period beginning in October
of 1968 and ending in September of 1969. These predictions
were found to be fairly accurate considering the extreme
circumstances in the evaluation period. Consequently,
the models may be useful in reducing price uncertainty
if forecasts are weighted by the producers own subjective
judgement.