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Title: A Short Run Price Forecasting Model for Slaughter Steers and Slaughter Cows in the Pacific Northwest

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The cattle industry in the Pacific Northwest is characterized by a large number of producers. Individual contributions to the market have little effect in moderating potential fluctuations in the prices received for the various classes of cattle. Price volatility is of constant concern to producers in planning future production, with decisions made in the current period affecting future profitability of the enterprise. Information that will assist in developing strategies to deal with this uncertainty may play a critical role in reducing the risk of continued production.

Inherent to this decision making process is a knowledge of the various factors influencing both biological parameters and economic conditions at a future point in time. The econometric models developed in this study attempt to quantify the economic relationships at the farm level, that affect the price received for the live animal. The economic relationships deemed important in this study are the factors influencing the demand and supply of beef cattle.

The supply and demand relationships at the feedlot level are in-

cluded in a model with coefficients estimated to reflect the individual influence of each variable on the price of slaughter steers for the quarter. A necessary condition of this price formulation process is that current supply and demand levels determine current prices.

The slaughter steer prices estimated in this procedure are developed to reflect the fluctuations in the Omaha market. This particular location is considered to more accurately reflect the aggregate data for the U.S. used in the price prediction model. The same strategy of using the Omaha market to reflect U.S. aggregated data is employed in developing a model to forecast utility cow prices.

The transition to regional price models for the Northwest was accomplished with little difficulty because of the close historical relationship between the two regions. This characteristic was specified in the Northwest steer and cow price models by including the Omaha price for the quarter as the determinant of prices in Oregon and Washington. Forecasted prices from one and two quarter Omaha steer and cow price models were then used in estimating future Northwest prices.

The steer prices estimated in this study compared favorably with price forecasting models from seven other sources evaluated by Just and Rausser (1981). Using the percent root mean square error statistic as a method of comparison, the values from their study ranged between 9.9 and 12.9 for a one quarter forecast, and 12.4 and 18.9 for a two quarter projection. The percent root mean square error calculated for Northwest steer price forecasts was 10.09 for the one quarter estimates and 11.08 for the two quarter projections.

These results proved promising in developing future price projections. The inclusion of this modeling process, as a management tool in developing short run production strategies, may be used advantageously in reducing the risk and uncertainty associated with the price fluctuations in the live cattle market.

A Short Run Price Forecasting Model for Slaughter Steers and Slaughter Cows in the Pacific Northwest

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CHAPTER I

INTRODUCTION

Cattle producers in Oregon and Washington generated 693 million dollars in gross income during 1981. Their contribution to the region in the form of additions to the state coffers and the service industries they support are sorely needed during the current recession. This regional industry includes 53,000 producers, with individual contributions to the market having little effect in moderating potential fluctuations in the prices received for the various classes of cattle.

Price volatility is a major concern to producers in planning future production when decisions made in the current period affect future profitability of the enterprise. For example, between the fourth quarter of 1980 and the fourth quarter of 1981, the price of choice slaughter steers in the Northwest ranged from a high of $72.11 per hundred weight to a low of $62.24. Information that will assist in developing strategies to deal with this volatility may play a critical role in reducing risk. In evaluating the sources and types of information deemed necessary to reduce the risks of producing and marketing cattle, the future price of the animal seems to be of paramount importance. The lack of information, in this regard, presents a challenge that is the basis of this study.

A. Problem Statement

The inclusion of a short run price prediction model, as a management tool of the cattle producer, is a way of developing estimates of future prices. These estimates may be incorporated into production strategies designed to optimize future returns.

This projected price information could be used in evaluating alternative management decisions in all phases of production, from adjusting culling strategies in the cow herd to developing marketing strategies for cattle on feed. Optimizing future returns in each of these enterprises could improve the soundness and vitality of the livestock industry.

A knowledge of future cattle prices would also be beneficial to those not directly engaged in the production of beef cattle. Extension personnel are in a better position to give advice when future trends in the market can be anticipated. Likewise, members of the financial institutions extending credit to cattle producers may reduce the risks of nonpayment if future revenue levels can be forecasted from the sale of livestock. It is apparent that a short run price forecasting model would be of value to all sectors of the agricultural community concerned with the welfare of the cattle industry.

B. Objectives

The general objective of this thesis is the development of a one and two quarter price prediction model for slaughter steers and slaughter cows in the Pacific Northwest. The factors considered important in forming the price forecasting models are the interaction of supply and demand relationships at the farm level from which price levels are determined. Specific objectives include:

1. To specify a one and two quarter price prediction model for Northwest slaughter steers and slaughter cows that is relatively simple to use with published secondary data.

2. To evaluate the performance of the price forecasting model(s).

To accomplish these objectives, this study will first discuss the response of market participants as it relates to the quantity of beef demanded and the quantity supplied. Chapter two discusses some important economic variables that influence the quantity of beef demanded by consumers. Chapter three then discusses the impact of changes in the price of the production inputs and the price of the slaughter animal on the supply of beef at the farm level. These economic relationships are then incorporated into models developed to predict farm level slaughter steer and slaughter cow prices one and two quarters into the future.

CHAPTER II

FACTORS INFLUENCING THE DEMAND FOR BEEF PRODUCTS

The primary demand for beef is measured at the retail level. Retail purchases by consumers determine aggregate demand levels for which wholesale buyers adjust their demand for live cattle required as an input to the meat processing industry (Hayenga and Hacklander, 1970). The level of consumer demand for beef products will vary, depending on the retail price for beef, competing (substitute) meat products, and the disposable income of the consumer. Each of these components of demand will be examined separately in order to introduce the methods of measuring consumer demand for beef products following a change in price or income.

A. Measuring Consumer Response to Changes in Retail Meat Prices

For measuring the response by consumers to a change in the retail price of a commodity, price elasticities are determined as the percentage change in the quantity consumed associated with a one percent change in price:

$$\frac{\Delta \text{ Quantity}}{\text{Quantity}} \bigg/ \frac{\Delta \text{ Price}}{\text{Price}}$$

Both direct price and cross price elasticities may be estimated from this procedure, with the price variables in the equation representing either own price (beef) or a substitute meat product (pork, poultry).

As a reference in the discussion to follow, Table 1 shows retail direct and cross price elasticities for beef and competing meat products from a study by George and King (1971). The direct price elasticity for beef, at -0.64, is found by matching the row and column in the table for this commodity. The negative sign on the coefficient reflects the reduced quantity of beef purchased when retail price moves higher, or an increase in the quantity demanded when prices drop.

An elasticity estimate with an absolute value of less than one falls into a classification of being inelastic, where a less than one percent change in quantity demanded follows a one percent change in retail price. Conversely, an elastic response results in a greater than one percent change in quantity demanded, indicated by an elasticity coefficient with an absolute value of greater than one. The relationship between price and quantity adjustments is represented in the demand schedule shown in Figure 1.

An important implication of an inelastic response to changes in price is that total revenue moves in the same direction as the price change. In the case of an inelastic demand for beef, an increase in price results in a reduced quantity demanded, but is offset by the higher price received per unit and thus an increase in total revenue. Inelastic commodities generally fall into a category of being low priced, few substitutes available, and viewed as necessities.

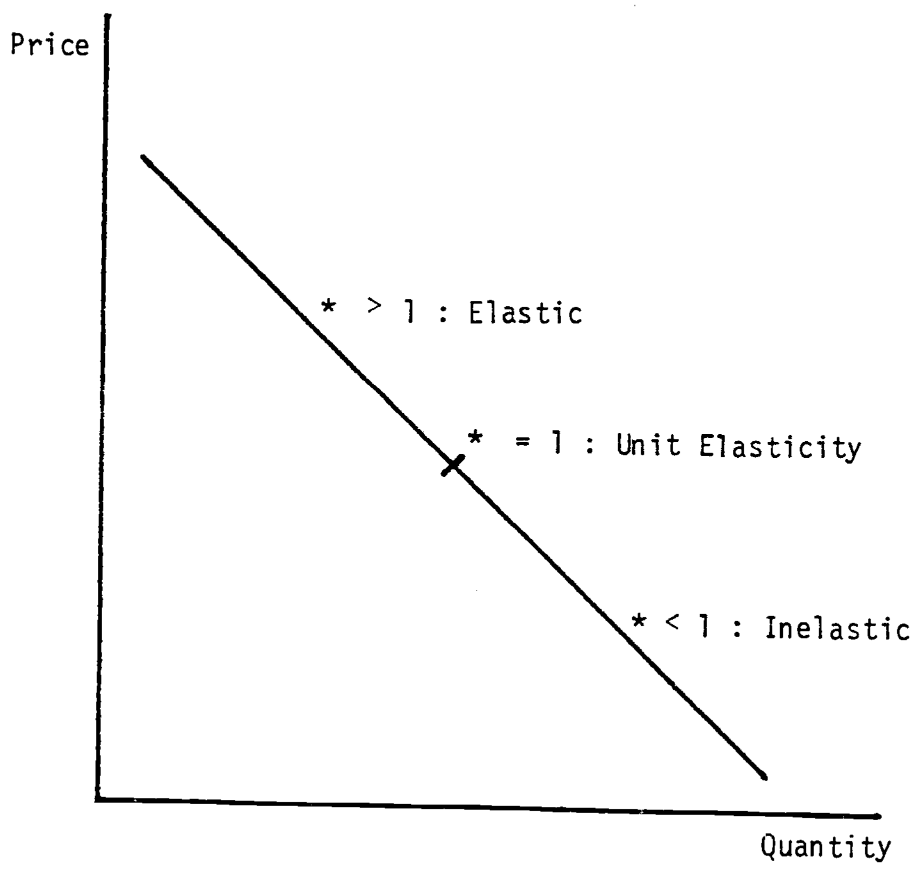
Whether the retail demand for beef is in fact inelastic may still be open to debate. Trierweiller and Hassler (1971) are among others who have estimated direct and cross price elasticities for beef and substitute meat products at the retail level. The direct price elasticity coefficient estimated in their study for beef was -1.19, falling in the elastic segment of the demand schedule (see Figure 1). In this

Table 1. Demand Interrelationships at the Retail Level[1/].

	Beef	Pork	Chicken	Turkey
Beef	-0.644	0.083	0.068	0.008
Pork	0.076	-0.413	0.035	0.005
Chicken	0.197	0.121	-.777	0.084
Turkey	0.098	0.065	0.400	-1.555

1/ Source: George and King, 1971.

Figure 1. A Demand Schedule



case, an increase in retail beef prices would result in a decline in quantity demanded and a decline in total revenue at the retail level.

Turning now to a discussion of cross price elasticity estimates between beef and competing meat products, the results of the George and King study (Table 1) show the cross price elasticities of beef for pork, chicken, and turkey products are 0.076, 0.197, and 0.098 respectively. The positive sign on these coefficients, indicates the substitutability of these meat products for beef, when the price of beef increases. Consumers respond by purchasing less beef and more pork and poultry products; assuming income, tastes and preferences and their prices remain constant.

An example of this type of consumer response to changes in retail price levels is found by observing the U.S. per capita consumption of beef, pork, and poultry products, as shown in Figure 2 on a per quarter basis, for the years 1975 through 1980. During this time period, per capita consumption of beef trended lower while pork and poultry consumption increased slightly. During this same period, the percent of income spent on beef trended lower while pork and poultry remained relatively constant (see Figure 3). Consumers were able to increase their consumption of pork and poultry products, without appreciably raising the level of expenditures, because their retail prices, if deflated to remove the influence of inflation, actually trended lower. Beef prices, on the other hand, moved higher generally keeping up with the rate of inflation.

B. Measuring Demand Response to Changes in Consumer Income

The final retail elasticity measurement discussed in this chapter

Figure 2.

PER CAPITA MEAT CONSUMPTION

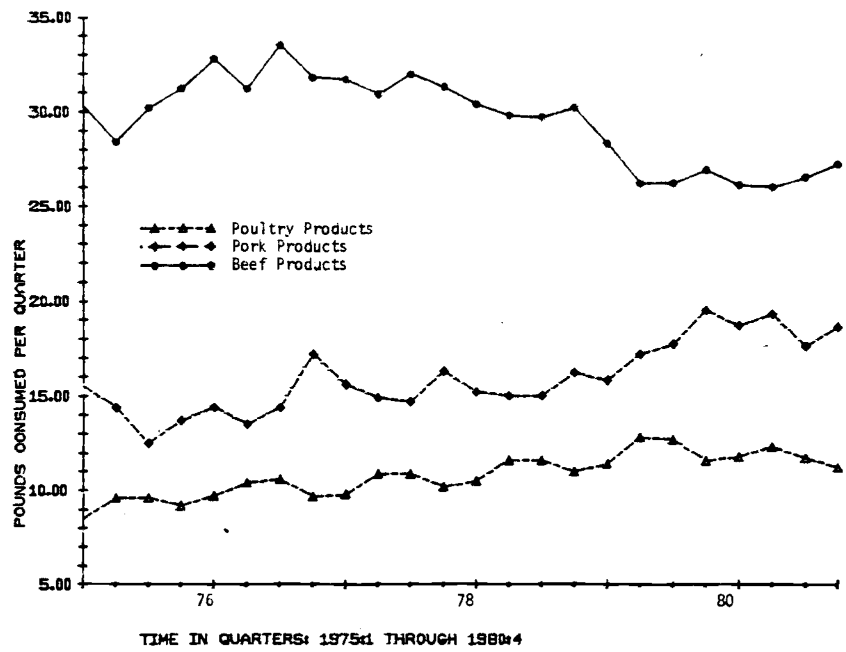
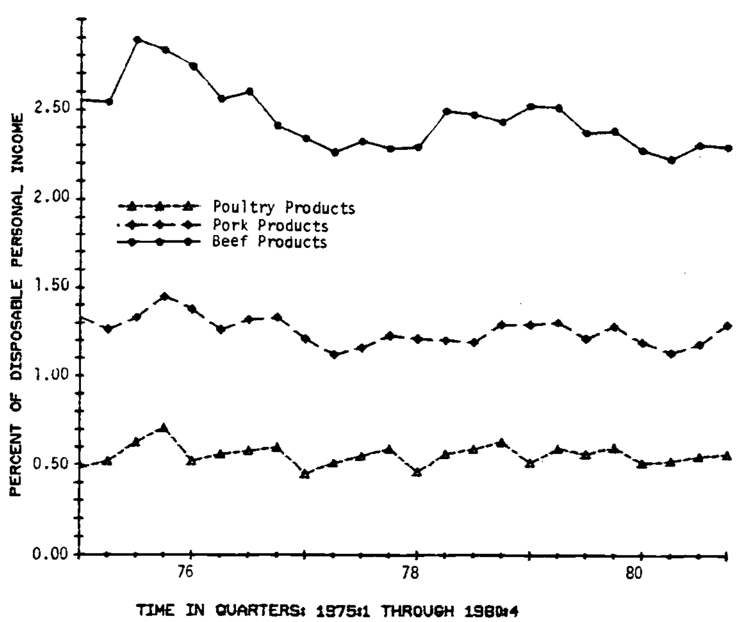


Figure 3.

PERCENT OF INCOME SPENT ON MEAT PRODUCTS



reflects the influence of consumer income on the quantity of beef products purchased by consumers. The income elasticity formula shown below measures the percentage change in quantity demanded associated with a one percent change in income.

$$\frac{\Delta \text{ Quantity}}{\text{Quantity}} \Big/ \frac{\Delta \text{ Income}}{\text{Income}}$$

The income elasticity estimates in Table 2, from the George and King study, may be evaluated in determining whether a particular commodity is an inferior or superior good. A superior good is a commodity that consumers increase their demand of following an increase in personal income. An inferior good is one that consumers reduce the quantity demanded when incomes rise.

Table 2. Income Elasticities

Beef	.29
Pork	.13
Chicken	.18
Turkey	.77

Commodities are categorized within the following numerical ranges with the symbol "ξ" denoting a particular commodity

$\xi < 0$	inferior good
$1 > \xi > 0$	marginally superior good
$\xi > 1$	superior good

In the case of beef, $\xi = .290$ and would be classified as a marginally superior good, where the increase in demand is proportionally <u>less</u> than the increase in income. Most food groups fall into a category of being marginally superior following a change in consumer income.

Beef products at the retail level, in the discussion to this point, have remained undifferentiated. Ospina and Shumway (1975) correctly stated that beef is a heterogeneous commodity consisting of carcasses from steers, heifers, and cows. The carcasses from these different animals will vary, depending on age and the type of feeding program prior to slaughter. Jarvis (1974) noted that beef from different quality grade animals is highly substitutable in consumption, with consumer preference for specific beef grades dependent on retail prices. Ospina and Shumway reported the own price elasticities of demand for choice and standard grade beef at the retail level to be negative, while good grade beef was positive. Fed and nonfed beef at the wholesale level were found to be substitutes by Shuib and Menkhaus (1977). They reported that the quantity of fed beef demanded increased with a rise in consumer income, while the quantity of nonfed beef demanded declined.

The continuing rise in consumer incomes during the past two decades has been associated with an increase in the demand for beef (McCoy, 1979). Breimyer (1961) reported a positive correlation between changes in beef consumption and the passage of time. Comparing income elasticities from two studies that are separated by a time period of ten years, changes in the magnitude of the coefficients are found. Table 3 shows this relationship for beef and other meat products at the retail level from a study by Brandow (1961) and the George and King study (1971).

Table 3. Income Elasticities

	Brandow (1961)	George and King (1971)
Beef	.47	.29
Pork	.32	.13
Chicken	.37	.18
Turkey	.49	.77

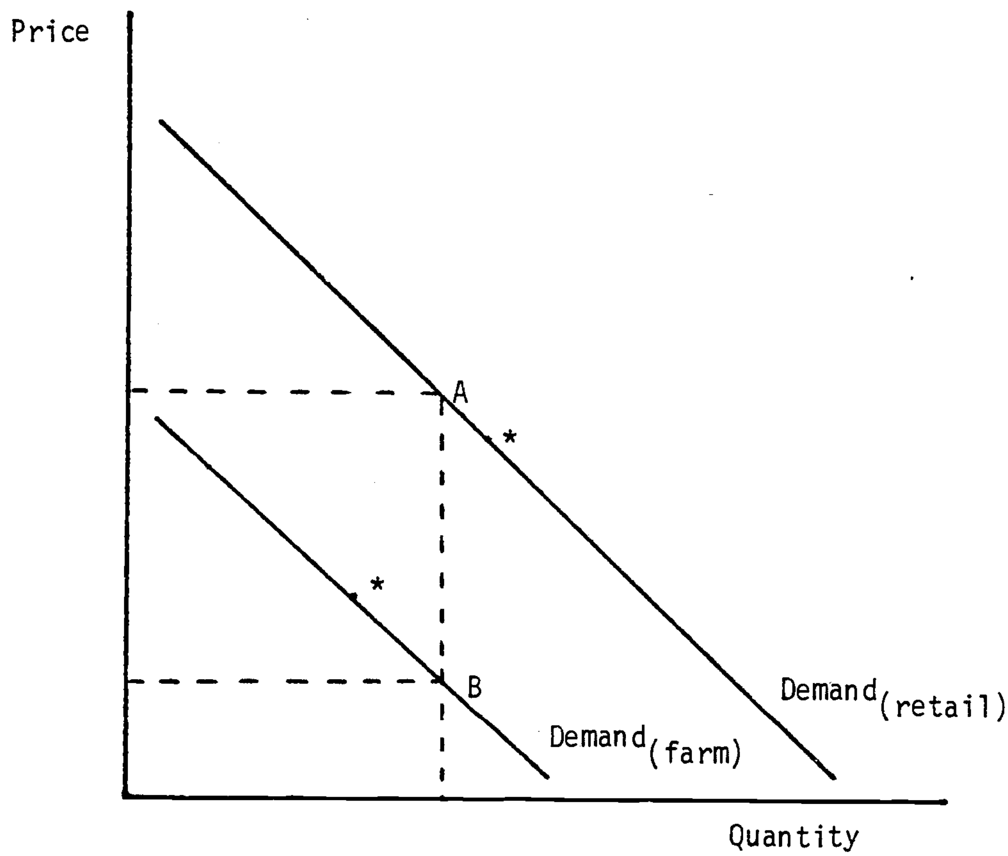
Income elasticities from the more recent study are smaller for all meat commodities except turkey, suggesting a more inelastic demand response following changes in the level of personal income.

C. Measuring Farm Level Beef Demand

One would expect a change in the demand for beef products at the retail level to have an impact on demand for live cattle at the farm level. The "derived" farm level demand for cattle by wholesale buyers does in fact reflect the movements of beef through retail outlets (George and King, 1971). Returning again to a discussion of elasticities, it is possible to estimate the demand for live cattle at the farm level from a retail demand schedule as shown in Figure 4. This derived demand schedule is located below the retail schedule with the vertical distance between them (A and B) representing the marketing margin (Waugh, 1964).

The margin, or price spread, between the farm and retail level includes the intermediary wholesale level in which live animals are slaughtered and carcass beef is prepared for the retail buyers. The marketing services provided at each level, including transportation,

Figure 4. Relationship Between Retail and Farm Level Demand Schedule [a]



[a] The farm level demand schedule refers to a retail carcass weight equivalent for price-quantity levels at the farm.

processing, packaging, along with the yield ratio of the carcass and the live animal to carcass yield, determine the price spread between the value of the live animal and final product purchased by consumers. Since the farm level demand schedule is derived from the retail level, potential variations in the margin for different price-quantity relationships will be important in estimating demand elasticities at the producer level.

The marketing margin depicted in Figure 4 is referred to as a constant absolute spread, where the vertical distance between the two schedules remains unchanged as price and quantity are allowed to vary. Other types of margins include the constant percentage margin, and a margin specified as a linear function of quantity handled. The latter margin includes a slope (b) and intercept (a) term in the equation along with a measure of the quantity (q) supplied. Equations for the three types of margins (M) are shown below.

1. Constant absolute spread

   $$p_r = p_f + M$$

2. Constant percentage spread

   $$M = kp_r$$

   $$p_r = p_f + kp_r$$

3. Linear function of quantity handled

   $$M = a + bq$$

   $$p_r = a + bq + p_f$$

Of the three possible methods of estimating the marketing margin for a particular commodity, Waugh (1964) suggested that the price spread may be derived from a combination of the constant absolute and constant percentage approach. Dalrymple (1961) drew a similar conclusion, stating that wholesalers appear to use a constant percentage calculation and that retailers base their pricing decisions on an absolute margin.

Returning now to a discussion of the derivation of the farm level demand elasticity, Figure 4 is again referred to. From a retail elasticity coefficient represented by A, the farm level coefficient is found at the intersection with the derived demand schedule at B. Comparing the distance between point A or B and its location with respect to the point of unit elasticity (*) on the demand schedule, B is found at a more inelastic value. George and King (1971) reported the farm level direct price elasticity at -0.42, compared with a retail estimate of -0.64, indicating a more inelastic demand response at the farm-wholesale level. The lower value at the farm level is one cause of highly volatile farm price fluctuations that occur with changes in supply (McCoy, 1979). Factors affecting supply adjustments at the farm level are examined in the next chapter.

CHAPTER III

FACTORS AFFECTING FARM LEVEL BEEF SUPPLIES

The supply of beef available for consumption is determined at the farm level. Producers adjust slaughter supplies in response to changes in prices received for the live animal, and to changes in input costs. Given the available supply, the price received by producers reflects the demand for beef carcasses by wholesale buyers. As stated in the previous chapter, the farm level demand is influenced by the consumer demand at the retail level.

Feed costs are a major expense in producing a market weight animal, influencing the number of animals available for slaughter and the slaughter weight. Cattle producers demand for feed grains, as an input to the enterprise, will depend on the price of grain and the profitability of producing grain fed animals. Grain prices respond to the level of demand, with cattle producers competing for available supplies with export markets and the hog and poultry sectors.

A. Beef Supply Response to Changes in Market Prices

Supply elasticities may be calculated in the same way as demand elasticities are calculated in the previous chapter. The general formula for calculating the elasticity of supply is:

$$\frac{\Delta\ \text{Quantity}}{\text{Quantity}} \Big/ \frac{\Delta\ \text{Price}}{\text{Price}}$$

Beef supply elasticities, with respect to changes in annual prices received by producers, are shown in Table 4 from several studies as an indication of the range in estimates reported. The supply elasticities for all but the Tryfos study were greater than zero, advocating a positive response to price changes by adjusting slaughter inventories in the same direction as price movements. The absolute value of the coefficients is less than one, indicating a short run inelastic supply response to changes in market prices. The proportionally smaller change in the number of animals slaughtered may be influenced by a number of considerations, although the biological characteristics of production are a critical short run determinant.

Table 4. Supply Elasticities With Respect To Changes in Wholesale Prices For Beef (All Types)

Ospina and Shumway	.14
Langemeier and Thompson	.16
Tryfos	-.01
Freebairn and Rausser	.14
Folwell and Shapouri	.04

Within the time frame of one year, the cattle producer has only a limited choice of options available in adjusting the number of animals slaughtered. The calf crop as a source of potential slaughter is essentially predetermined from previous cow inventories. Culling strategies for the cow herd may be adjusted within this period, although, the number of cows slaughtered currently and historically has remained a relatively constant proportion of the available inventories (Reutlinger, 1966).

The more elastic supply response to changes in price, in the long run, is hypothesized by some to be a cause of long term cycles in cow inventories (Ehrich, 1966). These cycles have been observed quite regularly during the twentieth century with each cycle characterized by an increase in cow numbers followed by an inventory liquidation period. Price movements and slaughter levels reflect the changes in aggregate cow numbers with a complete cycle extending more recently over a ten to twelve year period.

The influence of time on slaughter supply may be represented in the supply schedule, as shown in Figure 5, by distinguishing between an elastic and inelastic supply curve. The cattle producer would move along a more inelastic supply curve in the short run (S_2) with a longer time horizon required to shift to the more elastic schedule (S_3). If one constrained the time horizon to an even shorter period, actual slaughter adjustments possible with a change in price, would be even more limited and the supply schedule more inelastic (S_1).

To clarify, a time horizon of six months limits the slaughter number to cattle in feedlots at weights over 500 pounds and "nonfed" cattle nearing a slaughter weight. If prices trend higher during the six months, producers will slaughter the available supplies as they reach market weight. The key word being "available", in that only animals within specific weight and age classes would be considered candidates for slaughter during the six month period. If the time horizon is extended to three years, the producer is able to increase cow inventories and thus potential slaughter by retaining heifers for recruitment to the cow herd. The larger cow inventory produces a larger calf crop that may be raised for slaughter, resulting in a more elastic supply response with an increase in price.

For a graphical interpretation of changes in quantity supplied

Figure 5. Supply Schedules with Varying Degrees of Elasticity

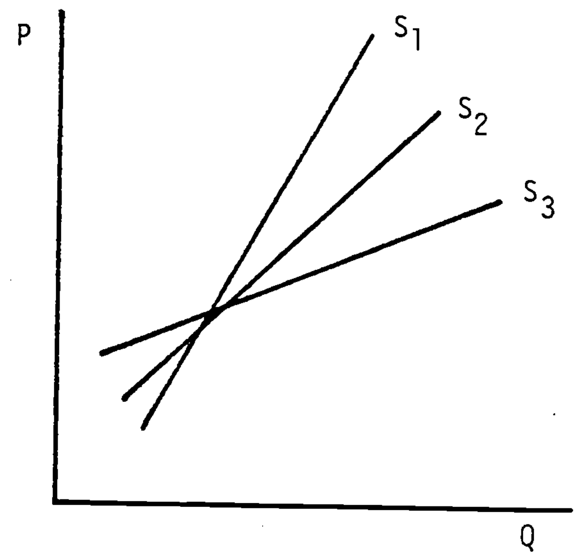
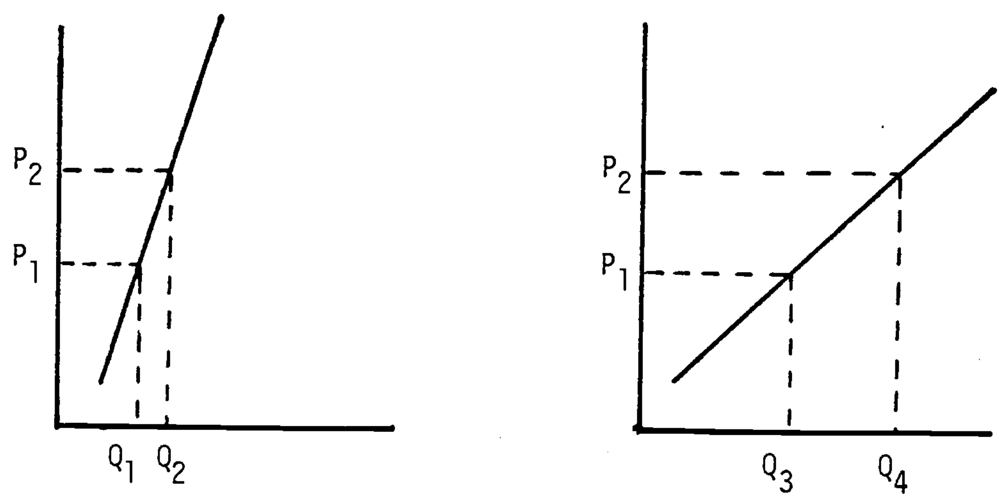


Figure 6. Supply Schedule Price-Quantity Relationships



with a change in price, Figure 6 shows the relationship between price and quantity adjustments for elastic and inelastic supply schedules. The price increase from P_1 to P_2 is the same in both graphs, however the resulting change in quantity supplied is quite different. For the relatively inelastic supply schedule, the change in quantity from Q_1 to Q_2 is small, whereas the change in quantity from Q_3 to Q_4 for the elastic supply schedule is greater than the proportional change in price.

This study will concentrate on beef producers short run supply response to changing market conditions. The short run being interpreted as a time horizon for which cattle inventories are predetermined by prior decisions of the producer. Supply response within the shorter time period is still flexible with numerous choices available to the cattle producer. These options include altering the time period and the type of ration fed to cattle in feedlots and the alternative production of nonfed steers and heifers on a grass ration. These production strategies will be evaluated by producers as they attempt to anticipate future market conditions and the expected price when the animals are sold.

Producers are thought to respond to expected prices in developing short run slaughter supply decisions (Hayenga and Hacklander, 1970). Future prices are extrapolated from current and past prices, and the rate of change in prices between periods. Nelson and Spreen (1978) and Jarvis (1974) reported the rate of change in price to be a significant short run determinant of slaughter supplies. Both studies examine the response of producers to price and input cost changes by evaluating cattle inventories as capital goods.

Within this context, cattle are appraised in terms of their current slaughter value vs. their value as a capital asset. Short run steer slaughter decisions would be made considering the current and future slaughter market value of the animal, with an additional factor considered in developing slaughter decisions for heifers and cows. Their current and future value as breeding stock would be evaluated in addition to the potential change in their slaughter market value.

For an example of this type of analysis: an increase in the slaughter price of steers increases the marginal value product of each production input, frequently increasing the optimal period on feed and age of slaughter (Jarvis, 1974). Jarvis concludes that an increase in price would result in a short term negative slaughter response during the period steers are withheld for additional weight gains prior to marketing. The same response is expected for heifers and cows whether they are fed to heavier weights or retained for breeding. Nelson and Spreen (1978) drew a similar conclusion reporting a price trend of three months resulted in a reduced or accelerated slaughter response.

B. Beef Supply Response to Changes in Feed Grain Prices

The price of feed grains will influence the available slaughter supply through adjustments in the number of animals marketed and the carcass composition. Applying the theory of capital value to animals on feed, Jarvis (1974) projected a positive short run slaughter response to a rise in grain prices. Producers faced with the higher cost of grain would reduce the level fed per animal while marketing the animals at an earlier age.

Once the animals in the current feedlot inventories have been fed to market weight, the producer has greater flexibility in dealing with the rise in grain prices. The choices available include selecting heavier animals for placement in the feedlot, producing nonfed beef on pasture, or slaughtering more calves as veal (Martin and Haack, 1977).

One might expect the demand for heavier cattle, for placement on feed, to be reflected in the market price associated with this weight class. Lighter weight feeder calves "normally" sell at a higher price per hundred weight than their heavier counterparts. Holding the fed steer price constant, a rise in grain prices makes the feeding out of all weights of feeder animals less profitable. Under such conditions, the price spread between the light and heavier weight classes has the potential to shrink if the price of the light weight feeders declines by a larger amount in response to the reduced profitability.

To illustrate this, the deflated price spread between 400-500 pound feeder steers and 600-700 pound feeders is shown in Figure 7 from average quarterly prices at the Kansas City Auction. The values plotted above the base line indicate the price of the 400-500 pound animals was greater than the 600-700 pounders. Directing the readers attention to the time period between the third quarter of 1973 and the fourth quarter of 1975, note the diminishing price spread between the two weight classes. From the fourth quarter of 1974 through the fourth quarter of 1975 a price reversal occurred with the heavier feeder class selling at a higher price than the lighter weight calves. During this period, prices for the 400-500 pound feeders

Figure 7.

PRICE MARGIN BETWEEN 400-500/600-700 LB. STEERS

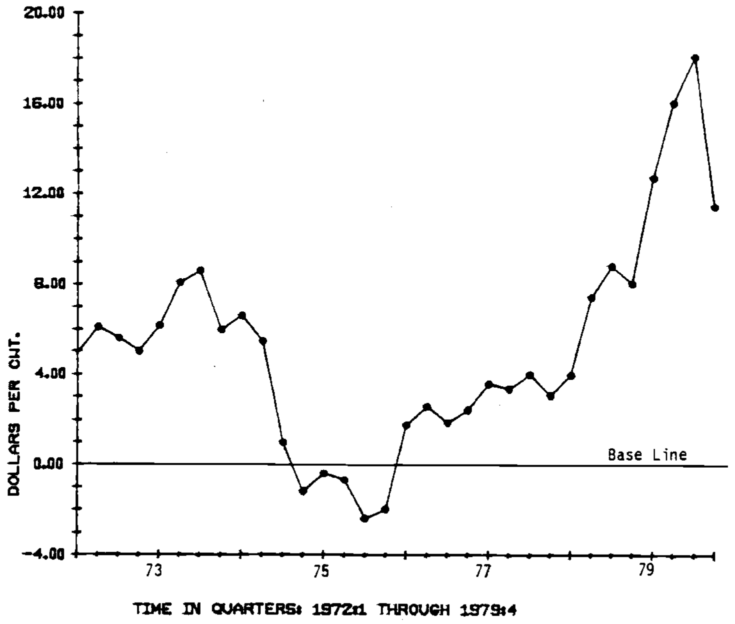
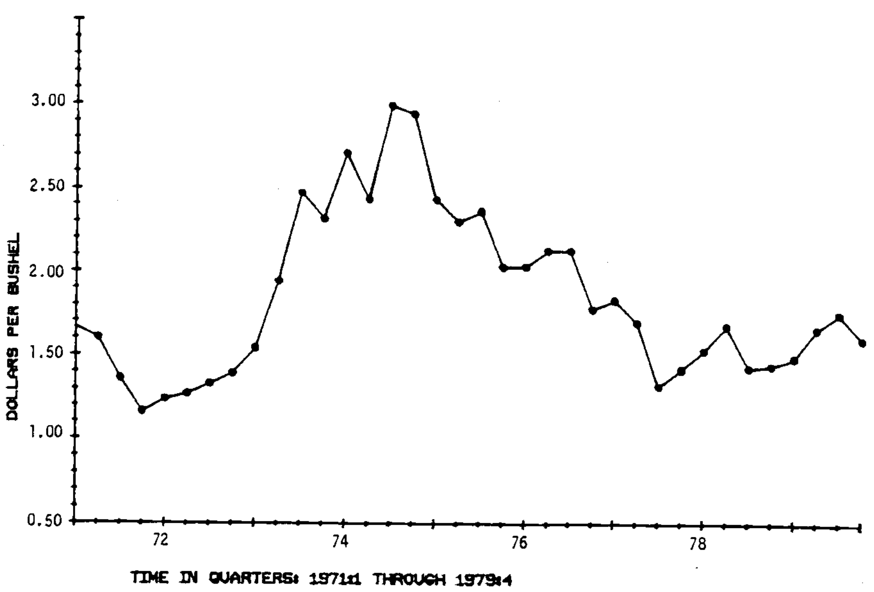


Figure 8.

DEFLATED CORN PRICE AT CHICAGO



ranged from a high of $66.57 in the third quarter of 1973 to a low of $26.99 in the first quarter of 1975. The 600-700 pounders followed a similar downward trend with prices ranging from a high of $57.98 to a low of $27.39 for the same quarters mentioned above.

A similar decline in the price of slaughter cattle also occurred during the 1973 to 1975 period, whereas corn prices increased substantially. Figure 8 depicts the movement of deflated corn prices during this period. The price decline for the various weight classes, and the concurrent rise in corn prices, resulted in significant financial losses during this period. As grain prices trended downward and cattle prices moved higher in the post 1975 period, the price spread between the lighter and heavier weight classes returned to "normal", with lighter feeders again priced above the heavier feeder class.

Changes in the composition of slaughter inventories may also be expected as a result of changes in grain prices. Ospina and Shumway (1979) determined annual supply elasticities for different grades of beef associated with a change in feed costs. Table 5 shows the results of this study for choice and good grade steers and heifers. The signs on the elasticity coefficients indicate that producers respond to a rise in grain prices by marketing a lower grade animal, thus supporting the conclusion drawn by Trapp (1974) with respect to a reduction in the grain fed per animal with an increase in feed prices.

An alternative beef enterprise, following an increase in grain prices, is to raise a lower grade grass fed animal. This production practice requires a longer growth period on pasture to reach a slaughter weight, although this may be warranted by high feed costs and/or low slaughter cattle prices. The ratio of nonfed to fed steers and heifers slaughtered under federal inspection is shown in Figure 9 for the years 1971-1979. This ratio ranged from a low of .02 to a high of .37 during the period.

Table 5. Estimated Slaughter Steer Elasticities With Respect to a Change in Corn Prices1/

Choice grade steers	-.65
Good grade steers	.31
Choice grade heifers	-1.03
Good grade heifers	.02

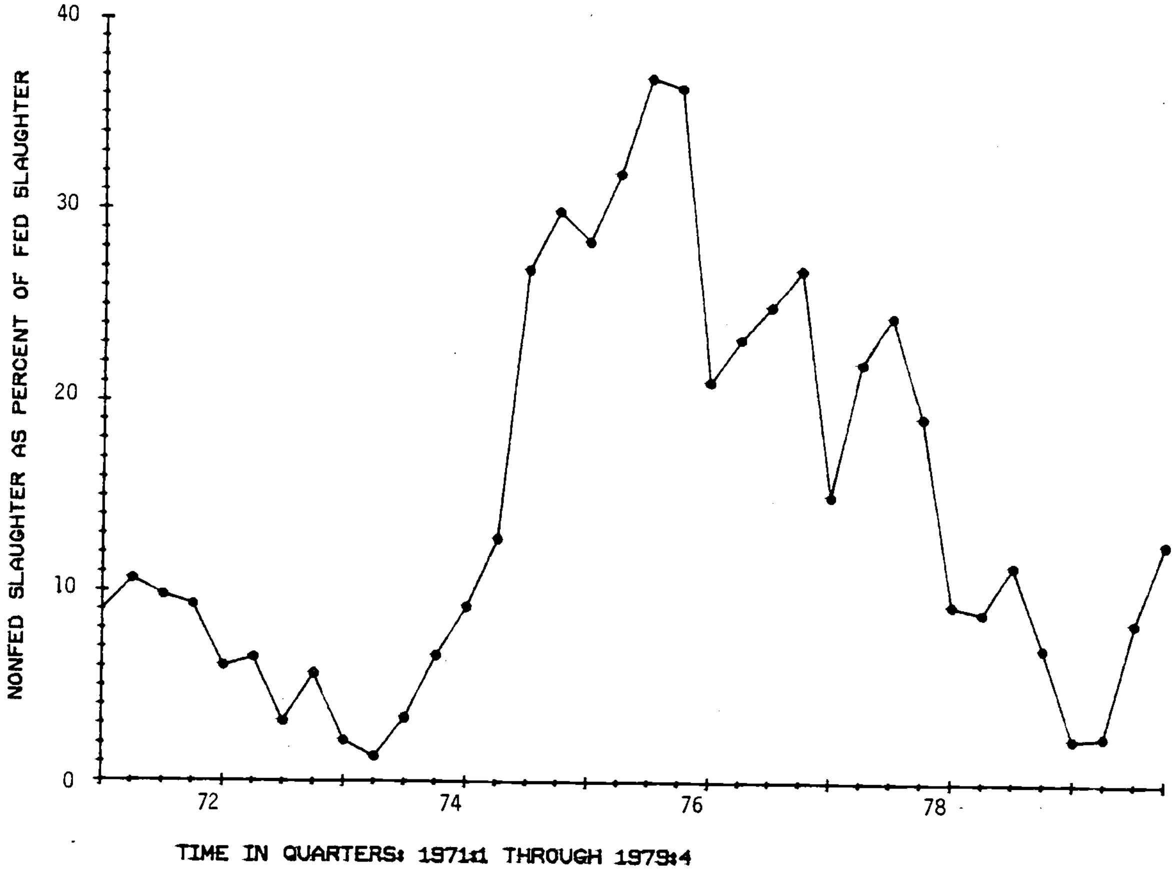
1/ Source: Ospina and Shumway

A comparison of the ratio of nonfed to fed slaughter in Figure 9 with deflated corn prices from the same period in Figure 8, shows a similar movement in both over time, illustrating the correlation between the two. The trend in nonfed slaughter moved in the same direction as corn prices with the peak in nonfed slaughter coming approximately one year after corn prices began to decline.

C. Characteristics of the Fed Cattle Sector

The production of fed cattle remains a significant proportion of the total beef supplied, although as indicated previously, will fluctuate in response to feed grain prices. Valuable information with respect to future fed cattle slaughter may be ascertained from U.S.D.A.

Figure 9
RATIO OF NONFED TO FED CATTLE SLAUGHTER



Cattle on Feed and Outlook and Situation reports. These periodicals publish feedlot placements and marketings in addition to current feedlot inventories by weight class.

The placement weight and rate of gain in the feedlot environment are important parameters considered in estimating future marketings. Trapp (1981) examined these parameters during the 1960-1978 period using data reported in Cattle on Feed. The results of this study include pertinent information on seasonal variations in growth rates and placement weights that will influence the expected date of marketing. Two of the tables from the Trapp article are reproduced here to aid in discussing his results.

The growth rate index in Table 6 indicates the highest rates of gain are found in the first and fourth quarter. Different climatic conditions and backgrounding programs were suggested to be the cause of this seasonal difference. A seasonal variation in the ratio of steers to heifers placed on feed was noted with a proportionally larger number of steers placed in the first and fourth quarters. Trapp reported the average weight of cattle on feed to be correlated with the average placement weight and the inventory of animals placed.

The percent of animals placed on feed by weight class and the average placement weight estimates are shown in Table 7. Based on the results of his analysis, Trapp concluded that a majority of the light weight placements occur in the first and fourth quarters, with the heavier average placement weights found in the second and third quarters.

The values shown in Table 6 and Table 7 are estimated from

Table 6. Average Estimated Characteristics of Cattle on Feed and Placed on Feed by Quarter1/.

Quarter	Growth Rate Index	Steer/Heifer Sex Ratio of Placement	Average Weight of Cattle on Feed
1	104	3.20	815
2	100	2.15	834
3	89	1.92	821
4	105	2.24	768

Table 7. Estimated Seasonal Distribution of Number of Cattle Placed and Average Placement Weight 1/.

Quarter	Percent of Cattle Placed			Average Placement Weight
	500 lb.	500-699 lb.	700-899 lb.	
1	53.2	40.3	6.6	518
2	26.7	66.3	7.6	571
3	26.5	43.7	29.8	612
4	64.4	42.2	9.1	502
Annual Average	42.2	44.5	13.2	549

1/ Source: Trapp

"average seasonal patterns", observed over the eighteen years. Within this time period, Trapp noted cyclical movements in placement weight, and the sex ratio of steers to heifers. The fluctuations in placement weights were attributed to movements in grain and cattle prices, whereas the ratio of steers to heifers was found to be correlated with fluctuations in cattle inventories.

An indication of the volatility both in placements on feed and cattle marketings over the past ten years is shown in Figure 10. Changes in feedlot placements are highly seasonal, with the fourth quarter absorbing a large proportion of available feeder stock. Comparing fourth quarter placements with the percent of feeders placed quarterly in Table 7 from the Trapp study, one could conclude that a significant number of these animals are weaned calves weighing less than 500 pounds. Fed cattle marketings indicate a smaller degree of seasonal variation as a result of the producers desire to provide a relatively constant market supply in order to stabilize prices (Barksdale, Hilliard, Ahlund, 1975).

Changes in the ratio of nonfed to fed beef during the past decade (Figure 9) are reflected in the spread between fed steer and heifer marketings and the number of steers and heifers slaughtered under federal inspection as shown in Figure 11. Federally inspected slaughter includes both fed and nonfed animals, with nonfed slaughter represented by the difference between fed animals marketed and federally inspected slaughter. Where the number of fed cattle marketed exceeded the number slaughtered in federally inspected plants, the residual inventories are assumed to have been slaughtered in non-

Figure 10.
COMPARISON OF CATTLE PLACED WITH MARKETINGS

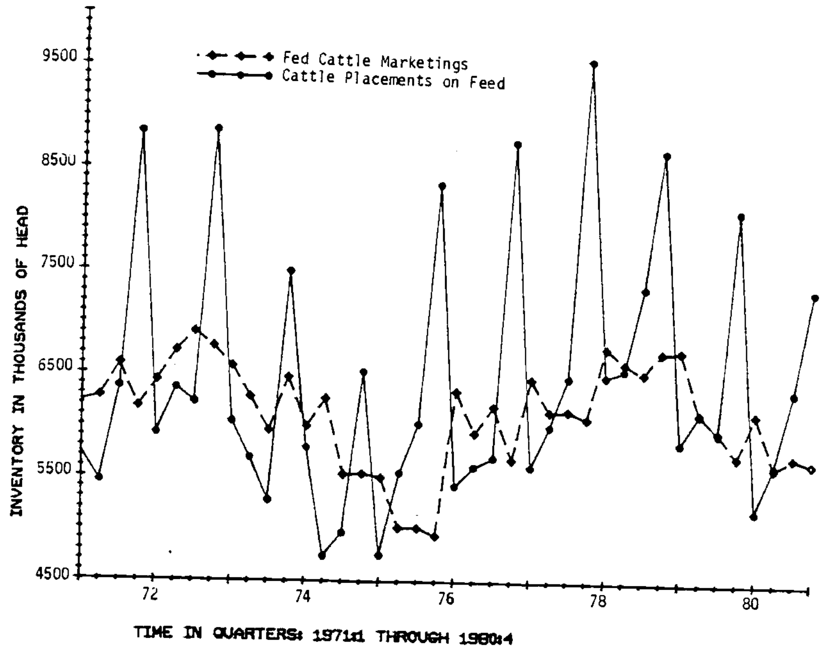
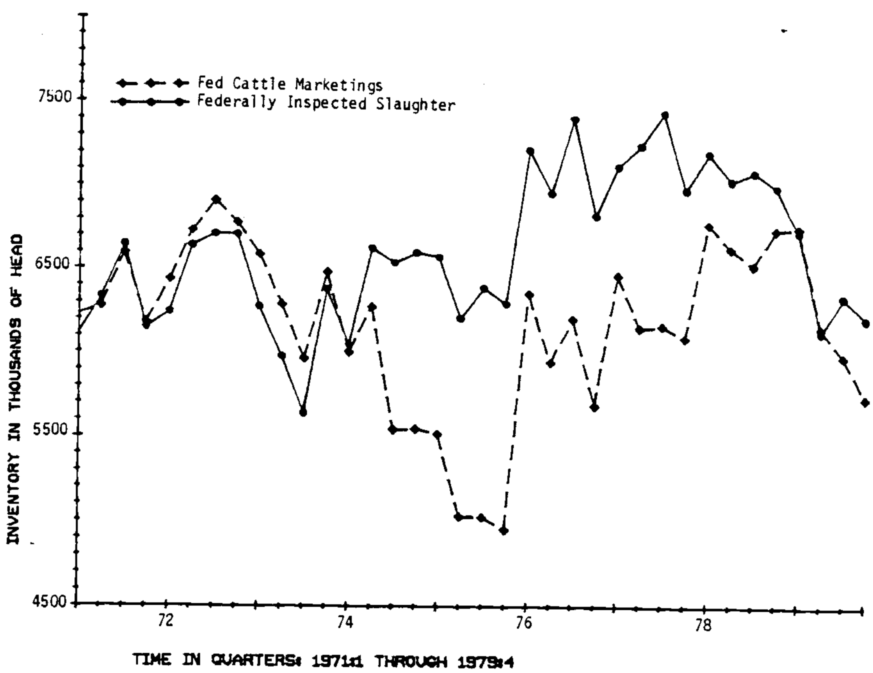


Figure 11.
COMPARISON OF FED MARKETINGS WITH FED. SLAUGHTER



federally inspected facilities.

The volatility in slaughter prices during the past ten years is indicative of adjustments in fed cattle marketings during this period. This price and quantity series is plotted together in Figure 12, with the price series shown in the graph being deflated choice slaughter steer prices at Omaha. Longer term cyclical trends are interpreted as the response of prices to the quantity supplied, whereas the short run fluctuations are associated with the adjustment in quantity supplied to prices (Barksdale, Hilliard, Ahland, 1975).

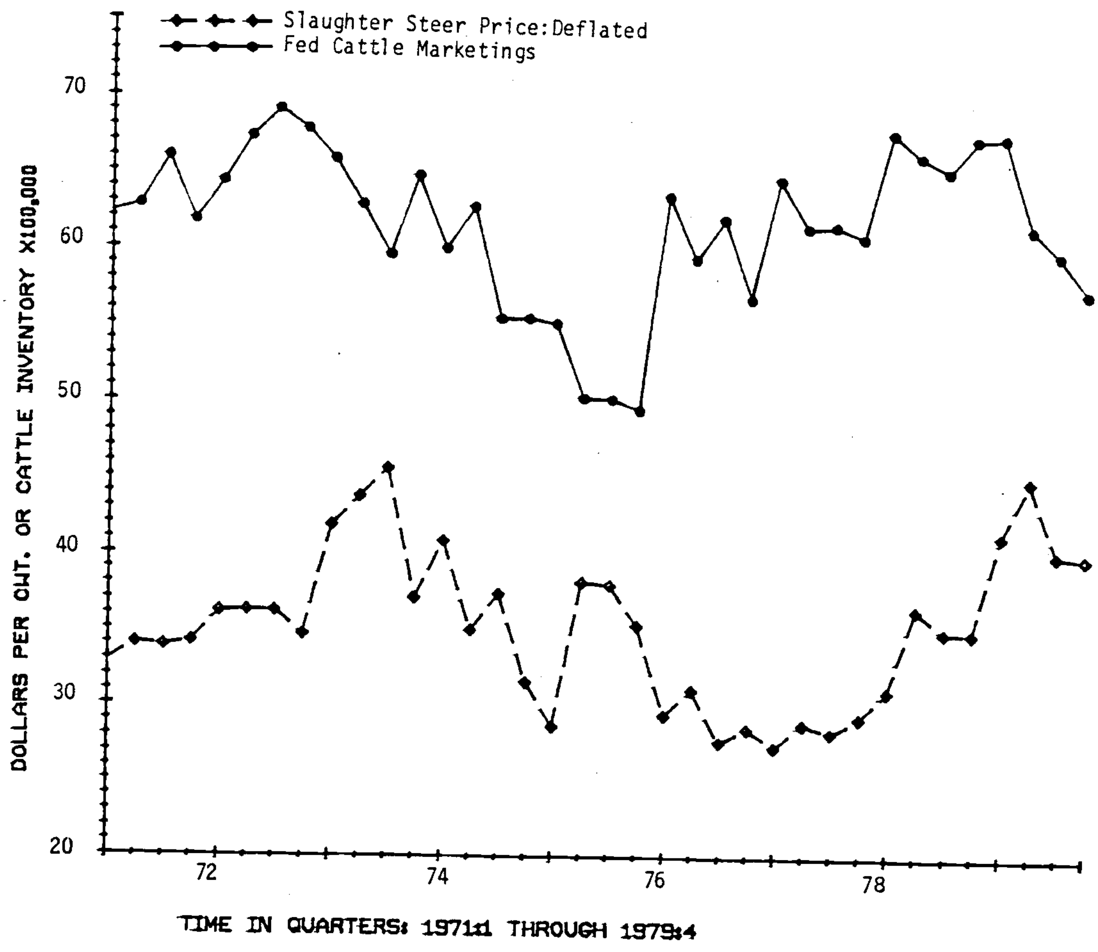
D. Concluding Remarks

The supply response of the producer to changes in feed grain and slaughter prices has been discussed separately, although it should be emphasized that the cause and effect relationships have been presented for a short run analysis. In the long run "the feed grain and livestock sectors are both technically and economically interdependent" (Shuib and Menkhaus, 1977). Supply and demand relationships within and between these two sectors act as signals to producers in planning future production.

Within the constraints of a short run analysis of response, the number of cattle and supply of feed grain at the farm level are essentially predetermined by producers response to past prices, and the time required to adjust cattle inventories and acreage planted (Heien, 1977). In the short run, the marketing date and slaughter weight are normally the only adjustments possible to total beef production.

A knowledge of the cattle producer's short run slaughter response to changing market conditions is imperative in forecasting future supplies. This information, combined with the relevant demand parameters, may be incorporated into a model designed to forecast future prices.

Figure 12.
COMPARISON OF DEFLATED STEER PRICE WITH MARKETINGS



CHAPTER IV

A SLAUGHTER STEER PRICE FORECASTING MODEL

A flow chart representing the price prediction procedure presented in this chapter is shown in Figure 13. The variables enclosed in boxes are to be estimated in developing price projections for one and two quarters into the future. The data required to develop these projections was obtained from several U.S.D.A. publications, with the data series used in projecting each estimate shown above the respective box. These variables were selected to represent the factors influencing the price of live cattle at the farm level.

The interaction of supply and demand in the market is essential to the price determination process of a competitive industry. Supply and demand relationships and key explanatory variables are discussed in previous chapters. The one and two quarter price projections for slaughter steers and cows in the Northwest were estimated from forecasted prices of these animal classes at Omaha, Nebraska. Rather than estimate Northwest prices directly, the terminal market at Omaha was considered to mirror the supply and demand relationships that are reported in aggregated data for U.S., that may not be reflected in other regional markets. As noted in Figure 14 and Figure 15, the average price of slaughter steers and cows in the Northwest during each quarter shown approximates the price received by producers in Omaha. This high correlation between regions was instrumental in estimating Northwest cattle prices once the price at Omaha had been estimated. To obtain the projected price of steers and cows at Omaha required models that

Figure 13 Model Flow Chart

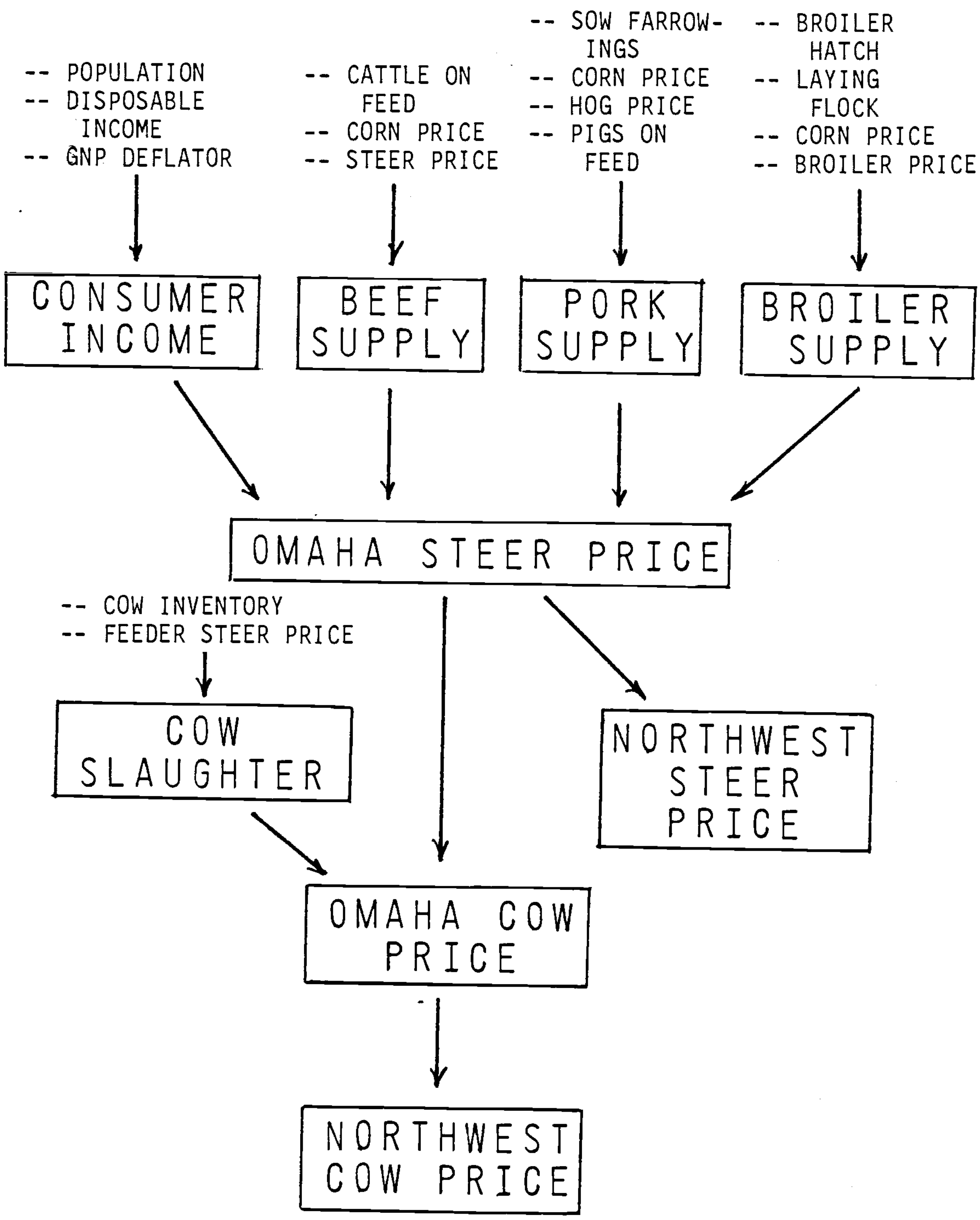


Figure 14
SLAUGHTER STEER PRICES IN OMAHA AND NORTHWEST

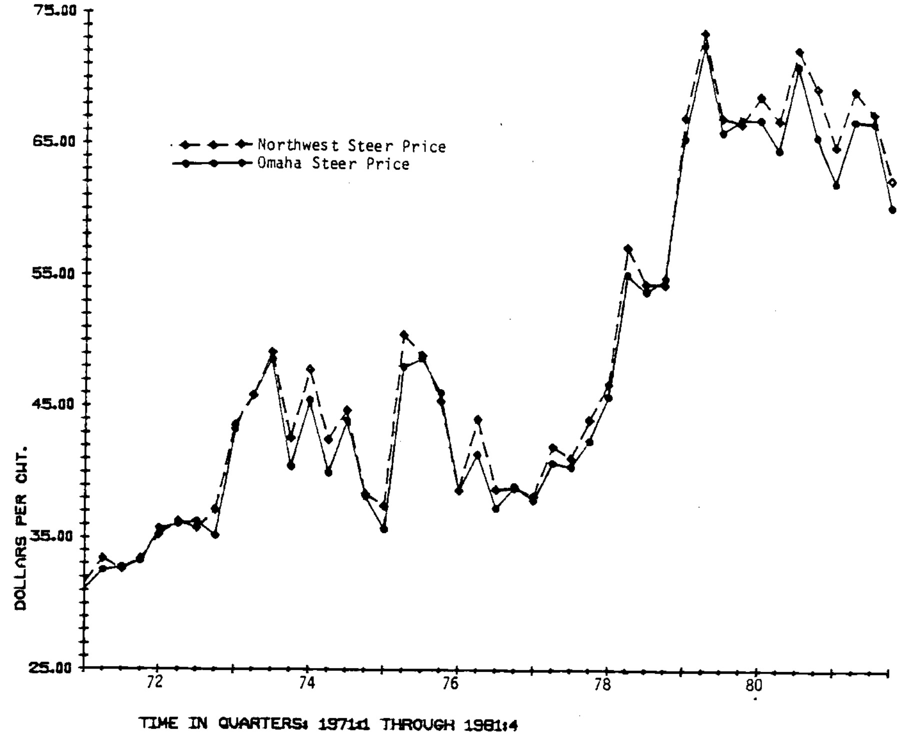
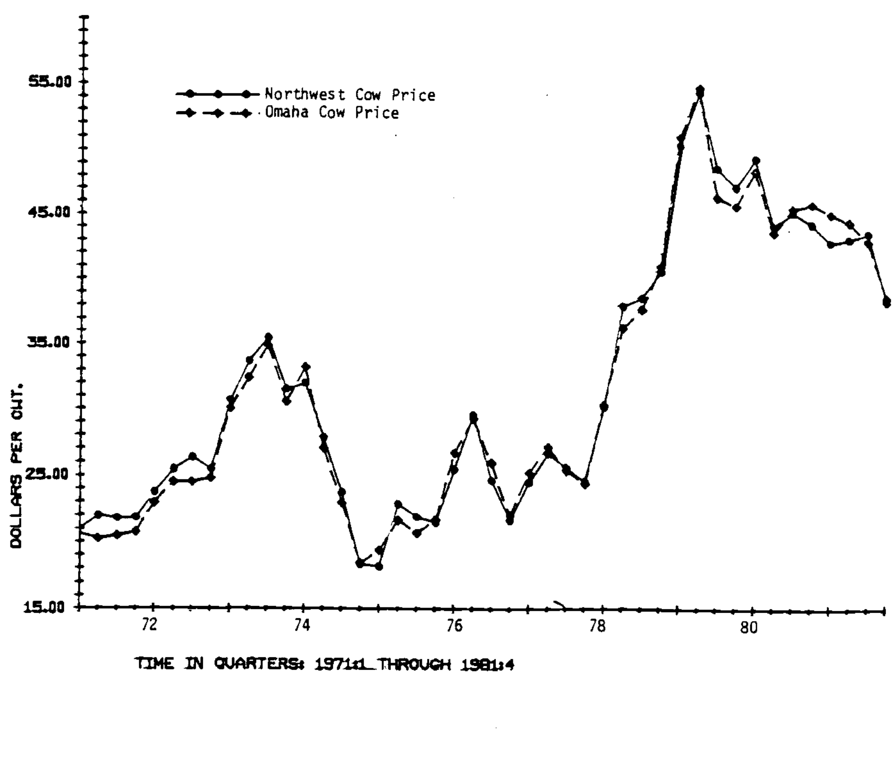


Figure 15
SLAUGHTER COW PRICES IN OMAHA AND NORTHWEST



simulated the interaction of supply and demand conditions that prevailed during the quarter.

The statistical estimation techniques presented in this study were developed after a review of several studies by other researchers. The choice of technique was based on previously discussed objectives and a priori assumptions of the author. This is not to say that the estimation techniques chosen were necessarily the best or the only procedure available. To give the reader an indication of the possible price prediction models available, a brief review of several forecasting models is now discussed.

Forecasting models may be differentiated according to the amount and type of information included in them. Prices may be forecasted from the interaction of estimated supply and demand relationships, or by extrapolation from current and past prices. The former approach will be discussed in the section on econometric modeling while the latter is presented as a time series analysis. Several estimation techniques for each category are reviewed in this chapter, however, due to the brevity of this review, the interested reader is referred to an econometric text for an in depth discussion.

A. Forecasting With Time Series Models[2/]

Time series analysis is distinct from the other methods of forecasting in that it does not use economic relationships in developing

2/ The material in this section was condensed from Econometric Models and Economic Forecasts by Pindyck and Rubinfeld.

price projections. The forecast of future prices is developed from past behavior of the price series. Within this category, the simplest of the forecasting techniques are the trend extrapolation and moving average models. The former technique is developed to assimilate long run trends without attempting to replicate the shorter run fluctuations in the price series.

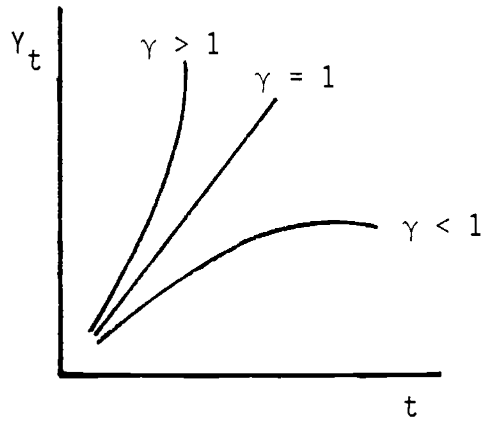
The first of the extrapolation methods is a linear trend model, which as the name suggests, is a straight line with intercept (γ_1) and slope (γ_2) coefficients estimated to track the change in prices over time. The model coefficients remain constant, with price projections ascertained from increasing the time interval (t) by increments of one. A linear trend model is shown in Equation 1.

$$(1) \quad Y_t = \gamma_1 + \gamma_2 t$$

$$(2) \quad Y_t = \gamma_1 + \gamma_2 Y_{t-1}$$

A second extrapolation technique that may be used to forecast prices by either linear of nonlinear estimation is the autoregressive trend model shown in Equation 2. The intercept (γ_1) may be assigned a value greater than or equal to zero with the slope (γ_2) always a positive value. If the intercept is equal to zero, the slope coefficient represents the rate of change in prices. As an example of the flexibility of this model, Figure 16 indicates trend lines for an intercept value of zero and the slope coefficient at different values. A slope coefficient equal to one would result in a linear extrapolation whereas values greater than or less than one provide non-

Figure 16. Autoregressive Trend Lines



linear trend lines. Autoregressive models are characterized by the presence of a lagged value of the parameter to be estimated as shown in Equation 2.

In contrast to the linear of nonlinear trends projected by extrapolation, moving average models will reflect any short run volatility in prices. The moving average approach determines an average from current and lagged values, with the number of lagged observations to be included depending on the time horizon selected by the forecaster. A larger number of observations included in developing the average generally smooths or reduces the volatility that may be present in the price series. The forecasted value for the next period ($\hat{Y}_{t+1}$) is estimated by a simple average of the current and past values as shown in the model in Equation 3.

$$(3) \qquad \hat{Y}_{t+1} = \frac{1}{n}(Y_t + Y_{t-1} + Y_{t-2} + \dots Y_{t-(n-1)})$$

If current observations have a greater influence on the forecast estimate, relative to more distant values, a weighting process may be applied to indicate this relationship over time. A way of placing a greater emphasis on more recent prices is known as an exponentially weighted moving average. The choice of weights (α) applied will depend on prior economic judgement, with any value between zero and one available. The model is shown in Equation 4.

$$(4) \quad \hat{Y}_{t+1} = \alpha Y_t + \alpha(1-\alpha)Y_{t-1} + \alpha(1-\alpha)^2 Y_{t-2} + \ldots$$

The trend extrapolation and moving average models are a useful and relatively simple method of forecasting. However, they do have a major shortcoming in that there is no method of determining the confidence intervals of the forecast. To alleviate this deficiency, more sophisticated time series models have been developed to provide a method of estimating forecast confidence intervals by a stochastic process.

This process assumes that each of the variables included in the model is drawn randomly from a probability distribution with a mean of zero. Another assumption of the stochastic process is that it is stationary or fixed in time, thus allowing the estimation of parameter coefficients from historical prices. A distinction between the next three models to be discussed and those reviewed previously is the inclusion of a random disturbance or error (ε_t) term in the equation. This term represents the unknown or unpredictable factors of a stochastic process that result from the simplification of reality inherent to model construction.

The first of the models discussed for a stochastic process is a weighted (Θ) moving average process of order q, with the weight attached to the disturbance term having either a positive or negative value. The mean (μ) of the moving average process is the other variable included in the model shown in Equation 5, representing the expected value of the parameter to be estimated (Y_t).

$$(5) \quad Y_t = \mu + \varepsilon_t - \Theta_1\varepsilon_{t-1} - \Theta_2\varepsilon_{t-2} - \cdots - \Theta_q\varepsilon_{t-q}.$$

Confidence intervals for this and the following models are generated from standard deviations of the forecast error, a measure of the variance from the mean value.

The second stochastic time series model is an autoregressive process of order p. This model generates a forecast estimate from the weighted average of past observations. These variables together with a disturbance term (ε_t), and a constant term (δ) which is related to the mean of the stochastic process, are shown in Equation 6.

$$(6) \quad Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p} + \delta + \varepsilon_t$$

The last time series model discussed is a mixed autoregressive-moving average process that combines the modeling techniques of the previous two examples, as shown in Equation 7.

$$(7) \quad Y_t = \phi_1 Y_{t-1} + \cdots + \phi_p Y_{t-p} + \delta + \varepsilon_t - \Theta_1\varepsilon_{t-1} - \cdots - \Theta_q\varepsilon_{t-q}$$

This approach may be useful when either the moving average or autoregressive process alone proves to be inadequate in explaining the changes in prices over time.

B. Forecasting With Econometric Modeling Techniques

In econometric modeling, the influence of supply and demand on market prices may be incorporated into the model structure. The unknown or dependent variables to be estimated by the model are referred to as endogenous, while the predetermined or exogenous variables are gathered from available resources or by prior estimation. The causal relationship between the exogenous or explanatory variables and the endogenous variable to be predicted, represents the economic environment in the market place at a point in time. As market conditions change over time, as reflected through changing values of the exogenous variables, the predicted value of the endogenous variable would be expected to adjust in response.

The influence of time may be incorporated into regression analysis through the development of distributed lag models designed to represent the time lapse between changes in the exogenous variables and the response of the endogenous variable. Coefficients (β) estimated in the regression analysis measure the change in the endogenous variable (Y_t) associated with a change in each exogenous variable (X). These variables together with the intercept (α) and disturbance term (ε_t) are shown in Equation 8.

$$(8) \qquad Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \cdots + \varepsilon_t$$

By weighting the lagged exogenous variables, the distributed lag model may be transformed into a geometric or polynomial lagged structure. The geometric lagged structure assumes that the weights assigned to the lagged parameters are positive and decline geometrically with time. This technique presumes that more distant lagged variables are of declining importance in their relationship with the endogenous variable. If this type of specification does not represent the actual causality, then a polynomial distributed lag may be more appropriate. The polynomial distributed lag model provides various weighting strategies that place an emphasis on more recent or more distant observations, or some combination inbetween.

A statistical problem that may arise with the inclusion of a number of lagged exogenous variables in the model is multicollinearity. In this case, it occurs because of a high correlation between a variable and its lagged value, with the coefficients (β) estimated from their combined influence instead of individually.

The final two econometric techniques discussed, and perhaps the most widely used, are regression analysis by a single equation using ordinary least squares (OLSQ), or by simultaneous equations. The choice of technique in this case would depend on the causal relationship between the endogenous and exogenous variables. An implicit assumption of OLSQ is that the cause and effect relationship between the variable to be predicted and the explanatory variables is unidirectional. Restated, the exogenous variables are the cause and the endogenous variable is the effect. Additional assumptions of the OLSQ regression are:

1. the exogenous variables (X) are nonstochastic
2. no exact linear relationship exists between two or more of the exogenous variables,

3. the error term (ε_t) has zero expected mean and a constant variance,

4. errors from different observations are not related to each other, and

5. the error term is normally distributed.

The single equation linear regression model shown in Equation 9 includes the intercept term (α), beta (β) estimates for each exogenous variable (X_i), and a disturbance term (ε_j).

$$(9) \quad Y_j = \alpha + \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_k X_{kj} + \varepsilon_j$$

There are situations where the single equation technique would not be appropriate, and its use in forecasting lead to biased and inconsistent parameter estimates. A serious violation is the absence of unidirectional causality. This may occur where not only is the dependent variable explained by values of the exogenous variables, but some of the exogenous variables are concurrently influenced by the value of the endogenous term. Under these conditions of two way or simultaneous causality, a system of simultaneous equations developed to forecast future prices would be more appropriate.

An example of a simultaneous equation model where <u>both</u> quantity and price are endogenous is shown below for a two equation supply and demand model such as in Equation 10 and 11.

(10) Supply $Q_t = \alpha_1 + \alpha_2 P_t + \varepsilon_t$

(11) Demand $Q_t = \beta_1 + \beta_2 P_t + \beta_3 Y_t + \mu_t$

This model is known as the structural model where endogenous variables (Q_t and P_t) are found on both the left and right hand sides of the equation. By algebraic manipulation, the endogenous variables are respecified in a two equation reduced form structure shown below:

$$Q_t = \frac{\alpha_2 \beta_1 - \alpha_1 \beta_2}{\alpha_2 - \beta_2} + \frac{\alpha_2 \beta_3}{\alpha_2 - \beta_2} Y_t + \frac{\alpha_2 \mu_t - \beta_2 \varepsilon_t}{\alpha_2 - \beta_2}$$

$$P_t = \frac{\beta_1 - \alpha_1}{\alpha_2 - \beta_2} + \frac{\beta_3}{\alpha_2 - \beta_2} Y_t + \frac{\mu_t - \varepsilon_t}{\alpha_2 - \beta_2}$$

As noted in the reduced form equations, the parameters of either equation may not be estimated without considering the information provided in the other.

C. Justification of Model Selection

The review of forecasting models presented in this section for estimating future prices is by no means comprehensive. It was the author's intent to only summarize some of the numerous options available. The choice of technique will depend on the needs of the forecaster and the interpretation of relevant parameters required in specifying the model. The slaughter cattle price forecasting model discussed in this chapter applies econometric modeling techniques because the inclusion of economic variables was deemed important in the price determination process. The choice of a single equation estimate rather than forecasting with simultaneous equations or a distributed lag model was based on the assumptions discussed below.

Within the constraints of a one and two quarter forecasting horizon, the potential supply of slaughter animals is limited by past prices and inventories. Significant supply adjustments within this time period are not biologically feasible. The estimation of price and quantity simultaneously would be appropriate when sufficient time is allowed for interdependence to take place (Tomek and Robinson, 1977). The one and two quarter forecasting model developed in this chapter do not meet the condition of "sufficient time" required for simultaneity to exist.

Tomek and Robinson subsequently stated that prices and quantities may be determined sequentially when time lags between changes in variables are long, or when the time unit over which the variables are observed is short. The sequential estimation of model parameters is known as a recursive equations system. The application of this forecasting technique is found in the next sections.

The decision not to attempt a price forecast with a distributed lag model was based on the expectation of a high correlation between current and lagged values of one or more exogenous variables. The high correlation would result in the multicollinearity problems discussed earlier.

D. Description of the Study Parameters

The variables included in the steer price model and all subsequent models discussed throughout the rest of this article are presented in Table 8. In addition to a description of each variable, the source from which the series was obtained is also included.

During the 1971-1979 period, from which the steer price model coefficients were estimated, trends were present both in prices and population. To reduce the influence of inflation on the data series, prices and per capita income were indexed by a GNP deflator. Beef, pork, and broiler production were adjusted to a per capita basis by dividing by U.S. population, to compensate for increases in population over this period, that otherwise might indicate an increase in total demand not found for individual consumers.

Beef production is defined as federally inspected steer and heifer slaughter multiplied by their average carcass weights. This approach, given limited data, differentiates between choice and lower quality carcasses. A proportion of the lower grade nonfed steer and heifer slaughter is included in this variable, however it does exclude all cow slaughter.

A separate variable representing estimated nonfed production from steers, heifers, and cows was originally included in the model, but was found to be statistically insignificant, with its exclusion resulting in no reduction of forecasting performance. The data source used for nonfed production was nonfed steer and heifer slaughter and commercial cow slaughter. Nonfed steer and heifer slaughter is an estimated value that the U.S.D.A. determines as the residual slaughter of steers and heifers in nonfederally inspected plants after subtracting out the federally inspected portion from total commercial slaughter.

Commercial cow slaughter is also determined as an estimate by the U.S.D.A. This variable is calculated by adding the cow slaughter

Table 8 : Description of Model Variables and Their Source

Variable	Unit	Description	Source
Beef production	lbs.	Federally inspected steer and heifer slaughter x average carcass weight ÷ population	USDA - Cattle Slaughter
Pork production	lbs.	Commercial hog slaughter (carcass weight) ÷ population	USDA - Beef and Hog Outlook and Situation
Broiler production	lbs.	Federally inspected slaughter ready to cook young chickens ÷ population	USDA - Eggs, Chickens and Turkeys
Disposable income	billion	U.S. disposable income	U.S. Government Economic Indicators
GNP	--	Implicit GNP deflator 1972 = 100	U.S. Government Economic Indicators
Population	million	U.S. civilian domestic population	U.S. Government Economic Indicators
Consumer income	$/person	Disposable income ÷ GNP ÷ population (quarter basis)	U.S. Government Economic Indicators
Heavy weight steers on feed	thos. head	1/3 (700-900 lb.) + 900-1100 lb. + > 1100 lb. steers on feed, 23 states	USDA - Cattle on Feed
Heavy weight heifers on feed	thos. head	1/3 (500-700 lb.) + 700-900 lb. + 900-1100 lb. heifers on feed, 23 states	USDA - Cattle on Feed
Corn price	$/bu.	Chicago corn price, U.S. No. 2, average for quarter	USDA - Feed Grains
Slaughter steer price	$/cwt.	Omaha choice grade slaughter steer price 900-1100 lbs., average for quarter	USDA - Beef and Hog Outlook and Situation
Ratio of heavy to light weight animals on feed	--	(700-1100 lb. steers + 700-1100 lb. heifers) ÷ (< 500 lb. steers + < 500 lb. heifers); cattle on feed, 23 states	USDA - Cattle on Feed
Cow production	lbs.	Federally inspected cow slaughter x average carcass weight ÷ population	USDA - Cattle Slaughter
Beef cow inventory	thos. head	Number in United States published Jan. 1 and July 1	USDA - Cattle
Dairy cow inventory	thos. head	Number in United States published Jan. 1 and July 1	USDA - Cattle
Utility cow price	$/cwt.	Omaha utility cow price average for quarter	USDA - Beef and Hog Outlook and Situation

Table 8 : Description of Model Variables and Their Source (cont.)

Variable	Unit	Description	Source
Northwest slaughter steer price	$/cwt.	Oregon-Washington direct trade, 900-1100 lb. choice slaughter steers, average for quarter	Oregon State University Extension Market News Office
Portland utility cow price	$/cwt.	Portland auction, utility and commercial 2-3 slaughter cows, average for quarter	Oregon State University Extension Market News Office
Medium weight heifers on feed	thos. head	500-700 lb. heifers on feed, 23 states	USDA - Cattle on Feed
Medium weight steers on feed	thos. head	500-700 lb. steers on feed, 23 states	USDA - Cattle on Feed
Feeder steer price	$/cwt.	Good and choice Kansas City feeder steer price, 600-700 lbs. average for quarter	USDA - Beef and Hog Outlook and Situation
Sow Farrowings	thos. head	Number of sows farrowing, 14 states	USDA - Hogs and Pigs
Pigs on Feed	thos. head	Pig inventory on feed by weight class, 14 states	USDA - Hogs and Pigs
Hog price	$/cwt.	Omaha U.S. 1-2 barrows and gilts, 200-240 lbs., average for quarter	USDA - Beef and Hog Outlook and Situation
Broiler hatch	million birds	Broiler type chicks hatched by commercial hatcheries	USDA - Eggs, Chickens and Turkeys
Hatchery supply flock	thos. head	Sum of domestic broiler type chicks placed in hatchery supply flocks 7-14 months earlier	USDA - Eggs, Chickens and Turkeys
Broiler price	¢/lb.	Chicago wholesale price of ready to cook broilers	USDA - Poultry Outlook and Situation
Trend	--	1971 quarter I = 1, . . . 1981 quarter IV = 44	
D_2	--	Quarter II = 1, otherwise = 0	
D_3	--	Quarter III = 1, otherwise = 0	
D_4	--	Quarter IV = 1, otherwise = 0	

in federally inspected plants to cow slaughter in nonfederally inspected facilities. The nonfederally inspected slaughter is estimated as the same proportion of slaughter in nonfederally inspected plants as reported in federally inspected facilities.

The omission of nonfed beef slaughter from the steer price model was based on its low statistical significance. Considering the influence of this portion of the total beef supply in the market, that competes for the consumer dollar with the higher priced beef grades, it was initially considered an important explanatory variable. The low t-value on nonfed beef supplies may be attributed to the high correlation between this variable and the fed beef component that masked its significance in the model and possible errors in the data due to the estimation technique.

E. Slaughter Steer Price Forecasting Model

The slaughter steer price forecasting model presented in this chapter attempts to replicate the interaction of supply and demand at the feedlot level. Determinants of demand discussed in a previous chapter included the price of beef and substitute meat products, and the income of the consumer. The supply of beef was argued to be a function of available inventories, influenced by previous input costs and price levels. A basic assumption of this price model is that current supplies at the slaughter level determine current prices. Therefore, the price of slaughter steers is estimated from supplies of beef, pork, and broilers included in the model along with consumer income as exogenous variables. The model developed to estimate future prices of slaughter steers is shown in Table 9.

The initial estimation of the steer price model by ordinary least squares (OLSQ) resulted in a low Durbin-Watson statistic, indicating the presence of serial correlation of the disturbance term. A correlation between error terms, estimated from time series data, results from errors associated with one time period being carried over to the next and future observations. Possible causes of its occurrence include:

1. prolonged influence of shocks
2. inertia between past and current actions
3. data manipulation from interpolation or smoothing techniques
4. mis-specification or omission of relevant exogenous variables in the model.

If this statistical problem is <u>not</u> corrected, the standard error (measure of the dispersion of the estimated coefficients around their mean) of the regression is biased downward, thus misrepresenting the accuracy of the parameters. When the presence of serial correlation can be attributed to model mis-specification, inclusion of relevant variables would be appropriate if they can be identified and are available. Unfortunately this is not always possible, leading to the next best alternative which, in this case, was to respecify the model using generalized differences.

The Cochrane-Orcutt iterative technique was applied to the OLSQ model to estimate a value of rho (ρ), representing the correlation coefficient associated with the disturbance term for adjacent observa-

Table 9. Parameters in Slaughter Steer Price Models Estimated by Ordinary Least Squares and by an Autocorrelated Correction Technique

Variable	OLSQ Model	Auto-Corr. Model
intercept	101.265 (5.55)[1/]	-44.06 (-1.50)
beef production	-3.35 (-6.86)	-2.49 (-10.27)
pork production	0.22 (0.68)	-0.54 (-2.47)
broiler production	1.71 (1.55)	1.60 (3.23)
consumer income	-0.19 (-0.87)	0.0999 (4.24)
standard error of the regression	3.29	1.56
R^2	.618	.850
adjusted R^2	.569	.830
F-value	12.55	39.59
Durbin-Watson[2/]	.548	1.99
Theil's Statistic[2/]	.043	.020
Root Mean Square Error[2/]	3.05	1.44
Value of rho		.972

[1/] t statistics shown in parenthesis below coefficients.

[2/] See Appendix A for a discussion of these statistical measures.

tions.[3/] Each variable included in the original OLSQ model is replaced by that variable minus the estimated value of rho times the previous period's observation, as shown in Equation 12.

$$(12) \qquad Y_t - \rho Y_{t-1} = \gamma(1-\rho) + \beta_1(X_{1t} - \rho X_{1t-1}) + \ldots + (\varepsilon_t - \rho\varepsilon_{t-1})$$

A comparison of the results obtained from the original OLSQ model and after correcting for autocorrelation is shown in Table 9. The superior performance of the latter model is reflected in the decline in root mean square error and by explaining a higher proportion of total variation in the dependent variable (R^2).

After deflating prices and respecifying meat production on a per capita basis, a problem with multicollinearity was still present in the initial estimation trials of the model corrected for serial correlation. In this case, its occurrence was attributed to a high correlation between poultry supplies and income, that both trended higher over the sample period.

In the autocorrelated model (referred to hereafter) beef and pork production coefficients have the correct signs and are statistically significant at the 95 percent confidence level. The negative sign on beef production represents the movement along the demand schedule, where an increase in supply results in a price decline or vice versa.

An increase in the supply of pork products is expected to have a

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3/ Pindyck and Rubinfeld, pp. 157.

negative impact on steer prices, with the consumer substituting pork for beef when pork prices decline as a result of increased production. This consumer response dampens the demand for beef products, resulting in a decline in demand at the wholesale level and the price received by producers.

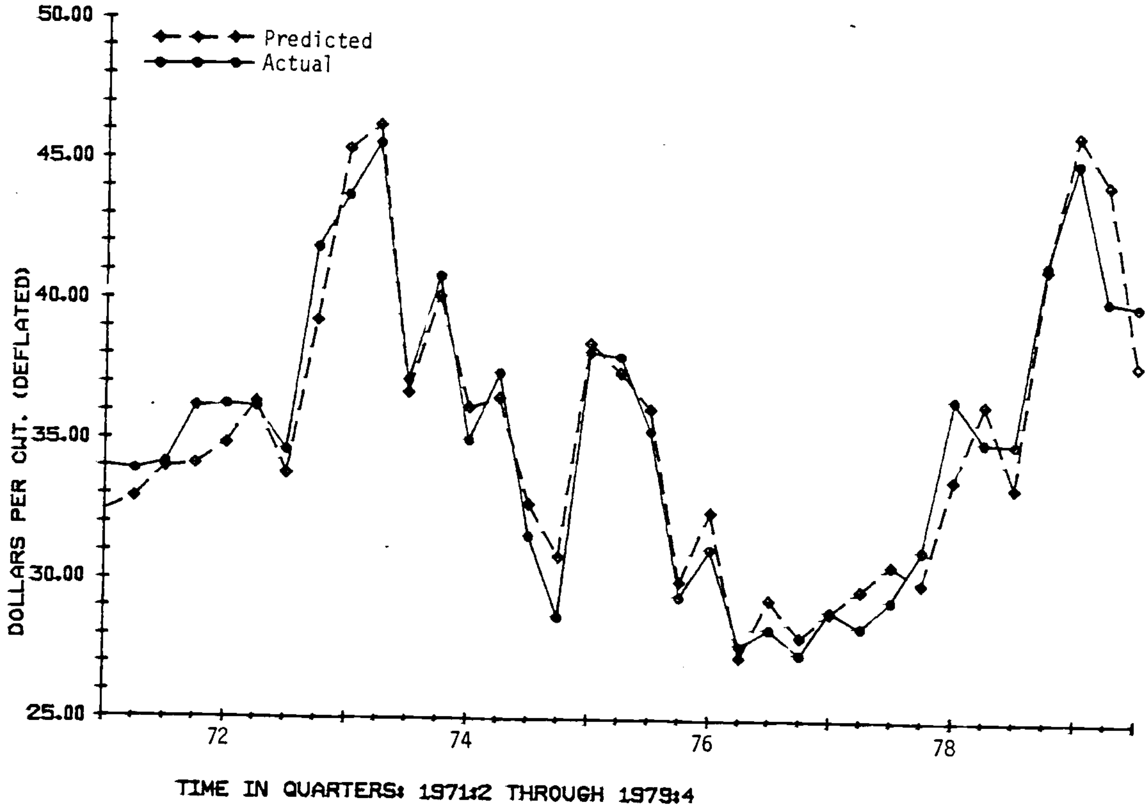
A similar response would be expected for changes in poultry production, but the sign on this coefficient was positive suggesting a complementary relationship. From the standpoint of economic theory however, one would disagree with this conclusion, thus questioning the validity of the sign on the variable. In this case, the sign on the coefficient is not consistent with the literature and may be due to problems of specification.

A dilemma arises whether to remove the variable representing poultry production for the quarter, or leave it in the model to avoid increasing the bias by mis-specifying the true economic relationship. This was resolved by acknowledging that the sign of the coefficient is wrong, but as a forecasting instrument, does a better job with poultry supplies included in the model. This variable was statistically significant.

Figure 17 shows the actual and estimated prices over the thirty-five quarters included in determining the regression coefficients. The model does a relatively good job of tracking the deflated price series over a volatile period, catching 86 percent of the turning points. The average absolute error is 1.17 dollars/cwt. with a range from -4.13 to +2.85. Seventy-four percent of the estimated prices fall within 1.5 dollars of the actual deflated price.

Figure 17.

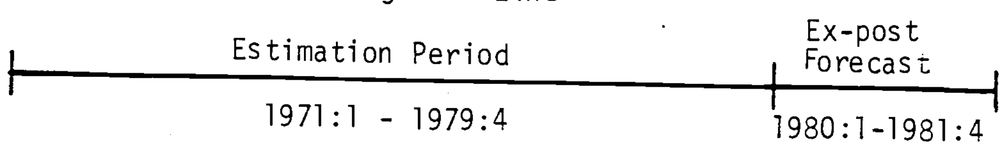
ACTUAL AND PREDICTED SLAUGHTER STEER PRICE



F. An Initial Evaluation of the Steer Price Model

Given the model's "acceptable" performance over the time period from which the coefficients were estimated, the next step in evaluating the model was to forecast future prices beyond the base period (1971-1979) without reestimating the coefficients. The ex-post forecast (see Figure 18), using actual values of the exogenous variables, should indicate potential limitations of the price prediction model over the forecast period.

Figure 18. Forecasting Time Line



Because the estimation technique is specified to correct for serial correlation, the value of the endogenous variable from the previous quarter is included in the formulation. In the static forecast, the actual lagged price is included in estimating the average price for the current quarter. Where as the dynamic forecast uses the estimated price from the previous quarter in the current projection.

Comparing the forecasted steer prices from the two estimation techniques in Table 10, the static simulation does a superior job of predicting actual prices over the period. This would be expected with the inclusion of the actual price from the previous quarter, that helps rectify any previous error in the forecasted value. When actual lagged prices are not included as frequently, as in the case of the dynamic simulation, the performance of the model may be used as an indication of potential weaknesses in extrapolating beyond the base period.

From the results in Table 10, the dynamic simulation seems to predict prices reasonably well although the projections are made for only two quarters before actual prices again enter the equation. When a dynamic simulation was estimated for the entire seven quarters being projected, the model's performance became increasingly worse beyond three quarters.

The two quarter dynamic forecast results did a better job of tracking the actual deflated prices over the period when compared with the one quarter static estimates. The majority of forecasted prices overestimated the actual values, with the mean absolute error 1.81 dollars in the static simulation and 2.35 dollars in the dynamic forecast.

G. <u>Forecasting With Fitted Values of the Exogenous Variables</u>

When evaluating the performance of the parameters for estimating future prices, the next and perhaps superior method of evaluating the model is to substitute predicted values of the exogenous variables into the steer price model for the ex-post forecast. For this purpose, separate models were developed to estimate one and two quarter projections of the exogenous variables. Different models were required to project each quarter's estimated value because of the time

Table 10. Slaughter Steer Price Projections from a Static One Quarter and Dynamic Two Quarter Ex-post Forecast[1,2]

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	39.02	42.17	-3.15		
1980-2	36.81	37.71	- .90	37.72	- .91
1980-3	39.52	37.40	2.12	38.28	1.24
1980-4	35.64	37.38	-1.74	35.22	.42
1981-1	32.95	35.90	-2.95	37.59	-4.64
1981-2	34.90	35.84	- .94	38.70	-3.80
1981-3	34.01	36.00	-1.99	36.91	-2.90
1981-4	30.07	30.79	- .72	32.72	-2.65
Root Mean Square Error		2.01		2.77	
Root Mean Square Percent Error[3]		5.60		8.32	
Mean Absolute Error[3]		1.81		2.35	
Mean Absolute Percent Error[3]		5.08		6.97	
Turning Point Error		.67		.40	

---

[1] Prices represent real (deflated) values.

[2] Actual values of exogenous variables included.

[3] See Appendix A for discussion of statistical measure.

period from which the exogenous variable in each of these models was specified.

The predetermined variables for a one or two quarter forecast model must be lagged to the current period or else estimated from another source. This procedure was necessary to insure that all variables in the model were available when the forecast was made. The predicted meat production and income value is then "plugged" into the steer price equation. The forecasted price being either a one or two quarter projection, depending on which models the predicted value of the exogenous variables were obtained from. An example of this recursive approach is introduced in a later section.

The U.S.D.A. publications: Cattle on Feed, Hogs and Pigs, and Eggs, Chickens, and Turkeys are valuable references for the variables included in the meat supply models. Animal inventories by age or weight class included in these periodicals were incorporated into meat production models to project future production levels. The dependence on U.S.D.A. data to develop the forecast was considered in determining when each one and two quarter estimate could be made. The release of Cattle on Feed during the third week of the quarter prevented an earlier projection, with forecasts made at this time as shown in Table 11 for both the current and next quarter.

When seasonal changes in meat production were found to be significant in the models, zero-one dummy variables were included. These variables eliminate seasonal variability by shifting the intercept value of the regression line. In an OLSQ model, the dummy variable is equal to one in the quarter specified, and equal to zero in all other

Table 11. Relationship Between Forecast Month and Quarter Being Forecasted

Forecast Month	Length of Forecast: One Quarter	Two Quarter
January	I	II
April	II	III
July	III	IV
October	IV	I

quarters. However, with the adaptation to an autocorrelated correction model, the influence of the dummy variable is also expressed in the following quarter. In this case, the lagged value of the dummy variable is equal to one times the value of rho. Using a second quarter dummy variable (D_2) specified in the first quarter as D_2^1, second quarter as D_2^2, and third quarter as D_2^3, the following example should clarify this relationship:

$$D_2^1 = 0$$
$$D_2^2 = 1$$
$$D_2^3 = 0$$

Quarter = 2 $\qquad \beta_i(D_2^2 - \rho D_2^1) = \beta_i(1 - \rho(0))$

Quarter = 3 $\qquad \beta_i(D_2^3 - \rho D_2^2) = \beta_i(0 - \rho(1))$

As shown, the second quarter dummy variable takes on the negative value of rho in the third quarter. This rather unorthodox specification of seasonal dummy variables raised the question of whether this was an appropriate specification. No discussion of the technique was found in the literature and since its inclusion improved the performance of the model, was therefore assumed to be acceptable.

H. Beef Production Models: Development and Discussion of Forecast Results

Recalling that it was necessary to correct the steer price model for autocorrelation, the same was true in developing models to estimate production of beef, hogs and broilers. The model coefficients measure the influence of the change in the exogenous variables between quarters on the variable to be predicted.

The exogenous variables included in the one quarter beef production forecast are shown in Table 12. The steer and heifer inventories on feed from the U.S.D.A. twenty-three state survey included one-third of the steers in the 700-900 pound weight class and all animals above 900 pounds. Fed heifer inventories included one-third of the 500-700 pound weight class plus all heavier inventories. The majority of these animals are expected to be slaughtered during the quarter. Thus, an increase in their numbers at the beginning of the quarter would increase total slaughter as indicated by the positive sign on these coefficients.

The price of corn was included in the model because of its influence on placement weight and the period on feed. A rise in corn price results in an increase in current slaughter, as producers thin feedlot inventories in an attempt to maximize profits. An increase in slaughter price, on the other hand, encourages the retainment of animals to heavier weights, and thus a negative slaughter response is

Table 12. One Quarter Beef Production Forecasting Model

Variable	Coefficient
intercept	3084.46 (9.79)
heavy weight steers on feed	0.23 (4.07)
heavy weight heifers on feed	0.61 (7.33)
corn price (t-2)	128.83 (2.45)
slaughter steer price (t-1)	-43.09 (-9.04)
ratio of heavy to light animals on feed	27.23 (3.53)
standard error of regression	144.76
R^2	.876
adjusted R^2	.853
F-value	35.19
Durbin-Watson	1.96
Theil's Statistic	0.015
Root Mean Square Error	130.9
Value of rho	-.454

expected.

The ratio of heavy animals ($\geq$ 700 pounds) to light weight feeder calves ($\leq$ 500 pounds) in the current feedlot inventories is used as a proxy for the inventory weight distribution. An increase in this ratio, possible by having either a larger proportion of heavy animals or a reduction in the lightest weight class on feed, represents an increase in the number of animals nearing market weight and thus near term slaughter.

All variables in the model were highly significant from zero, with their combined influence explaining 85 percent of the total variation in the dependent variable. The Durbin-Watson statistic, at a value close to two, indicates the presence of autocorrelation has been removed. The information available at the time the one quarter forecast is made appears to reflect the actual movement of slaughter inventories quite well.

The development of the two quarter model for projecting beef production proved to be challenging with the information available when this forecast is made. Of particular concern, was the poor performance of the model when lagged prices and light weight cattle inventories on feed were included as descriptive variables. The only variable that significantly increased the model's predictive ability was the inclusion of beef production from the most recent quarter (t + 1), and more specifically, the change in production between this quarter and the current quarter ((t + 1) - t). This specification requires the output from the one quarter forecast, which increases the possibility of forecast error, but proved to be an acceptable alternative.

The variables included in the two quarter forecasting model are shown in Table 13.

The positive sign on the change in beef production coefficient is hypothesized to be representative of the short run trend in slaughter. This would be expected to continue into the next quarter, assuming market conditions remain relatively stable. The lagged inventory of heifers on feed includes animals that should reach market weight by the end of the second quarter. An increase in their numbers would be expected to increase total beef production during this period. The negative sign on the lagged steer inventory raised some questions initially, although considering the growth rate and time required to feed out these animals, its sign may be justifiable. It is hypothesized that the majority of these animals would not reach market weight until the third quarter, thereby reducing slaughter numbers in the two quarter forecast.

The corn price and steer price coefficients have the expected sign under the same assumptions as the one quarter model. The price of feeder calves from one year earlier was included in the two quarter model as an indication of the profitability of retaining brood cows in the herd. An increase in calf prices would encourage the retainment of cows, resulting in a larger calf crop in the current year and an increase in beef production when the calves are fed to slaughter weight.

The adjusted R^2 value for both the one and two quarter beef production models are approximately equal, whereas the root mean square error, as a measure of the variation between actual and predicted

Table 13. Two Quarter Beef Production Forecasting Model

Variable	Coefficient
intercept	4032.94 (9.37)
change in beef production (t+1) - t	1.03 (8.78)
medium weight heifers on feed (t-1)	1.14 (5.01)
medium weight steers on feed (t-1)	-0.43 (6.38)
corn price (t-3)	150.61 (1.96)
slaughter steer price (t-2)	-31.11 (-5.88)
feeder steer price (t-4)	13.85 (3.69)
D_3	-282.69 (-2.38)
standard error of regression	174.39
R^2	.890
adjusted R^2	.857
F-value	24.39
Durbin-Watson	2.27
Theil's Statistic	0.017
Root Mean Square Error	150.2
Value of rho	-0.822

values, was 15 percent lower in the one quarter model.

The ex-post forecast values from the one and two quarter beef production models are shown in Table 14. The one quarter forecast estimates are relatively close to actual values in all but the third quarter of 1981. During this quarter, corn prices declined by $.40/bu., thereby encouraging the retainment of heavier animals on feed. Steer inventories in the 900-1100 pound weight class increased by 19 percent from the previous quarter with 700-900 pound heifer inventories up by 31 percent. This large influx of heavy animals would be expected to move to market during the quarter, but instead were kept for additional fattening due to the lower feed costs incurred. In this case, the model was unable to reflect this short term producer response to changing market conditions.

If the fitted and actual beef production values are plotted over the eight quarters (see Figure 19) an additional "limitation" of the one quarter model becomes apparent. Third quarter projections in both 1980 and 1981 overestimated actual production. The model mis-specifies the time period required to fatten out third quarter animals in the heavy weight inventories for which a large number may be long yearlings coming off of summer pasture. In this case, the animals could require additional time on feed to reach a choice grade, which may not be true if the animals were being grain fed prior to entering this weight inventory.

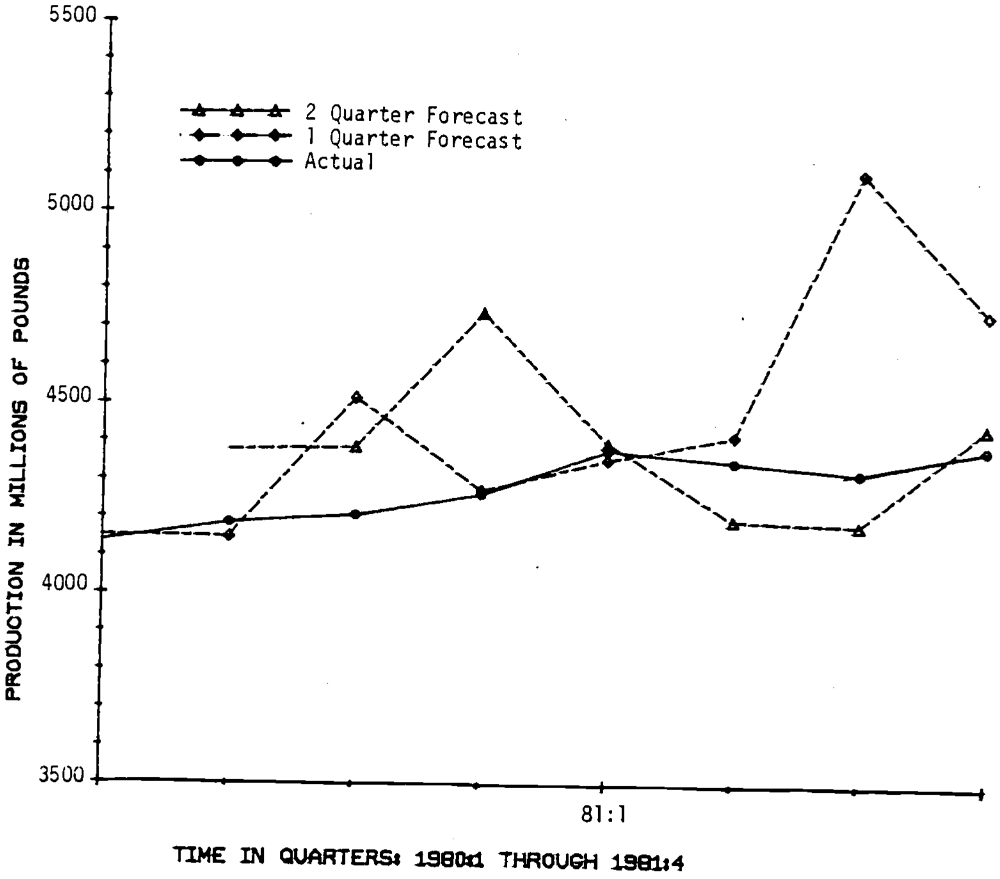
The seasonal variation in the forecasted beef production estimates was considered to be the principal cause of the one quarter model's

Table 14. Forecasted Beef Production Levels from a Static One Quarter and Dynamic Two Quarter Ex-post Forecast

Quarter	Actual Level	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	4137	4151	- 14	--	--
1980-2	4186	4150	36	4380	-194
1980-3	4208	4516	-308	4385	-177
1980-4	4263	4273	- 10	4739	-476
1981-1	4380	4355	25	4399	- 19
1981-2	4351	4419	- 68	4199	152
1981-3	4322	5110	-788	4188	134
1981-4	4388	4743	-355	4445	- 59
Root Mean Square Error		325.71		206.22	
Root Mean Square Percent Error		7.54		5.18	
Mean Absolute Error		200.50		172.71	
Mean Absolute Percent Error		4.65		4.05	
Turning Point Error		.67		.40	

Figure 19.

ACTUAL AND FORECASTED BEEF PRODUCTION



poor performance with respect to tracking beef production. While the two quarter model did a better job in this respect, there was still a seasonal variation present in the forecasted values. Whereas actual beef production gradually trended higher over the eight quarters, the two quarter model reported significant increases in fourth quarter production. This characteristic of the two quarter model may be attributed to the large number of light weight calves on feed during this period, and the inclusion of a forecasted value for the exogenous variable representing the change in beef production between t + 1 and t.

These seasonal biases would suggest the inclusion of dummy variables to correct for such variations in estimated production. Unfortunately, this procedure was attempted without success because of problems with multicollinearity between the dummy variables and the respective inventories on feed that were to be deseasonalized. Overall, the beef production estimates were considered acceptable, with the exception of the third quarter 1981 estimate from the one quarter model. The large forecast error in this quarter is responsible for the higher root mean square error (RMSE) when compared with the two quarter model. This statistic weights larger errors more heavily and thus accentuates major differences between actual and fitted values.

The percent root mean square error, as another measure of the model's forecast performance, is in many cases a more appropriate statistical tool since it allows a comparison of forecasts over different periods or for a different number of forecasted observations. Comparing the difference between the percent root mean square error, calculated for the estimated values of the one and two quarter beef production models, the two quarter model is superior in this respect. The lower value of this statistic indicates the magnitude of errors between actual and fitted values is smaller than found in the one quarter model.

I. Pork Production Models: Development and Discussion of Forecast Results

The specification of the one and two quarter pork production models rely on U.S.D.A. data published in Hogs and Pigs. Their breakdown of inventories on feed by weight class, along with sow farrowings in previous quarters, provide an indication of potential slaughter levels.

Recent changes to more intensive feeding operations have resulted in an increase in nonfeed costs, thus lowering the impact of feed grain prices on sow inventory adjustments (Shepherd, Futrell and Strain, 1976). This technological shift in production has reduced some of the seasonal variation in supply, however it is difficult to indicate this relationship in a model covering the period in which it occurred. This is a possible reason for the lower performance of the models shown in Table 15 for the one and two quarter pork production equations.

Referring first to the one quarter model, potential slaughter inventories during this period are represented by the number of sows farrowing six months earlier and the inventory of 60-120 pound pigs on feed in the previous quarter. The relatively high t-value for sow farrowings reflects its importance in estimating changes in future production. Coefficients on both inventory variables have positive signs. The negative slaughter response to hog price changes is hy-

Table 15. One and Two Quarter Pork Production Forecasting Models

Variables	1 Qtr. Model	2 Qtr. Model
intercept	2304.52 (6.60)	1264.67 (2.97)
sow farrowings (t-2)	0.48 (7.67)	0.55 (8.52)
slaughter hog price:		
(t-1)	-14.55 (2.20)	
(t-2)		7.63 (1.09)
corn price (t-3)	-128.85 (-1.26)	
number of pigs on feed:		
60-120 lbs. (t-1)	0.05 (1.96)	
< 60 lbs. (t-2)		0.02 (2.04)
standard error of regression	148.77	153.67
R^2	.770	.757
adjusted R^2	.736	.732
F-value	20.09	28.03
Durbin-Watson	1.78	1.62
Theil's Statistic	0.021	0.022
Root Mean Square Error	136.7	144.1
Value of rho	.692	.809

pothesized to reflect the reaction of producers, who hold animals to heavier weights when prices trend higher, or market animals earlier when prices move lower. A similar producer reaction to price movements was found in the cattle sector. The three quarter lag on corn prices depicts the period when farrowing intentions are being made, with an increase (decrease) in price likely to reduce (increase) breeding inventories and production in the current period.

The specification of the two quarter model was developed from the same approach discussed for the one quarter forecast, with basic changes made only in the period observed and the ommission of corn price. This variable was found to be correlated with hog prices in t - 2 and entered the model with a very low t-value, in addition to partially masking the influence of hog prices during this quarter. The positive response in current production to changes in hog prices two quarters earlier represents the potential adjustments in slaughter inventories possible during this quarter. Only six to eight months are required to raise a slaughter weight animal from birth to marketing. A decline in price during this period would discourage placements on feed and thus current production levels.

The number of sows farrowing from two quarters earlier is the most important explanatory variable in both the one and two quarter models. Very similar results were obtained by substituting the pig crop from this period for the farrowing inventory. However, the root mean square error was slightly higher in the models when it was substituted in, and the inclusion of both inventory variables was prevented by a decline in model performance due to a high correlation between the two.

Estimated pork production levels from the ex-post forecast of the one and two quarter models are shown in Table 16. The projections from both models tract relatively well with actual production levels during this period. The production forecasts tend to underestimate actual production in both forecast horizons although no persistent pattern seems to exist. The superior performance of the one quarter model is evident from a comparison of the statistical summary.

F. Poultry Production Models: Development and Discussion of Forecast Results

The ability of poultry producers to hatch, grow out, and slaughter broilers within a one quarter period provides a great deal of flexibility in responding to market conditions. While nine months are required to substantially increase total production, this is still a much shorter period than found in the beef or hog sectors. The one and two quarter broiler production models shown in Table 17 include variables representing future supply inventories, market prices and input costs, and seasonal dummy variables.

The number of broiler type chicks hatched in the previous quarter was highly significant in the one quarter model, having a positive influence on current production levels. Prices of broilers and corn from the previous quarter had little effect on current production with supplies essentially predetermined from last quarter's hatch. These variables did not become significant until projections were made for

Table 16. Forecasted Pork Production Levels from a Static One Quarter and Dynamic Two Quarter Ex-post Forecast

Quarter	Actual Level	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	4126	4127	- 10	--	--
1980-2	4299	4025	274	3944	355
1980-3	3755	3581	174	3673	82
1980-4	4252	4222	30	4354	-102
1981-1	4073	3947	126	3754	319
1981-2	3879	3977	- 98	3736	143
1981-3	3608	3508	100	3584	34
1981-4	4025	3813	212	3751	274
Root Mean Square Error		152.76		220.91	
Root Mean Square Percent Error		5.34		5.36	
Mean Absolute Error		126.88		187.0	
Mean Absolute Percent Error		3.17		4.59	
Turning Point Error		.50		0.0	

Table 17. One and Two Quarter Broiler Production Forecasting Models

Variables	1 Qtr. Model	2 Qtr. Model
intercept	1457.65 (7.35)	2264.62 (5.21)
broilers hatched (t-1)	1.20 (9.71)	
hatchery supply flock		0.007 (1.44)
broiler price (t-2)		622.42 (1.84)
corn price (t-2)		-59.77 (-1.26)
seasonal dummy:		
D_2	99.78 (7.91)	194.11 (9.54)
D_3		180.30 (10.12)
D_4	-49.34 (-3.67)	
standard error of regression	50.37	55.77
R^2	.873	.860
adjusted R^2	.860	.834
F-value	68.54	30.75
Durbin-Watson	2.11	2.04
Theil's Statistic	0.011	0.014
Root Mean Square Error	47.32	50.44
Value of rho	.943	.963

two quarters, so were excluded from the one quarter model.

In the two quarter model, both corn price and broiler price entered the equation with a higher t-value indicating producers are now given sufficient time to adjust potential slaughter inventories in response to market conditions. The two quarter model replaces lagged broiler hatch with cummulative chick placements in hatchery supply flocks seven to fourteen months earlier. Both inventory variables are found in the U.S.D.A. publication Eggs, Chickens and Turkeys.

Seasonal variation in production, represented by the inclusion of dummy variables in the models, was found to be statistically significant. The capability of producing a market broiler within a one quarter period may be an important contributing factor to the high significance of these variables.

Comparing the summary statistics for both models, the two quarter model appears to perform well with potential production inventories represented by the size of the hatchery supply flock. The low t-values on the inventory and price variables are attributed to a relatively high correlation between the three, that tends to mask the individual contribution of each variable in explaining the variation in the dependent variable.

The ex-post forecasted values of broiler production from the one and two quarter models are shown in Table 18 along with actual production levels. The one quarter estimates all fall within 3.5 percent of the actual values, with the largest error from the two quarter models off by seven percent. Both models were able to project production levels that followed the cyclical pattern of broiler production over

Table 18. Forecasted Broiler Production Levels from a Static One Quarter and Dynamic Two Quarter Ex-post Forecast

Quarter	Actual Level	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	2722	2633	89	--	--
1980-2	2923	2951	-28	2854	69
1980-3	2759	2858	-99	2865	-106
1980-4	2685	2596	89	2691	- 60
1981-1	2826	2740	86	2631	195
1981-2	3084	3013	71	2924	160
1981-3	3063	3043	20	3013	50
1981-4	2865	2904	-39	2913	- 48
Root Mean Square Error		71.40		109.85	
Root Mean Square Percent Error		2.56		3.79	
Mean Absolute Error		65.13		90.57	
Mean Absolute Percent Error		2.31		3.12	
Turning Point Error		.33		1.00	

the forecast period. The decline in performance of the two quarter model is attributed to the specification of potential slaughter inventories from changes in the hatchery supply flock in previous quarters, rather than actual broiler hatch included in the one quarter model. Another contributing factor may be related to the inclusion of an estimated value as the lagged dependent variable in the forecasting procedure. The absence of more current information in the two quarter model resulted in a 48 percent increase in the percent root mean square error value.

G. Income Model: Development and Discussion of Forecast Results

Three additional variables were required to estimate forecasted income levels one and two quarters into the future. These were U.S. population, disposable personal income, and the GNP deflator. All three trended higher over the sample period in essentially a linear pattern. Modeling these parameters was kept simple by using a trend variable to represent the linear path of these values over time. The trend variable has a value of one in the first quarter of the base period with each consecutive observation determined by adding one to the current value.

Serial correlation between error terms was present in developing models for each of the variables. This was attributed to the linear relationship between current, past and future values. The problem was partially corrected by re-estimating the models by generalized differences with the inclusion of rho, but this approach was not entirely successful. Rather than attempt a more complicated modeling technique with no guarantee of improved performance, the models were used with only the correction for serial correlation.

As a result, the models developed to forecast, U.S. population, disposable income, and the GNP deflator include only an intercept term and the trend variable. The estimated coefficients and relevant statistical measurements are shown in Table 19 for each variable, with the same model used for both the one and two quarter forecast. Using estimated values, the income variable in the steer price model is derived by deflating disposable personal income (total for U.S.) by the GNP deflator and then dividing by U.S. population to develop a per capita estimate.

The one and two quarter income projections are differentiated by the method of forecasting, with the one quarter forecast using a static simulation and the two quarter forecast derived from a dynamic simulation. The results from both forecasting techniques are shown in Table 20. The projected income values, estimated from the simple trend models, are acceptably close to the actual values. Since the models included only a trend term in the equation, different models for each quarter were not required.

The projection of the income variable completes the discussion of models developed to forecast future levels of meat production and the average consumer income for the quarter. With this accomplished, the discussion now returns to the estimation of one and two quarter slaughter steer prices using fitted values of the exogenous variables.

Table 19. Trend Models Developed to Forecast U.S. Population, GNP Deflator, and Disposable Income

Variable	Model Coefficients		
	Population	GNP Deflator	Disposable Income
intercept	203.30 (917.51)	0.90 (15.77)	662.28 (7.67)
trend	0.57 (76.07)	0.02 (16.72)	30.69 (7.67)
standard error of regression	0.079	0.011	15.73
R^2	.99	.82	.58
adjusted R^2	.99	.815	.57
F-value	49.9446	182.63	55.19
Durbin-Watson	1.06	.55	1.31
Theil's Statistic	.001	.053	.045
Root Mean Square Error	.592	.149	120.0
Value of rho	.938	.982	.983

Table 20. Forecasted Income Levels from a One Quarter Static and Two Quarter Dynamic Ex-post Forecast

Quarter	Actual Level	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	1147	1141	60	--	--
1980-2	1129	1148	-19	1148	-19
1980-3	1136	1131	50	1131	50
1980-4	1139	1138	10	1139	0
1981-1	1140	1140	0	1140	0
1981-2	1141	1142	0	1141	1
1981-3	1145	1143	2	1143	2
1981-4	1142	1145	- 3	1145	- 3
Root Mean Square Error		7.38		7.56	
Root Mean Square Percent Error		0.65		0.67	
Mean Absolute Error		4.50		4.29	
Mean Absolute Percent Error		0.39		0.38	
Turning Point Error		0.33		0.40	

L. Slaughter Steer Price Forecasting Procedure and Results

An additional transformation required, prior to projecting one and two quarter steer prices, was to respecify the forecasted meat production values on a per capita basis. The estimated population levels during the period were used for this adjustment. After introducing the estimated values of the exogenous variables in the original steer price model, the forecasted and actual price series are shown in Table 21 for both the one and two quarter forecasting horizon.

The price forecasts for the one quarter projection were determined from a static simulation technique. As mentioned previously, this approach includes the actual lagged value of the endogenous variable in the model specified to correct for serial correlation of the error term. Actual lagged values of the exogenous variables are also included in this formulation. The predicted values of both the endogenous and exogenous variables from the one quarter projection are then incorporated into the two quarter dynamic simulation as the lagged values. The following example should clarify this forecasting approach:

γ = constant term

Y = actual price

Y* = one quarter forecasted price

Y** = two quarter forecasted price

X = actual value of exogenous variable

X* = one quarter forecasted value of exogenous variable

X** = two quarter forecasted value of exogenous variable

ρ = rho

Note: X*, and X** are determined from previously discussed production and income models.

<u>one quarter forecast</u>:

$$\hat{Y}_t^* = \gamma(1-\rho) + \beta_i(X_t^* - \rho(X_{t-1})) + \rho(Y_{t-1})$$

<u>two quarter forecast</u>:

$$\hat{Y}^{**} = \gamma\ (1-\rho) + \beta_i(X_t^{**} - \rho(X_{t-1}^*)) + \rho(\hat{Y}_{t-1}^*)$$

where $X_t^* = X_{t-1}^*$

$$\hat{Y}_t^* = \hat{Y}_{t-1}^*$$

Referring to the forecasted price series from the one quarter model, Figure 20 depicts actual and estimated prices over the period. The projected prices follow the general decline in actual deflated prices over the eight quarters although miss a majority of the turning points during this relatively volatile period. The largest forecast error is found in the third quarter of 1981, underestimating the actual price by 21 percent. Recalling that the one quarter estimate of beef production for this quarter was over estimated by 18 percent, the large error in the forecasted price was not totally unexpected. If the percent root mean square error is recalculated without this particularly large error in the third quarter of 1981, the value becomes 7.85 percent. This value compared favorably with similar estimates derived from forecasts of cattle prices reported by Just and Rausser (1981).

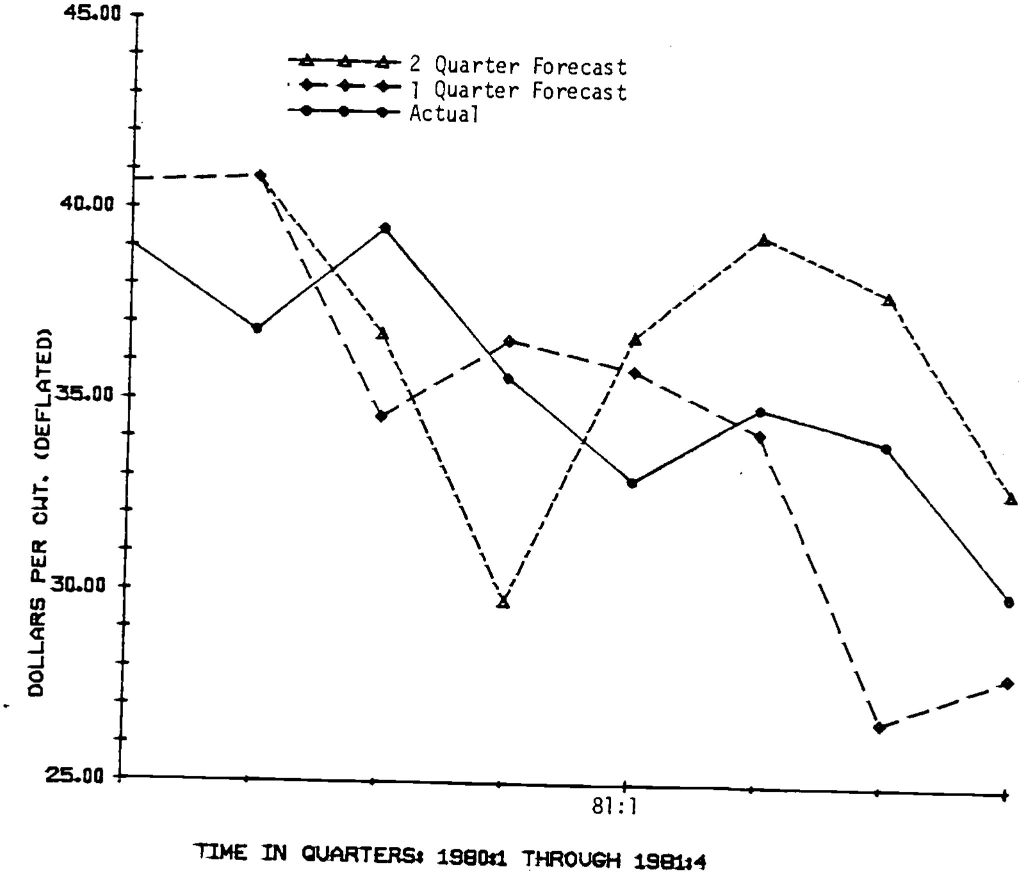
The mean absolute error from the two quarter forecasted series is

Table 21. Forecasted Slaughter Steer Prices From Fitted Values of the Exogenous Variables

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	39.02	40.70	-1.68	--	--
1980-2	36.81	40.83	-4.02	40.84	-4.03
1980-3	39.52	34.58	4.94	36.74	2.78
1980-4	35.64	36.61	-0.97	29.78	5.86
1981-1	32.95	35.85	-2.90	36.75	-3.80
1981-2	34.90	34.24	0.66	39.44	-4.54
1981-3	34.01	26.72	7.29	37.91	-3.90
1981-4	30.07	27.96	2.11	32.77	-2.70
Root Mean Square Error		3.72		4.07	
Root Mean Square Percent Error		13.89		11.67	
Mean Absolute Error		3.07		3.94	
Mean Absolute Percent Error		11.13		11.34	
Turning Point Error		.67		.60	

Figure 20 .

ACTUAL AND FORECASTED SLAUGHTER STEER PRICES



higher than found for the one quarter projection, increasing by 28 percent. The percentage error in the one quarter forecasts ranged from 1.9 percent to 21.4 percent with the two quarter forecasts off by 7.0 percent to 16.4 percent. Comparing the forecasted prices from the two quarter projection with actual prices in Figure 20, the predicted prices tracked movements in the actual prices reasonably well over the period. One notices that the forecasted series tended to anticipate turning points over the seven quarters by predicting shifts in the direction of prices one quarter before it actually occurred.

The inclusion of estimated values of the exogenous variables reduced the forecasting performance of the one and two quarter models. The root mean square error statistic for the one quarter model increased from 2.01 to 3.72, with a similar increase in the two quarter model for 2.77 to 4.07. A forecasting procedure that in this case proved superior to the one and two quarter expost price projections using fitted values of the exogenous variables is discussed in Appendix B. However, the models presented here did succeed in projecting prices from data sources readily available and with a forecasting procedure that is easily duplicated by interested parties. This was a primary objective of the research and in this case proved successful.

CHAPTER V

REGIONAL STEER AND COW PRICE ESTIMATES USING A RECURSIVE MODELING TECHNIQUE

The price of Omaha slaughter steers was found to be highly significant in estimating Omaha slaughter cow prices for the same quarter. This strong correlation between animal categories proved valuable in developing a forecasting model for utility cow prices. The price of Omaha slaughter steers was also instrumental in predicting slaughter steer prices in the Northwest (Oregon and Washington), and indirectly, the price of utility cow prices at the Portland, Oregon Auction. Each of these animal classes, at their respective market location, require the forecasted prices of Omaha slaughter steers from the previous chapter as an explanatory variable in developing a one and two quarter price projection. This chapter discusses the results of this exercise.

A. Utility Cow Price Forecasting Model

The autocorrelation model developed to forecast one and two quarter utility cow prices includes a variable for slaughter steer prices and slaughter cow production. The initial specification included production levels of hogs and broilers, but these were found to be statistically insignificant in the model. The same was true when consumer income was included in the model as a exogenous variable. The correlation between these variables and slaughter steer prices was high enough that multicollinearity problems may have been present. The wrong signs on the income and pork production coefficient added further evidence of its presence. Rather than include these variables, it was assumed that the steer price variable represented the sum of their affect on cow prices so they were eliminated.

Slaughter cow production was determined by multiplying federally inspected cow slaughter by average carcass weight for the quarter. This variable was then divided by U.S. population to develop a per capita estimate. The slaughter inventory and carcass weight data were obtained from the U.S.D.A. publication Cattle Slaughter, which also includes an additional cow slaughter series called "commercial cow slaughter". Commercial cow slaughter includes both federally and non-federally inspected slaughter, with the nonfederally inspected inventories estimated as the same percentage of total commercial slaughter (which includes steers, heifers, cows, and bulls) as cow slaughter reported in federally inspected plants.

Because of some uncertainty surrounding the actual level of cow slaughter in nonfederally inspected facilities, the cow slaughter number used in developing the cow price model includes only inventories slaughtered in federally inspected plants as a proxy for total cow slaughter. A description of the variables included in the cow price model, and other models presented in this chapter, is found in Table 8 of the previous chapter.

The negative sign on the cow production coefficient (see Table 22) reflects the price-quantity adjustments along the demand schedule, with an increase (decrease) in slaughter supplies resulting in a decline (increase) in current prices. The positive sign on the steer price coefficient suggests cow and steer prices move together over time, indicating a substitution relationship between the two. Comparing the historical price series for steers and cows in Figures 14 and 15 in Chapter IV, their movements over the past decade appear to be closely correlated.

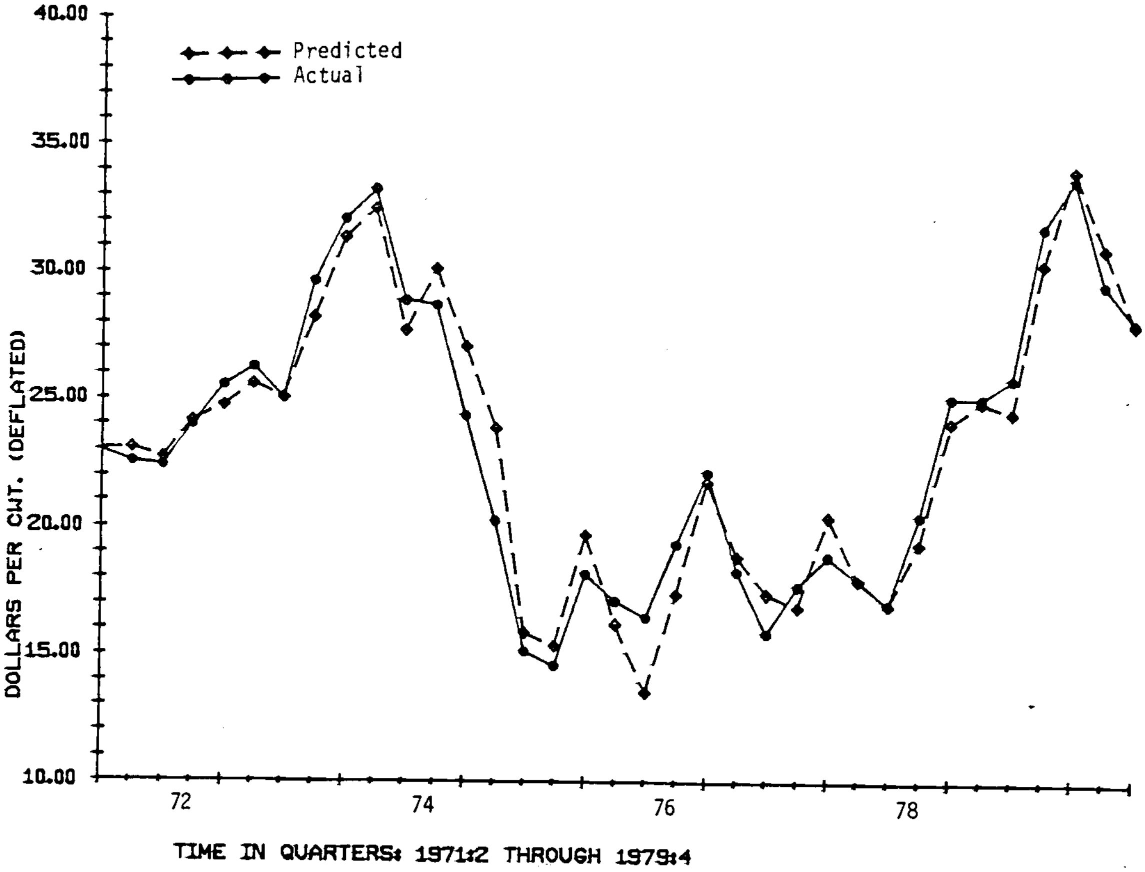
An evaluation of the summary statistics from the cow price model, indicates the presence of serial correlation of the error after a generalized difference technique was applied to the original OLSQ model. When an initial estimation of the model included the other meat production and income variables, this statistic remained approximately the same. It is possible that the cow production levels used in estimating the model coefficients misrepresent actual production because of the use of federal inspected cow slaughter as a proxy for total production. The lack of actual data for this slaughter series is a problem that frequently arises in collecting information for regression analysis. In such cases, the forecaster is limited to selecting data sources that are reliable and representative of the desired variable(s) that are not available.

The mean absolute error, during the 35 quarter estimation period of the utility cow price model, was one dollar with 60 percent of the estimated prices falling below this value. All variables in the model were statistically significant, explaining 75 percent of the total variation in the dependent variable. Actual and fitted prices from the period the model coefficients are estimated from are shown in Figure 21. The estimated prices track the actual deflated series quite well over the base period, correctly matching the majority of turning points that occurred.

Table 22. Slaughter Cow Price Forecasting Model

Variable	Coefficient
intercept	15.0074 (4.60)
cow production	-2.18756 (-5.89)
slaughter steer price (t)	.508835 (7.78)
standard error of regression	1.364
R^2	.767
$\bar{R}^2$	.753
F-Statistic	52.76
Durbin Watson	1.04
Root Mean Square Error	1.304
Theil Statistic	.027
Value of rho	.825

Figure 21.
ACTUAL AND PREDICTED SLAUGHTER COW PRICE



To test the forecasting ability of the model coefficients, actual values of the exogenous variables were used in an ex-post forecast. Eight one quarter projections were obtained using a static simulation, with seven price estimates determined from a dynamic simulation. Both forecasted series shown in Table 23 performed reasonably well outside the base period, with the average absolute error for the one quarter estimates 1.16 dollars and 1.59 dollars for the two quarter dynamic simulation. The two quarter model did a better job of tracking the change in deflated prices during the period, missing only one directional change in price from the previous quarter. While the mean error of the one quarter model was smaller than found in the two quarter projections, the ability to track price movements over the forecast horizon was slightly inferior.

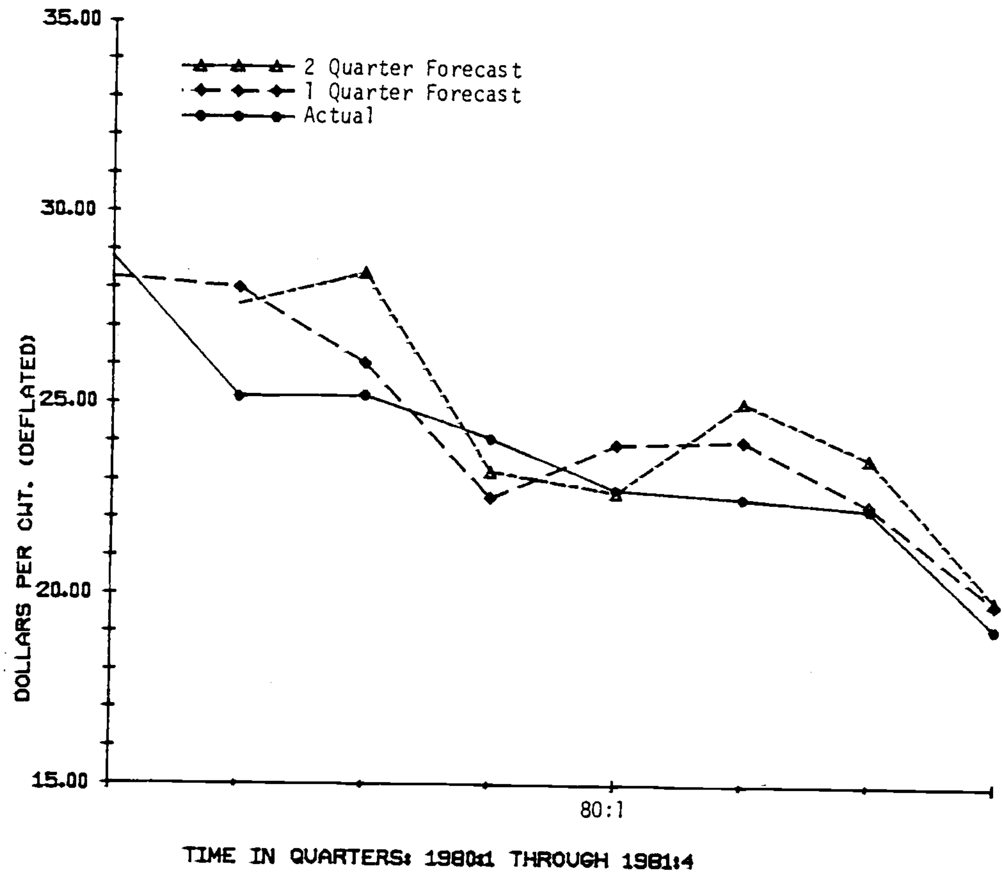
Both the one and two quarter projected prices tend to overestimate the actual series for a majority of the observations (see Figure 22). This characteristic of the models is attributed to the presence of serial correlation of the error between quarters. One of the disadvantages of its presence in the model is that the estimated values tend to be below/above the actual series for several consecutive observations and then overadjust in the opposite direction for several periods.

To evaluate the forecasting performance of the cow price model using predicted values of the exogenous variables, a model was required to project future slaughter cow production levels. The estimated slaughter steer prices, to be included in the model, were already available from the modeling output of the previous chapter.

Table 23. Forecasted Slaughter Cow Prices from a One Quarter Static and Two Quarter Dynamic Ex-post Forecast

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	28.80	28.28	.52		
1980-2	25.14	28.01	-2.87	27.58	-2.44
1980-3	25.19	26.04	-.85	28.41	-3.22
1980-4	24.07	22.53	1.54	23.23	.84
1981-1	22.74	23.95	-1.21	22.68	.06
1981-2	22.54	24.04	-1.50	25.04	-2.50
1981-3	22.25	22.37	-.12	23.60	-1.35
1981-4	19.15	19.81	-.66	19.90	-.75
Root Mean Square Error		1.405		1.915	
Root Mean Square Percent Error		5.82		7.97	
Mean Absolute Error		1.159		1.594	
Mean Absolute Percent Error		4.87		6.76	
Turning Point Error		.67		.40	

Figure 22.
ACTUAL AND FORECASTED SLAUGHTER COW PRICE (I)



B. Cow Production Model: Development and Discussion of Forecast Results

In developing a model to forecast cow slaughter one and two quarters into the future, current and lagged inventories of beef and dairy breeding stock were considered to be important explanatory variables. Unfortunately, the U.S.D.A. publishes cow inventory data biannually at the beginning of the first and third quarters. This presented a problem in specifying a model to project future cow slaughter on a quarterly basis when half the data was missing.

To rectify this situation, at the expense of introducing additional bias to the model coefficients, beef and dairy cow inventories for the second and fourth quarter were estimated by an interpolation process. Taking the published values of the beef and dairy cow inventory for the first and third quarter, the change between these periods was determined with this value then divided by two and added to the smaller of the one or third quarter inventory. The beef and dairy inventory values are lagged two quarters, to insure ample time has been provided to develop second and fourth quarter estimates for use in forecasting future production.

The coefficients in the cow slaughter production model shown in Table 24 were estimated from OLSQ analysis, with the specified variables explaining 87 percent of the total variation in the dependent variable. The positive sign on the beef inventory coefficient is correctly specified, with beef breeding herd inventories a major source of cow slaughter. As mentioned in a previous chapter, the proportion of beef cows culled from the herd remains a relatively con-

Table 24. Cow Slaughter Production Model

Variable	Coefficient
intercept	1832.64 (3.46)
cow inventory:	
dairy (t-2)	-.177481 (-4.29)
beef (t-2)	.037131 (6.38)
feeder steer price (t-2)	-12.6448 (-6.37)
seasonal dummy	
D_2	-111.459 (-3.05)
D_4	133.448 (3.78)
R^2	.89
$\bar{R}^2$	.87
F-value	45.42
Durbin Watson	1.55
Standard Error of regression	85.05
Root Mean Square Error	77.80
Theil Statistic	.041
mean absolute error	58.89

stant percentage of total herd size. By following the adjustments in beef cow inventories in Figure 23 during the years 1971-1979, one observes the trend in beef cow numbers is correlated with movements in federally inspected cow slaughter.

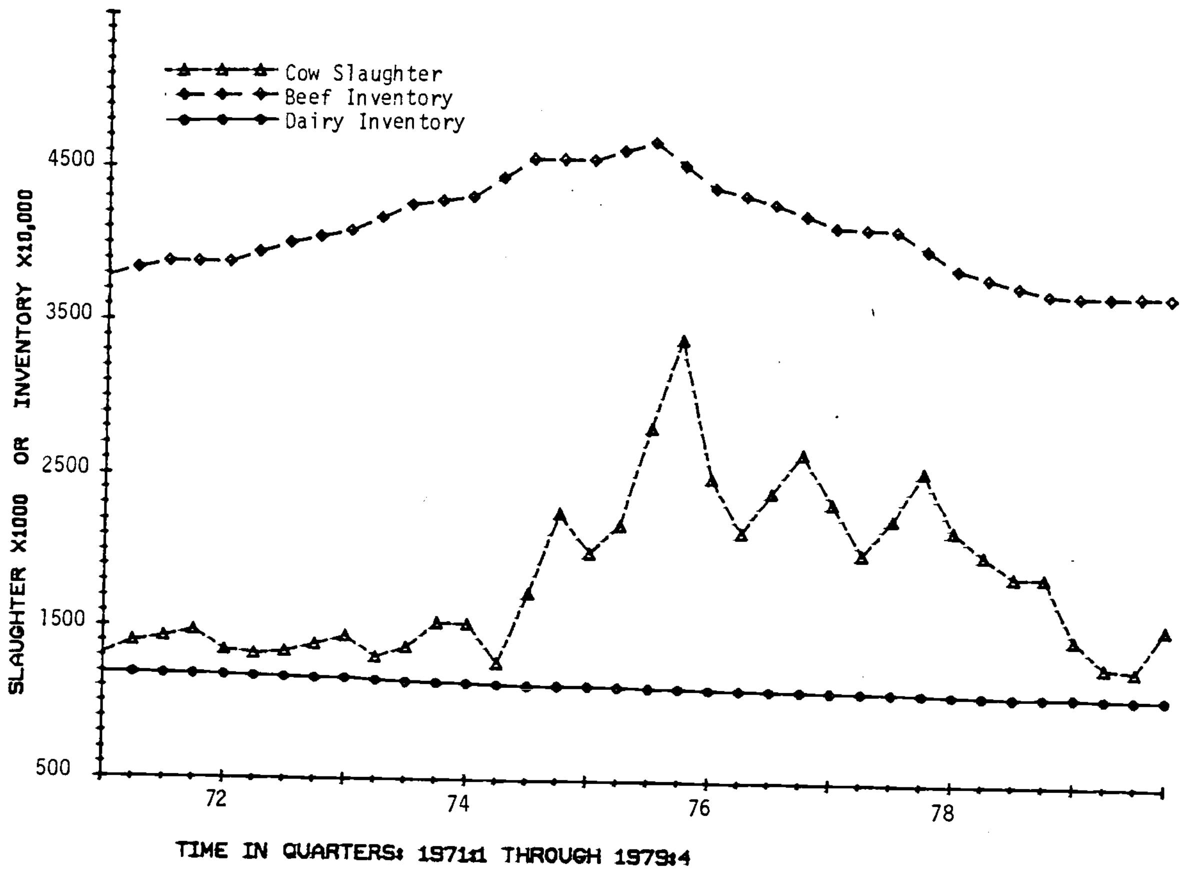
The relationship between changes in animal numbers and slaughter levels is not found in comparing dairy herd inventories with cow slaughter in Figure 23. Dairy herds were reduced by 11 percent during this nine year period at a rate seemingly unrelated to either inventories of beef cow herds or federally inspected cow slaughter. It was assumed that a portion of the dairy stock culled from the herds would be slaughtered at federally inspected facilities so this variable was included in the model. The steady decline in dairy inventories appears to be be the cause of the negative sign on it's coefficient and not an indication of an inverse relationship between cow slaughter and animal inventories in the nation's dairy herds.

The negative sign on the feeder cattle price coefficient represents the reaction of producers to price changes in the feeder market and consequent adjustments in culling strategies for the cow herd. When feeder cattle prices trend higher, more animals are retained in the breeding herd to increase future calf production, thus lowering current slaughter levels. Conversely, a decline in feeder prices brings about diminishing returns to the cow/calf enterprise and an increased incentive to cull marginally productive cows. This variable was lagged two quarters to coincide with cow inventory levels during that quarter.

With all exogenous variables specified with a two quarter lag,

Figure 23.

COW SLAUGHTER COMPARED WITH BEEF AND DAIRY INVEN.



and because the parameters were estimated by an OLSQ regression, only one model was needed to develop both a one and two quarter ex-post static forecast. Unlike previous projections, the values obtained from a two quarter projection are also the next period's one quarter estimate. The forecasted values from this estimation technique are shown in Table 25 along with the summary statistics of the model's performance.

The estimated production tracked the actual series quite well over the eight quarters, where only one turning point was incorrectly estimated by indicating a decline when in fact the values remained unchanged between quarters. The mean absolute error increased from 58.89 to 81.93 in the ex-post forecasted values, with the root mean square error increasing by 20 percent to 93.20. The overall performance of the model was considered acceptable with these cow production estimates retained for use in re-estimating future utility cow prices from fitted values of the exogenous variable.

C. Evaluation of Cow Price Model Using Fitted Values of the Exogenous Variable

The one and two quarter forecasted slaughter steer prices developed in the previous chapter, and the cow production values estimated in this chapter, were introduced as values of the exogenous variables in re-estimating the prices of utility grade cows at Omaha. The price projections from this procedure are shown in Table 26 and Figure 24.

Comparing both quarters fitted price series with actual values

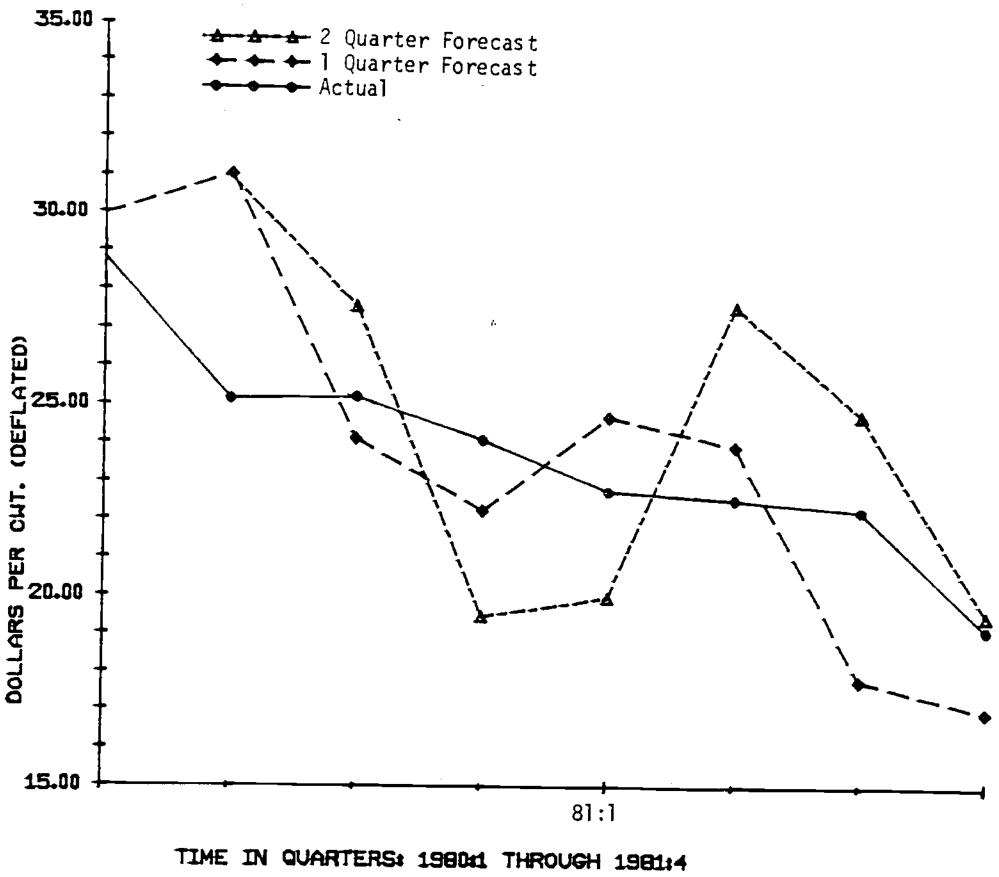
Table 25. Forecasted Slaughter Cow Production from a One and Two Quarter Static Ex-post Forecast

Quarter	Actual Level	One and Two Quarter Static Model	Error
1980-1	722.5	676.5	46
1980-2	672.1	572.1	100
1980-3	761.0	602.6	58.5
1980-4	880.0	960.9	-80.9
1981-1	762.5	839.9	-77.4
1981-2	762.9	741.0	21.9
1981-3	788.4	876.8	-88.4
1981-4	881.3	1064.0	-182
Root Mean Square Error		93.20	
Root Mean Square Percent Error		11.56	
Mean Absolute Error		81.93	
Mean Absolute Percent Error		10.38	
Turning Point Error		.33	

Table 26. Forecasted Slaughter Cow Prices Using Fitted Values of the Exogenous Variables

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	28.80	29.96	-1.16		
1980-2	25.14	31.03	-5.89	30.91	-5.77
1980-3	25.19	24.09	1.10	27.56	-2.37
1980-4	24.07	22.24	1.83	19.47	4.60
1981-1	22.74	24.69	-1.95	19.97	2.77
1981-2	22.54	23.92	-1.38	27.57	-5.03
1981-3	22.25	17.81	4.44	24.74	-2.49
1981-4	19.15	16.99	2.16	19.53	-.38
Root Mean Square Error		2.97		3.77	
Root Mean Square Percent Error		12.64		15.84	
Mean Absolute Error		2.49		3.34	
Mean Absolute Percent Error		10.67		14.16	
Turning Point Error		.50		.60	

Figure 24 .
ACTUAL AND FORECASTED SLAUGHTER COW PRICE (II)



in Figure 24, the one quarter projections appear to follow the trend in deflated prices more closely than the output from the two quarter forecasts. Both period's price estimates reflect the presence of serial correlation in the cow price model by alternately exceeding and then underestimating the actual values. The two quarter projections are worse in this respect, primarily caused by the larger errors in the two quarter forecasted steer prices used in developing these projections. The percentage error from the one quarter forecasts ranged from a low of four percent to a high of 25 percent with the two quarter results similarly two percent and 24 percent respectively. An evaluation of the summary statistics from Table 23 and Table 26 shows the root mean square error for the most recent estimates increased two fold from the previous one and two quarter projections. A similar increase is found when percent root mean squared statistics are compared.

The movement of estimated prices in an alternating pattern first above and then below the actual values is attributed to serial correlation of the error term. A similar pattern is obtained when the one and two quarter estimates from Table 23 are plotted. The inclusion of estimated values of the exogenous variables accentuates this volatility, with the error between actual and fitted prices significantly larger. Unfortunately, this characteristic of the models is carried over to the next phase, which is to develop regional models for the Northwest based on the forecast estimates derived for Omaha slaughter steers and slaughter cows.

D. Development and Evaluation of Regional Price Forecasting Models

The high correlation between Northwest steer and cow prices and the Omaha market made it possible to specify the price equations with only an intercept term and the respective price of either slaughter steers or slaughter cows. The models that resulted from this approach are shown in Table 27. The t-values on the price variables from Omaha were highly significant in explaining the variation in steer and cow prices in Oregon and Washington. The Durbin-Watson statistics for both models indicated the absence of serial correlation when an OLSQ regression was developed.

For the Northwest steer price model, the mean absolute error was 64 cents during the estimation period with the percentage error ranging from .03 percent to 4.35 percent. The percentage error between actual and fitted values for utility cow prices at the Portland Auction ranged between .05 percent and 5.88 percent with a mean absolute error of 55 cents/cwt. The estimated steer and cow prices were extremely accurate in following the trend in deflated prices during the thirty six quarter estimation period. The cow price model correctly specified 97 percent of the turning points in the actual series with the steer price estimates only slightly inferior at 94 percent.

When actual prices from Omaha were included in the regional models for an ex-post forecast, the projected prices of steers and cows in the Northwest continued to closely approximate the actual values. The results from this procedure provided further evidence of the model's satisfactory performance in projecting future prices. The next

Table 27. Regional Models for Forecasting Slaughter Steer and Slaughter Cow Prices

Variable	Coefficients: Steer Price	Coefficients: Cow Price
intercept	.700992 (0.72)	.756572 (1.42)
Omaha Prices:		
slaughter steers	.998339 (36.56)	
utility cows		.951484 (42.50)
standard error of regression	.809	.724
R^2	.975	.982
$\bar{R}^2$	.974	.981
F-Statistic	1336.64	1805.98
Durbin Watson	1.57	1.48
Root Mean Square Error	.787	.703
Theil Statistic	.010	.015

step in evaluating both the steer price and cow price models required the estimated prices of steers and cows from previously estimated one and two quarter forecasts.

Referring to the results from the Northwest slaughter steer price model first, the estimated prices from a one and two quarter static ex-post forecast are shown in Table 28. As expected, these values reflect the errors in the forecasted Omaha steer prices from which they were estimated. It was rather surprising to observe that the summary statistics from the Northwest steer price forecasts indicated a superior fit between actual and projected values than calculated from the original estimates for Omaha steers. The improved performance of the model is shown by the percent root mean square error statistic being 13 percent lower in the Northwest steer price model, with the two quarter projections improving by 4 percent.

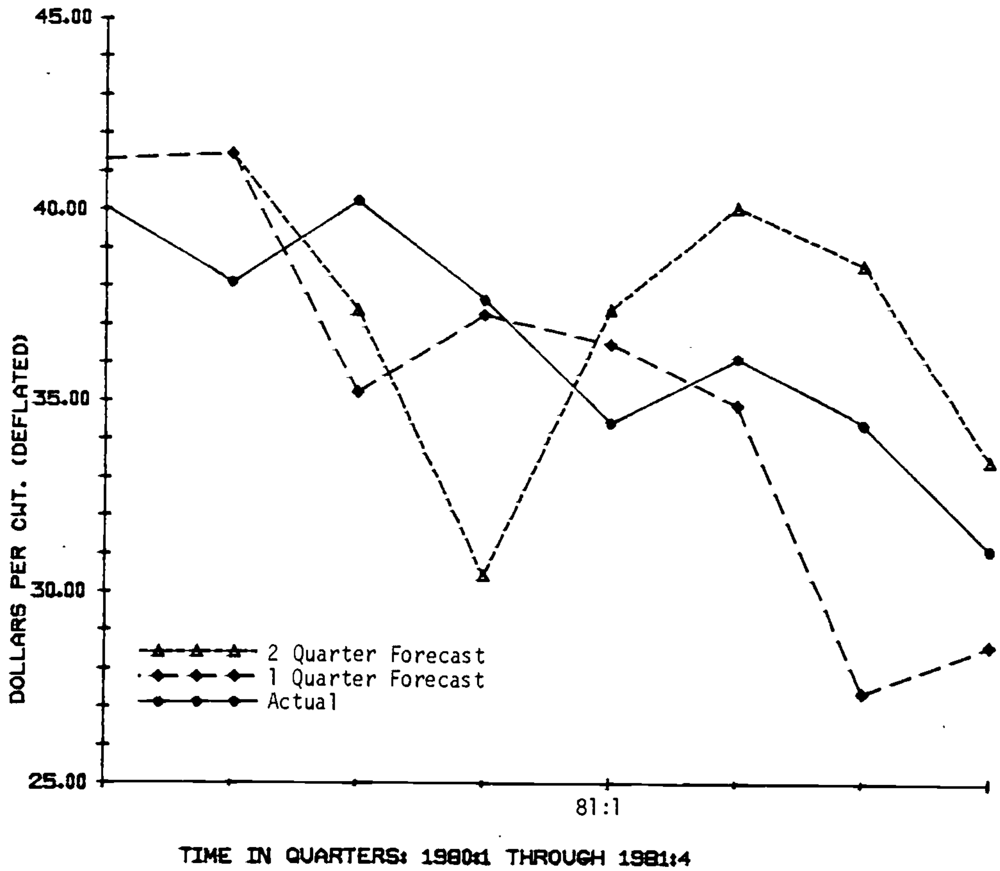
The mean absolute error from the one quarter Northwest steer price projections was 2.85 dollars/cwt., with the percent error between actual and fitted series ranging from 1 percent to 26 percent. The range in percent error in the two quarter estimates at 9 percent to 24 percent was smaller than the one quarter forecasts while the mean absolute error was larger, with a calculated value of 3.54 dollars/cwt.. Comparing both quarter's price estimates with the actual prices in Figure 25, the similarities between these projections and one previously obtained for Omaha steers again becomes apparent. The two quarter estimates from the Northwest model reflect the trend in the deflated prices more accurately than the one quarter projections, al-

Table 28. Forecasted Prices of Northwest Slaughter Steers from a One and Two Quarter Ex-post Forecast

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	40.07	41.33	-1.26		
1980-2	38.09	41.46	-3.37	41.47	-3.38
1980-3	40.24	35.22	5.02	37.38	2.86
1980-4	37.63	37.25	.38	30.43	7.20
1981-1	34.43	36.49	-2.06	37.39	-.90
1981-2	36.10	34.88	1.22	40.08	-3.98
1981-3	34.38	27.38	7.00	38.55	-4.17
1981-4	31.10	28.61	2.49	33.42	-2.32
Root Mean Square Error		3.52		3.98	
Root Mean Square Percent Error		9.82		10.87	
Mean Absolute Error		2.85		3.54	
Mean Absolute Percent Error		7.90		9.76	
Turning Point Error		.67		.60	

Figure 25.

ACTUAL AND FORECAST STEER PRICE IN NORTHWEST



though the variability between the actual and estimated values is greater for a majority of the observations.

The third quarter price projections in 1980 and 1981 from the one quarter model both underestimate the actual price by a large margin. Recalling that the one quarter beef production model in the previous chapter overestimated actual slaughter supplies during these quarters, the error in third quarter steer price estimates is attributed to this mis-specification. Unfortunately, this bias in the model has the potential of continuing in future projections and may require a different specification of third quarter slaughter inventories prior to developing additional forecasts.

The development of the price forecasting models using deflated (real) prices was attempted to reduce the influence of inflation during the past decade, and the statistical problems associated with its presence in the data. As a result, the model coefficients were estimated with the inclusion of price indexes rather than the actual prices. When the forecasted prices from these models are returned to nominal values, by multiplying each quarter's value by the GNP deflator, an additional bias in the estimated series occurs. This procedure is considered essential however since decisions are based on nominal rather than real prices in the market.

With this consideration in mind, the actual and projected prices in Table 28 were transformed to nominal values, using the original and predicted GNP deflator respectively, with the results shown in Table 29. A comparison of the summary statistics from Table 28 and Table 29 shows the latter estimates to be slightly inferior when percent root mean square error statistics are evaluated. This statistical measure

Table 29. Forecasted Prices of Northwest Slaughter Steers in Nominal Values

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	68.60	70.30	-1.70		
1980-2	66.77	72.06	-5.29	72.07	-5.30
1980-3	72.11	62.62	9.49	66.46	5.65
1980-4	69.16	67.68	1.48	55.29	13.87
1981-1	64.76	67.98	-3.22	69.66	-4.90
1981-2	68.99	66.48	2.51	76.39	-7.40
1981-3	67.25	52.98	14.27	74.59	-7.34
1981-4	62.23	56.68	5.55	66.21	-3.98
Root Mean Square Error		6.84		7.56	
Root Mean Square Percent Error		10.09		11.08	
Mean Absolute Error		5.44		6.92	
Mean Absolute Percent Error		8.06		10.20	
Turning Point Error		.33		.60	

of the error component increased by three percent in the one quarter forecasts and two percent for the two quarter projections. The mean absolute error increased to 5.44 dollars/cwt. and 6.92 dollars/cwt. in the one and two quarter estimates respectively.

In defense of the price forecasts developed in this article, they still compare favorably with other commercial forecasts evaluated by Just and Rausser (1981). Their article compares the forecasting performance of five commercial firms with the U.S.D.A. and the Futures Market by comparing root mean square error and percent root mean square error statistics from the forecasted prices for one through four quarters into the future. The percent root mean square error statistic from these seven sources ranged from 9.9 to 12.9 for a one quarter forecast, and 12.4 and 18.9 for a two quarter projection.

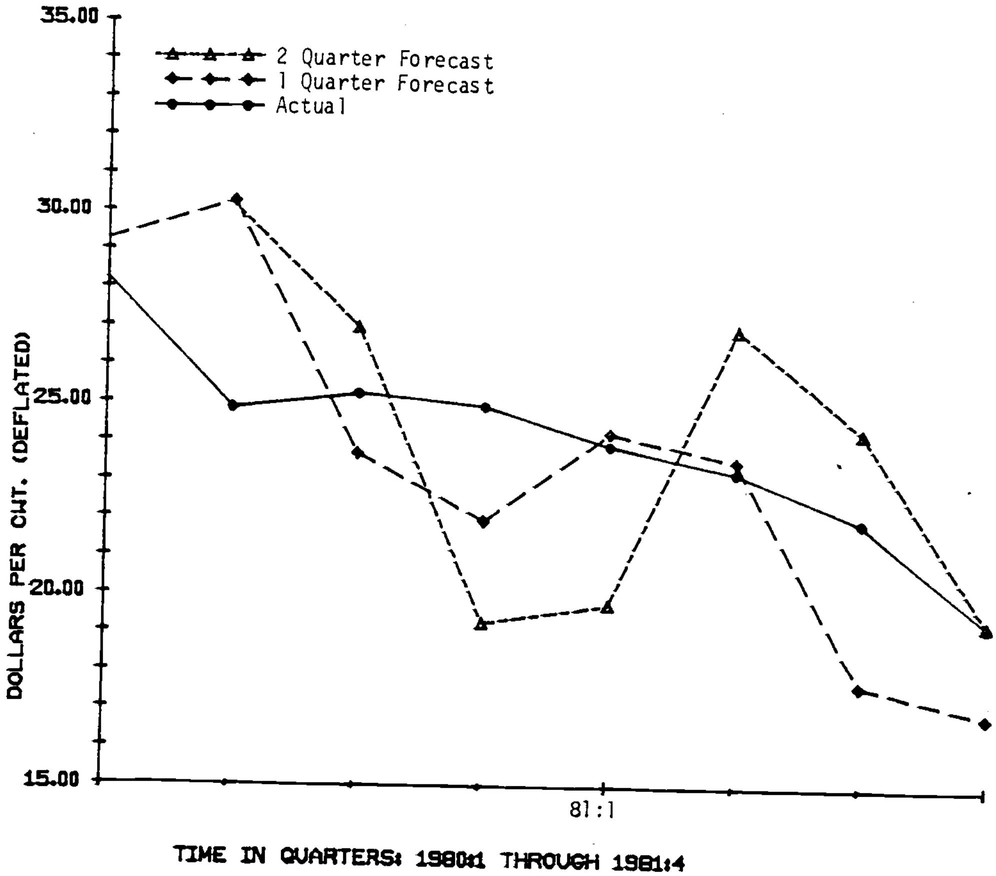
A similar reference was not available in evaluating the performance of the cow price model developed in this study. Turning now to a discussion of the results obtained from this previously discussed modeling process, the one and two quarter forecast estimates for the Portland Auction are shown in Table 30. The Northwest regional price model again proved to be slightly superior in projecting future prices in Portland versus the Omaha cow price model. The mean absolute error for the one quarter estimates declined by 21 cents in the Portland model with a decline of 5 cents noted in the two quarter forecasts.

A comparison of the estimated and actual prices in Figure 26 from the Portland Auction indicates the same trends in price movements as found in Figure 24 for the Omaha market. The superior performance in the Portland cow model appears to be related to the more gradual de-

Table 30. Forecasted Prices of Portland Slaughter Cows from a One and Two Quarter Static Ex-post Forecast

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	28.24	29.26	-1.02		
1980-2	24.85	30.28	-5.43	30.17	-5.32
1980-3	25.24	23.68	1.56	26.98	-1.74
1980-4	24.92	21.92	3.00	19.28	5.64
1981-1	23.91	24.25	-.34	19.76	4.15
1981-2	23.22	23.52	-.30	26.99	-3.77
1981-3	21.93	17.70	4.23	24.30	-2.37
1981-4	19.28	16.92	2.36	19.34	-.06
Root Mean Square Error		2.86		3.78	
Root Mean Square Percent Error		12.24		15.58	
Mean Absolute Error		2.28		3.29	
Mean Absolute Percent Error		9.74		13.66	
Turning Point Error		.50		.60	

Figure 26.
ACTUAL AND FORECAST COW PRICE IN NORTHWEST



cline in actual prices between the third quarter of 1980 and the third quarter of 1981, that allowed a closer fit between the deflated and forecasted series. The inability of either quarter's forecasts to reflect the gradual decline in actual prices is attributed to serial correlation problems in the original Omaha model from which they were estimated. A procedure for correcting this problem has been evasive with no solution readily available. While it is dangerous to anticipate potential errors in the forecast model, the estimated series do appear to follow a pattern in their movements around the actual prices that may be considered in evaluating future projections.

When the forecasted prices for Portland utility cows are returned to nominal values, as shown in Table 31, the average error becomes 4.25 dollars/cwt. in the one quarter projections and six dollars/cwt. in the two quarter estimates. The percentage error between actual and fitted values ranges from 0.4 to 21 and 0.7 to 24 for the one and two quarter projections respectively. The percent root mean square statistic increased by two percent when nominal values were determined for the one quarter forecasts, while the two quarter estimates actually improved by 0.5 percent when this statistical measure was compared with the calculated value from the deflated price series.

In evaluating the overall performance of the Portland utility cow price model as a forecasting tool, both quarter's estimates do reflect the downward trend in prices during the period. The one quarter projections are superior in this respect with half of the estimated values falling within seven percent of the actual price. When the

Table 31. Forecasted Prices of Portland Slaughter Cows in Nominal Values

Quarter	Actual Price	One Quarter Static Model	Error	Two Quarter Dynamic Model	Error
1980-1	48.35	49.77	-1.42		
1980-2	43.56	52.63	-9.07	52.44	-8.88
1980-3	45.23	42.10	3.13	47.97	-2.74
1980-4	45.80	39.83	5.97	35.03	10.77
1981-1	44.97	45.18	-.21	36.81	8.16
1981-2	44.37	44.83	-.46	51.44	-7.07
1981-3	42.90	34.25	8.65	47.02	-4.12
1981-4	38.58	33.52	5.06	38.31	.27
Root Mean Square Error		5.37		6.93	
Root Mean Square Percent Error		12.45		15.50	
Mean Absolute Error		4.25		6.00	
Mean Absolute Percent Error		9.81		13.48	
Turning Point Error		.17		.20	

output from this modeling process is combined with other sources of information, and a little common sense on the part of the forecaster, future production decisions may be made with a smaller degree of uncertainty regarding future price expectations.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Cattle producers in the Pacific Northwest develop production strategies based on the availability of required resources and the anticipated price level when the animals are to be marketed. Inherent to this decision making process is a knowledge of the various factors influencing both biological parameters and economic conditions at a future point in time. The econometric models developed in this study attempt to quantify the economic relationships that affect the price received for the live animal at the farm level.

The demand for beef products was discussed initially at the retail level as a function of consumer income and the farm price of beef and competing meat products. Increases in consumer income in the post World War II period were associated with an increased demand for beef products, although this trend appears to be moderating as satiation levels are reached and income levels continue to expand. Recent declines in the "real" price of pork and broiler products have brought about a reduction in consumer demand for beef products, which in turn is reflected in the demand for live cattle. The farm level or derived demand for live cattle is a function of retail demand for beef products. The marketing margin that separates the producer from the consumer includes all intermediary steps involved in transforming the live animal to the final product purchased by consumers. Through this processing channel, consumer demand response to changing retail prices is transformed back to the farm level, with buyers adjusting the price they are willing to pay for live cattle in responding to the demand for carcass beef.

The current supply of cattle will reflect the anticipated trend in prices and the availability of cattle supplies nearing slaughter weight. Marketing decisions may be adjusted in responding to the current level of demand for live cattle, however, biological constraints on reproduction and rate of growth of cattle on feed prevent significant inventory adjustments in the short run. Under these assumptions, producer response to changing market conditions may be evaluated in the form of various production strategies available in maintaining a profitable enterprise.

A large proportion of the total cattle production comes from feedlot operations. Within this environment, marketing strategies may be anticipated in developing future slaughter projections. Producers are thought to respond to changing cattle prices by feeding animals to heavier weights when prices trend higher, or marketing animals at a lighter than usual weight when prices move lower. This response will depend on future price expectations, where the opposite marketing response may in fact occur if the current trend in prices is expected to reverse soon.

The price of feed grains also plays a role in the production and marketing strategies of the cattle producer. The number of animals placed on feed and their placement weight are partially determined by the costs incurred in grain feeding these animals. At the other end of the production scheme, grain prices influence the time and weight at which animals are slaughtered. The resulting animal carcass composition will have a significant influence on the total production of the various quality grades of beef.

The supply and demand relationships at the feedlot level are included in models that represent the market conditions that determine price levels. The estimated model coefficients represent the individual influence of each explanatory variable on the price of slaughter steers for the quarter. A necessary condition of this price formulation process was that current supply and demand levels determined current prices. Therefore, when future prices were to be forecasted, future values of the variables in the model were also required to complete the procedure.

The specification of the variables to be included in the steer price model was accomplished first, with separate models then developed to project future values of these independent variables. Once estimated, these values were then returned to the steer price equation to develop a price projection for the quarter.

The slaughter steer prices estimated in this procedure were developed to reflect the fluctuations in the Omaha market. This particular location was selected as representative of trends in supplies and prices that are important when aggregated data for the U.S. is used in estimating price projections. The same reasoning was employed in developing a model to forecast utility cow prices. As noted in the text, the price of Omaha slaughter steers and slaughter cows tracked the historical prices of these same animal categories in the Pacific Northwest quite closely. This characteristic of the two regions was specified in the Northwest steer and cow price models by including the

Omaha price for the quarter as the determinant of prices in Oregon and Washington. The forecasted prices from the one and two quarter Omaha models were then used in estimating future Northwest prices.

A distinct advantage of this price forecasting procedure is the amount and type of information gained in developing the price projection. Current information on cattle inventories on feed and similar supplies in the hog and broiler sector are ascertained in addition to recent prices of these animal classes. Keeping abreast of developments in the various sectors of the meat industry provides an insight to potential adjustments in the hog and broiler industries that directly influence the price received for live cattle. The knowledge gained, in this respect, is essential in developing production strategies to maximize profits or minimize losses.

An additional advantage of this forecasting procedure is that it provides a method of checking the estimated values at the conclusion of each step. If the projected value does not appear to reflect the change occurring in the variables specified in the model, potential causes of the error may be investigated. This procedure requires some judgement on the part of the forecaster, but this involvement in the interpretation and evaluation of model estimates is considered imperative prior to accepting the results. In this regard, the author stresses the importance of <u>not</u> taking a "black box" approach to developing the one and two quarter price projection.

There are deficiencies in the models that were attributed to statistical problems in the data and the regression procedure. However, these problems are not considered insurmountable in developing price projections. The steer prices estimated in this study for the Northwest compared favorably with forecasted prices from seven other sources evaluated by Just and Rausser (1981). Using the percent root mean square error statistic as a method of comparison, the values from their study ranged between 9.9 and 12.9 for a one quarter forecast, and 12.4 and 18.9 for a two quarter projection. The percent root mean square error calculated for Northwest steer price forecasts was 10.09 for the one quarter estimates and 11.08 for the two quarter projection. These results proved promising. This model may be used advantageously in reducing the uncertainty of future price levels in the live cattle market.

As a final note, the author learned recently that the U.S.D.A. was changing their inventory of cattle on feed to a thirteen state survey. Unfortunately, this will require a respecification of the beef production models prior to developing additional forecasts. However, it also provides an incentive to re-evaluate the various models previously developed as new information becomes available.

BIBLIOGRAPHY

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

2. Barksdale, H. C.; J. E. Hilliard; and M. C. Ahlund. "A Cross-Spectral Analysis of Beef Prices." American Journal of Agricultural Economics, 57 (1975): 309-315.

3. Bessler, David A., and Jon A. Brandt. Composite Forecasting of Livestock Prices: An Analysis of Combining Alternative Forecast-Methods. Purdue University, Agricultural Experiment Station, Bulletin No. 265, December 1979.

4. Brandow, G. E. Interrelationships Among Demands for Farm Products and Implications for Control of Market Supply. Pennsylvania Agricultural Experiment Station, Bulletin No. 680, 1961.

5. Breimyer, H. F. Demand and Prices for Meat. U. S. Department of Agriculture, Economic Research Service Technical Bulletin No. 1253, 1961.

6. Chen, Dean T. "The Wharton Agricultural Model: Structure, Specification, and Some Simulation Results." American Journal of Agricultural Economics, 59 (1977): 107-116.

7. Crom, R. A Dynamic Price-Output Model of the Beef and Pork Sectors. U. S. Department of Agriculture, Economic Research Service Technical Bulletin No. 1426, 1970.

8. Cromarty, William A., and Walter M. Myers. "Needed Improvements in Application of Models for Agricultural Commodity Price Forecasting." American Journal of Agricultural Economics, 57 (1975): 172-177.

9. Dalrymple, D. G. On the Nature of Marketing Margins. Michigan Agricultural Experiment Station, Agricultural Economic Report, No. 824, 1961.

10. Ehrich, R. L. Economic Analysis of the United States Beef Cattle Cycle. University of Wyoming, Agricultural Experiment Station, Scientific Monogram, No. 1, April 1966.

11. Elam, Thomas E. "Canadian Supply Functions for Livestock and Meat: Comment." American Journal of Agricultural Economics, 57 (1975): 364-365.

12. Folwell, Raymond J., and Hosein Shapouri. An Econometric Analysis of the U. S. Beef Sector. Washington State University, Technical Bulletin No. 89, September 1977.

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

14. Freebairn, J. W., and Gordon C. Rausser. "Effects of Changes in the Level of U. S. Beef Imports." American Journal of Agricultural Economics, 57 (1975): 676-688.

15. George, P. S., and G. A. Kings. Consumer Demand for Food Commodities in the United States with Projections for 1980. Giannini Foundation Monogram No. 26, 1971.

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

17. Hein, Dale. "Price Determination Process for Agricultural Sector Models." American Journal of Agricultural Economics, 59 (1977): 126-132.

18. Intriligator, Michael D. Econometric Models, Techniques, and Applications. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1978.

19. Jarvis, Lovell S. "Cattle as Capital Goods and Ranchers as Portfolio Managers: An Application to the Argentine Cattle Sector." Journal of Political Economics, 82 (1974): 489-520.

20. Just, Richard E., and Gordon C. Rausser. "Commodity Price Forecasting with Large-Scale Econometric Models and the Futures Market." American Journal of Agricultural Economics, 63 (1981): 197-208.

21. Keith, Kendall, and Wayne D. Purcell. "Possible Implications of Voids in U. S. D. A. Cattle Slaughter Data." American Journal of Agricultrual Economics, 58 (1976): 568-571.

22. Kennedy, Peter. A Guide to Econometrics. The MIT Press, Cambridge, Massachusets, 1979.

23. Kenyon, David E. Quarterly Broiler Price Forecasting Models. Virginia Polytechnic Institute and State University, Research Report, October 1981.

24. Kulshreshtha, S. N. "An Analysis of Canadian Cattle Supply Using Polynomial Distributed Lags." Canadian Journal of Agricultural Economics, 24 (1976): 1-14.

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

26. McCoy, J. Livestock and Meat Marketing. Westport, Connecticut: Avi Publishing Co., 1979.

27. Martin, Larry J., and Richard Haack. "Beef Supply Response in North America." Canadian Journal of Agricultural Economics, 25 (1977): 29-47.

28. Myers, Lester H., and Joseph Havlicek, Jr. "Some Theoretical Aspects of Short-Term Hog Supply." Journal of Farm Economics, 49 (1967): 1395-1405.

29. Nelson, Glenn, and Thomas Spreen. "Monthly Steer and Heifer Supply." American Journal of Agricultural Economics, 60 (1978): 117.-125.

30. Nerlove, Marc. "The Dynamics of Supply: Restrospect and Prospects." American Journal of Agricultural Economics, 61 (1979): 874-887.

31. Ospina, Enrique, and C. Richard Shumway. Disaggregated Econometric Analysis of U. S. Slaughter Beef Supply. Texas A. & M. University, Agricultural Experiment Station, Technical Monogram No. 9, 1979.

32. Pindyck, Robert S., and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts. McGraw-Hill Book Company, 1981.

33. Purcell, Wayne. Agricultural Marketing: Systems, Coordination, Cash, and Futures Prices. Reston Publishing Co., Inc., Reston, Virginia, 1979.

34. Reutlinger, Sholomo. "Short Run Beef Supply Response." American Journal of Agricultural Economics, 48 (1966): 909-919.

35. Shepard, G. S.; G. A. Futrell; and J. R. Strain. Marketing Farm Products. Iowa State University Press, 1976.

36. Shuib, A. B., and D. J. Menkhaus. "An Econometric Analysis of the Beef-Feed Grain Economy." Western Journal of Agricultural Economics, 1 (1977): 152-156.

37. Talpaz, Hovav. "Multi-Frequency Cobweb Model: Decomposition of the Hog Cycles." American Journal of Agricultural Economics, 56 (1974): 38-49.

38. Tomek, William G., and Kenneth L. Robinson. Agricultural Product Prices. Cornell University Press, 1972.

39. Trapp, James N. "Forecasting Short-Run Fed Beef Supplies with Estimated Data." American Journal of Agricultural Economics, 63 (1981): 457-465.

40. Trierweiller, John E., and James R. Hassler. "Measuring Efficiency in the Beef-Pork Sector by Price Analysis." Agricultural Economics Research, 23(1971): 11-17.

41. Tryphos, P., and N. Tryphonopoulos. "Consumer Demand for Meat in Canada." American Journal of Agicultural Economics, 55(1973): 647-52.

42. Tryphos, Peter. "Canadian Supply Functions for Livestock and Meat." American Journal of Agricultural Economics, 56 (1974): 107-113.

43. Uvacek, Edward. " A New Look at Demand Analysis for Beef." American Journal of Agricultural Economics, 50 (1968): 1501-1506.

44. U. S. Department of Agriculture, ESCS. Cattle on Feed. Washington, D. C., selected issues, 1971-1981.

45. U. S. Department of Agriculture, ESCS. Feed Grain Situation. ERS, Commodity Economics Division, Washington, D. C., bimonthly.

46. ______________. SRS. Eggs, Chickens and Turkeys. Washington, D.C., selected issues, 1971-1981.

47. ______________. SRS. Hogs and Pigs. Washington, D.C., selected issues, 1971-1981.

48. ______________. ERS. Livestock and Meat Situation. Washington, D.C., selected issues, 1971-1981.

49. ______________. ERS. Poultry and Egg Situation. Washington, D.C., selected issues, 1971-1981.

50. Waugh, F. Demand and Price Analysis. U.S. Department of Agriculture, ERS., Technical Bulletin No. 1316, November 1964.

APPENDIX

Appendix A [b/]

Summary of Statistical Tests

P = predicted value

A = actual value

T = number of observations

Root Mean Square Error:

$$\sqrt{\frac{1}{T}\sum_{t=1}^{T}(P_t - A_t)^2}$$

Root Mean Square Percent Error:

$$\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{P_t - A_t}{A_t}\right)^2}$$

Mean Absolute Error:

$$\left|\frac{1}{T}\sum_{t=1}^{T}(P_t - A_t)\right|$$

Mean Absolute Percent Error:

$$\left|\frac{1}{T}\sum_{t=1}^{T}\frac{P_t - A_t}{A_t}\right|$$

[b/] Source: Pindyck and Rubinfeld, pp.362-65.

Theil's Statistic:

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(P_t - A_t)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(P_t)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}(A_t)^2}}$$

Durbin Watson Statistic:

$$DW = \frac{\sum_{t=2}^{T}(\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2}{\sum_{t=1}^{T}\hat{\varepsilon}_t^2}$$

Appendix B

A price forecasting technique that is relatively simple to develop for a one and two quarter price projection is the naive approach. In this case, the current price is used as the price level in the next quarter and two quarters into the future. As noted in the two tables that follow, the naive approach can be a reliable method of projecting future prices within an acceptable range of the actual value in the short run. The forecasted prices from the naive approach are superior to the price forecasts using fitted values of the exogenous variables, as indicated by a comparison of the summary statistics at the bottom of the tables.

Two Quarter Slaughter Steer
Price Projection

Quarter	Actual	Forecast[1/]	Forecast[2/]	Forecast[3/]
1980-2	36.81	37.72	40.84	39.10
1980-3	39.52	38.28	36.74	39.02
1980-4	35.64	35.22	29.78	36.81
1981-1	32.95	37.59	36.75	39.52
1981-2	34.90	38.70	39.44	35.64
1981-3	34.01	36.91	37.91	32.95
1981-4	30.07	32.72	32.77	34.90
Root Mean Square Error		2.77	4.07	3.27
Root Mean Square Percent Error		8.32	11.67	10.15
Mean Absolute Error		2.35	3.94	2.45
Mean Absolute Percent Error		6.97	11.34	7.43
Turning Point Error		.40	.60	.40

1/ Actual values of exogenous variables included in steer price forecasting model.

2/ Fitted values of exogenous variables included in steer price forecasting model.

3/ Naive forecast using the actual price from two quarters previously.

One Quarter Slaughter Steer
Price Projection

Quarter	Actual	Forecast[1/]	Forecast[2/]	Forecast[3/]
1980-1	39.02	42.17	40.70	39.10
1980-2	36.81	37.71	40.83	39.02
1980-3	39.52	37.40	34.58	36.81
1980-4	35.64	37.38	36.61	39.52
1981-1	32.95	35.90	35.85	35.64
1981-2	34.90	35.84	34.24	32.95
1981-3	34.01	36.00	26.72	34.90
1981-4	30.07	30.79	27.96	34.01
Root Mean Square Error		2.01	3.72	2.61
Root Mean Square Percent Error		5.60	13.89	7.73
Mean Absolute Error		1.81	3.07	2.29
Mean Absolute Percent Error		5.08	11.13	6.67
Turning Point Error		.67	.60	.67

1/ Actual values of exogenous variables included in steer price forecasting model.

2/ Fitted values of exogenous variables included in steer price forecasting model.

3/ Naive forecast using the previous quarters actual price.