1982

Monthly cattle supply and price forecasting models

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Monthly cattle supply and price

forecasting models

by

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A Thesis Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

Department: Economics

Major: Agricultural Economics

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Iowa State University
Ames, Iowa

1982

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CHAPTER I

INTRODUCTION

The general topic of forecasting beef and/or cattle prices has been the subject of considerable research over the years, primarily because of its potential usefulness to producers, processors, and retailers. Reliable price estimates can be extremely valuable to producers, meat packers, food retailers, and the food service industry.

A majority of previous research has focused on explaining or forecasting annual average price behavior. However, many production decisions are made in a six-month time frame; in many cases even quarterly estimates have limited usefulness. For instance, as much as 10% of the cattle slaughtered each quarter are placed on feed at heavy weights and marketed within three months. While annual forecasts are important to the producer for identifying years when cattle feeding may be profitable, accurate monthly forecasts are useful in determining the optimum months within the year to place and market cattle. An individual producer may believe he can increase his returns by holding cattle an additional month, but may be hesitant to do so because of uncertainty about prices. An accurate price forecast can aid in this decision, helping to avoid costly mistakes.

Packers can use accurate monthly forecasts in planning purchases to keep their costs lower. Packer buyers may change their buying strategies substantially in response to forecasts of significantly higher or lower prices in the upcoming months. For instance, a plant buyer aware of a likely uptrend in prices may contract for cattle several days or weeks in advance, but avoid forward commitments when prices are expected to decline.

This information can be useful to retailers as well. A supermarket manager planning to purchase large quantities of beef for a hamburger special in two or three weeks might revise his plans if he knew that cattle and beef prices would be increasing rapidly before his purchase price could be established.

Short-run price movements affect decisions made throughout the entire beef marketing system. A system for accurately estimating monthly prices as far as six months into the future would be valuable to many market participants.

Previous Studies

Through the years many economists have studied supply, demand, and price relationships for the livestock sector. Studies by Waugh (1964), Fox (1953), Brandow (1961), George and King (1971), and Hassan and Johnson (1976) have examined meat product relationships as part of a general study of food demand and supply. Working (1954) and Breimyer (1961) examined demand for meat products in more detail.

Analyses of complete systems of annual beef supply, demand, and price relationships have been done by Reutlinger (1966), Langmeier and Thompson (1967), Hunt (1972), Houck (1974), Freebairn and Rausser (1975), Walters, Moore, and Neghassi (1975), Folwell and Shapouri (1977), and numerous others. Most of these models were developed to investigate the price impact of beef imports, not for forecasting prices. Hein, Kite, and Matthews (1976) outlined an annual supply, demand, and price model of the beef, pork, and poultry sectors which the USDA has used in intermediate and long-term outlook applications.

Ikerd (1981) chose to forecast beef prices using a different approach. Utilizing annual data, he estimated total meat demand and a composite meat price, from which he derived separate beef, pork, and chicken prices.

Early short-term models also dealt primarily with structural supply and demand relationships. Tomek and Cochran (1962), Logan and Boles (1962), Tomek (1965), and Fuller and Ladd (1961) all estimated livestock demand and supply elasticities and responses utilizing quarterly data. While Maki (1963) did develop a semi-annual price and supply forecasting model for cattle and hogs, one of the few quarterly forecasting models of the 1960s was estimated by Craddock (1966).

The first paper dealing with monthly cattle price forecasting of any significance was the 1970 research bulletin, Short-Run Livestock Price Prediction Models by Hayenga and Hacklander. Prior to this time few, if any, studies focused on this topic. Hayenga and Hacklander estimated supply and demand equations for both cattle and hogs using 1962-68 data. In this study, production was considered exogenous to the demand model, since short-run cattle supplies were assumed to be predetermined within a month. Thus, ordinary least squares estimation was appropriate. Choice cattle prices were estimated as a function of beef production per working day in the month, pork production per working day, per capita income, percent cow slaughter, and cold storage pork holdings. One of the more important findings of the Hayenga-Hacklander study was the usefulness of including the number of packers' slaughter working days in the month when estimating monthly slaughter-price relationships. Beef production was predicted using quarterly USDA 23-state reports of cattle on feed. Fits were fairly good throughout, with most R^2 values ranging from .77 to .94. However, test period forecasting results indicated there was still room for improvement, particularly in the supply models.

Hayenga and Hacklander (1970) also explored the possibility of short-term beef and pork prices being simultaneously determined with production. Fits were generally good in this system of equations also, but evidence for simultaneity did not appear strong. In the supply models, price levels were not found to significantly affect slaughter. However, the change in price levels did appear to have a significant explanatory effect, suggesting that while beef supplies are largely predetermined, the exact time an animal is marketed may be influenced by recent price movements.

Throughout the remainder of the '70s quarterly livestock models received a good deal more attention than monthly models. Crom (1970), Rahn (1973), Mann, Rahn, Futrell, Paulsen, and Ladd (1975), Kamal-Abdou (1975), Kulshreshtha (1975), Woods (1975), Leuthold and Nwagbo (1977), Handke and Futrell (1978), and Arzac and Wilkinson (1979) all estimated quarterly livestock supply and demand models. Many of these studies utilized much of the same methodology used by Hayenga and Hacklander. For example, Handke and Futrell (1978) estimated quarterly models which were very similar in many respects, though there were differences in their approach. Rather than directly estimating total beef production from cattle on feed data, they chose to estimate fed, non-fed, cow, and bull slaughter individually. Also, separate cow slaughter equations were estimated for accumulation and liquidation phases of the cattle cycle. Another interesting aspect of their study was the use of the "flexibility" method for forecasting prices, i.e. multiplying expected percentage changes in production and income (versus year-ago levels) by their respective price impacts to arrive at the expected percentage change in price.

Nelson and Spreen (1978) estimated monthly steer and heifer slaughter using quarterly cattle on feed data and placement figures, the number of working days, and a price trend variable, which was the unique part of their research. Three sets of price trend dummy variables were used in combination with price differences to capture the supply response which results when producer expectations are based upon extrapolated price trends. While these variables were marginally significant (at best) in most of the equations, their results indicated that commercial slaughter had a weak positive relationship with recent price "trends" of one to two months length. If the price trend continued into a third month, slaughter levels typically exhibited a negative relationship in that month.

Hoffman (1979) developed an extensive monthly model for the U.S. livestock industry, which included fifty-four behavioral equations and 13 identities. As Handke and Futrell did, he chose to estimate individual slaughter components separately, but also estimated fed and non-fed beef production as well. His entire system of forecasting beef production was considerably more complicated and thorough than any previous attempts.

Other recent research developments in this area include

Trapp's (1981) use of estimated placement weight and growth rate data (estimated using optimal control techniques) to improve fed beef supply forecasts, and the integration of time-series and regression models by Spriggs, Kulshreshtha, and Akinfemiwa (1981) in forecasting Canadian cattle prices.

Research Objectives

The primary objective of this study is to develop a relatively accurate, simple, and easy to use system for forecasting monthly cattle prices. The complete set of objectives is as follows:

1. Determine the principal supply and demand factors affecting monthly cattle prices during 1970-79.

2. Compare the impact of the factors influencing prices during the 1960s and the 1970s.

3. Develop price forecasting models which are more accurate than those of the past, but which vary in complexity and ease of use.

4. Develop a cattle supply forecasting model for estimating commercial beef production that is relatively simple, but accurate.

5. On a preliminary basis, test and evaluate the accuracy and usefulness of these supply and price forecasting models during 1980-81.

Research Procedures

1. Estimate the impact of beef production, pork production, income, and other demand shifters on the monthly average choice steer price at Omaha, utilizing 1970-79 monthly data and ordinary least squares multiple regression.

2. Using ordinary least squares regression procedures, estimate the relationship between available USDA cattle inventory data and subsequent monthly slaughter for fed steers and heifers, non-fed steers and heifers, and cows and bulls as far as six months into the future.

a) Estimate the relationship between monthly fed steer and heifer slaughter, quarterly USDA 23-state cattle on feed data, and monthly USDA 7-state feedlot placements during 1970-79. Develop separate models for each forecast month following the release of the *Cattle on Feed* reports.

b) Estimate the relationship between monthly non-fed steer and heifer slaughter, quarterly USDA feeder cattle supply data, and range conditions.

c) Estimate the relationship between monthly cow and bull slaughter levels, semi-annual USDA cow herd and bull inventory data, and reported beef cow replacements.

3. Estimate the relationship between monthly commercial beef production (in pounds) and the number of head slaughtered in several classes of cattle (fed steers

and heifers, non-fed steers and heifers, and cows and bulls) during 1970-79, using ordinary least squares estimation.

4. Evaluate the usefulness of these cattle supply and price relationships in forecasting applications for 1980-81.

a) Calculate the average residual, average absolute residual, and the standard deviation of the forecast errors for each individual supply and price model, using known levels of explanatory variables for 1980-81.

b) Determine the accuracy of the cattle price model for making one to six month price forecasts, using predicted beef production figures and known levels of all other explanatory variables for 1980-81.

CHAPTER II

PRICE MODELS

Model Specification

The primary purpose of this study was to identify the key factors affecting monthly cattle prices during the 1970s, and use this information to forecast prices in upcoming years. The objective was to formulate relatively accurate models varying in complexity to match differing abilities and time constraints of potential users. Simple models containing only a few explanatory variables were estimated for making relatively fast and reasonably accurate forecasts. These models are primarily intended to be used by producers or other individuals who are inexperienced or want to spend less time in developing forecasts. More complex models were developed for more knowledgable users who are willing and able to spend the extra time needed to acquire more market information and incorporate it into forecasting procedures that could potentially provide greater forecasting accuracy.

The analytical framework of this portion of the study is an evolution of the approach used by Hayenga and Hacklander (1970). The general model relates the steer price to a variety of demand and supply influences:

Steer price = f(Beef Prod./Workday, Pork Prod./Workday, Broiler Prod./Workday, Income, Other supply and demand influences, Monthly dummy variables)

The dependent variable is the choice steer price at Omaha (CSP), a terminal market price which serves as a good indicator of price movements throughout most of the country, though other market prices might differ by the relevant transportation cost differential.

Since beef cold storage is typically small, nearly all beef produced is consumed within a relatively short time span. For this to happen, prices must adjust to clear the market. Therefore, commercial beef production (BQ) should serve as the key supply factor influencing price behavior. As production rises packers must accept lower prices from wholesalers and retailers in order to move the additional quantities; as a result, lower prices are passed back to the producer. Thus, we would expect beef production to be inversely related to steer prices. Pork production (PQ) and broiler production (BRQ) are hypothesized to be substitute goods, and have a negative impact upon steer prices. As the supply of these competing goods declines their prices should rise, which in turn should have a positive effect upon steer prices. Personal or disposable personal income (PY or DPI) is expected to have a positive impact on beef demand and choice steer prices. Monthly intercept shifters are included to capture the price effect of any seasonal influences, such as temperatures or holidays.

In addition to these key supply and demand variables, a variety of other explanatory variables were examined. The expected signs (in parentheses) and the rationale for the likely price influence of each variable, are shown below. The symbols in parentheses are used to identify these variables in tables throughout this chapter. Table 2.1 contains the complete definitions and sources for all of these variables.

U.S. civilian population (POP) (+)

The more mouths to feed, the more demand for all food products, including beef.

Number of women working (WWF) (-)

As women spend more time outside the home, less time is left for meal preparation. Demand for highly processed foods (which compete against beef) increases and the demand for beef declines.

Unemployment rate (UR) (-)

Unemployed individuals should tend to reduce expenditures on more expensive food items such as beef in an effort to make ends meet.

Consumer expenditures in restaurants (CER) (?)

At first glance one would think that spending in restaurants would have a positive impact upon beef consumption and cattle prices. However, it may be that restaurant customers eat less beef than at home since the meal price includes the cost of services provided. Also, when consumers eat away from home they may tend to order dishes normally not prepared at home (such as seafood), in which case the effect may be negative.

Percent fed cattle slaughter (CPFQ) (-)

Given the total slaughter volume, the increased (relative) supply of high grade grain-fed beef should exert downward pressure on choice steer prices.

Price index (CPI or IPD) (+)

When the prices of competing goods rise, the demand curve for beef shifts upward and cattle prices should increase.

Net beef and veal imports (NBVIM) (-)

The beef production variable specified in the general model does not include imports. As net imports rise, total beef supplies will also increase, and prices should decline.

Food program expenditures (FPE or STAMP) (+)

Federal food program expenditures, which include such items as food stamps, should have a positive effect on cattle prices since they are a form of income which must be used for food purchases by consumers who have a relatively high income elasticity for beef.

Meat packing wage rate (WRMP) (-)

Higher meat packing wage rates raise processing costs and marketing margins. Wider margins should place downward pressure on cattle prices.

Interest rates (PR or IR) (-)

Consumers may tend to lower expenditures for more expensive food items such as beef to keep up with rising loan payments. Also, interest charges are a cost of doing business for meat packers, food retailers, etc. Higher interest rates may increase the marketing margin and depress cattle prices.

Cold storage stocks of pork (PSB) (-)

Higher frozen pork inventories exert downward pressure on pork prices; as a result, beef demand may also decline.

Percent cow slaughter (PCS) (+)

As the portion of federally inspected cattle slaughter made up of cows increases, the number of carcasses reaching the choice grade should decline. Thus, percent cow slaughter should have a positive impact upon choice steer prices.

Equations were estimated using 1970-79 monthly data and multiple regression techniques. As in the Hayenga and Hacklander study (1970), all explanatory variables were regarded as predetermined in the short-run and assumed to be exogenous to the model. Thus, the ordinary least squares estimation technique is appropriate. Most of the equations were estimated in the log-log format in order to directly estimate the price flexibilities or the percentage price impacts of the independent variables in the model. When formulated in this manner, the estimated slope coefficients are easily interpreted as the percentage change in the cattle price associated with a one percent change in each independent variable. To simplify matters the simple, complex, and autoregressive price models are presented first, followed by a discussion of each model's performance in explaining cattle price behavior during 1970-79.

Table 2.1

Variable Definitions and Sources

CSP	Choice steer price in Omaha, monthly average, 900-1100 pounds, $/cwt. Sources: Livestock and Meat Situation Livestock Meat and Wool Market News
BQ	Total U.S. commercial beef production in the month, millions of pounds, carcass weight. Source: Livestock Slaughter
PQ	Total U.S. commercial pork production in the month, millions of pounds, carcass weight. Source: Livestock Slaughter
BRQ	Total federally inspected broiler production in the month, millions of pounds. Sources: Poultry Slaughter Poultry and Egg Situation
Workdays	Number of full slaughter days in the month. Normal weekdays = 1, weekday holidays = 1/2, Saturdays = 1/3, Saturday holidays and Sundays = 0.
PY	Total U.S. personal income (before taxes), annual rate in billions of dollars, seasonally adjusted. Sources: Survey of Current Business Economic Indicators
DPI	Total U.S. disposable personal income, annual rate in billions of dollars, seasonally adjusted. Sources: Survey of Current Business Economic Indicators
POP	U.S. civilian population, in millions. Source: Population Estimates and Projections Series P-25. Department of Commerce, Bureau of Census.
WWF	Number of women over age 20 employed in the civilian work force, seasonally adjusted, in millions. Source: Monthly Labor Review

Table 2.1 (cont.)

UR	Civilian unemployment rate, workers over age 20, seasonally adjusted, in percent. Source: Survey of Current Business
CER	Consumer expenditures in restaurants, eating and drinking places, seasonally unadjusted in millions of dollars. Sources: Survey of Current Business Business Statistics
CFQ	Fed steer and heifer slaughter for the month, in thousands of head. See Appendix C for estimation of monthly data. Source: Livestock and Meat Situation for quarterly data.
CCQ	Commercial cow slaughter for the month, in thousands of head. See Appendix C for estimation of monthly data. Source: Livestock and Meat Situation for quarterly data.
CAQ	Total commercial cattle slaughter for the month, in thousands of head. Sources: Livestock Slaughter Livestock and Meat Situation
CPFQ	Percent fed cattle slaughter (CFQ/CAQ).
PCS	Percent cow slaughter (CCQ/CAQ).
CPI	Consumer price index, CPI-W, seasonally unadjusted, 1967=100. Sources: Survey of Current Business Economic Indicators
IPD	GNP implicit price deflator, seasonally adjusted, 1972=100. Sources: Survey of Current Business Economic Indicators
NBVIM	Net beef and veal imports (imports less exports), millions of pounds, carcass weight. Source: Livestock and Meat Situation

Table 2.1 (cont.)

WRMP	Wage rate in the meat packing industry, $/hour. Source: U.S. Department of Labor
PSB	Cold storage stocks of pork, beginning of the month, in millions of pounds. Source: Livestock and Meat Situation
FPE	Total USDA food program expenditures during the month, in millions of dollars. Source: National Food Review
STAMP	Total federal expenditures for food stamps (bonus stamps) during the month, in millions of dollars. Source: National Food Review
IR	Interest rate on 3-month treasury bills, monthly average, in percent. Sources: Economic Indicators; Survey of Current Business
PR	Prime lending rate charged by banks on short-term loans, monthly average, in percent. Source: Federal Reserve Bulletin
Dummy	Monthly dummy variables (0,1), Feb. through Dec., January serving as the base month. 1 if the price is for that month, 0 otherwise.
R^2	The proportion of variation in the dependent variable explained by the independent variables; the coefficient of determination.
D.W.	The Durbin-Watson statistic, a measure of the degree of autocorrelation of the residuals.
P_1	The serial correlation coefficient for errors in the previous period (t-1).
P_2	The serial correlation coefficient for errors in time period t-2.

Simple Models

The models shown in Table 2.2 are relatively simple in nature. Of all the simpler models examined, these had the expected signs on the coefficients, explained a high proportion of cattle price variability in 1970-79, and were the most accurate in forecasting 1980-81 prices.[1] To provide alternative forecasting procedures, a linear model incorporating the same variables was also estimated and is presented with the logarithmic model in Table 2.2.

Recall that the slope coefficients in the logarithmic model provide direct estimates of the percentage price change associated with a one percent change in the independent variables. These models may be used in their entirety as shown in Table 2.2, or each logarithmic coefficient (flexibility) can be used individually as a rough approximation of the likely price impact of a change in a particular variable. For example, if beef production per working day in July is expected to be 10% higher than the previous year's level, holding all other factors constant, we would expect cattle prices to be 12-13% lower during the month of July. Chapter IV covers the use of these models in forecasting applications in considerable detail.

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[1] Refer to Chapter IV.

Table 2.2

Simple Monthly Cattle Price Models

	Dependent Variable Omaha Choice Steer Price 900-1100 pounds, $/cwt.	
Independent Variables	1970-79 Linear Model	1970-79[a] Logarithmic Model
Intercept	-47.221**	9.771**
BQ/Workday	-.740**	-1.238**
PQ/Workday	-.241**	-.388**
(DPI/POP)/IPD	4030.408**	3.677**
Monthly dummy variables:		
February	-3.149	-.0303*
March	-4.034*	-.0362*
April	-2.149	-.0166
May	-1.858	-.0177
June	-1.785	-.0196
July	-3.343	-.0374
August	-2.735	-.0284
September	-.603	-.0066
October	.630	.0077
November	-1.789	-.0124
December	-4.821**	-.0421**
R^2	.895	.903
D.W.	.65	.77

[a]The price and all independent variables, except the monthly dummy variables, are in logarithms.
*Significantly different from zero at the .05 level.
**Significantly different from zero at the .01 level.

Complex Models

The models presented in Table 2.3 were estimated for use by knowledgable users who can devote extra time to making price forecasts. These models incorporate additional price influences, such as consumer expenditures in restaurants, which were not included in the simpler models. Because more market price influences are taken into account, these models explain more of the price variability in 1970-79, and would be expected to be more accurate forecasting tools (see Chapter IV).

Autoregressive Models

It is apparent from the Durbin-Watson statistics in Tables 2.2 and 2.3 that these models have a serial correlation problem. Serial correlation is the problem of errors in a particular time period carrying forward into following periods. Autoregressive versions of the simple and complex models were investigated for several reasons. First, since standard errors are underestimated in the presence of serial correlation, corrected models must be estimated to determine if all of the explanatory variables from the complex model were in fact significant price influences during the 1970s. While the coefficients are unbiased estimates, the standard errors of the

Table 2.3

Complex Monthly Cattle Price Models

Independent Variables	Dependent Variable Omaha Choice Steer Price 900-1100 pounds, $/cwt. 1970-79 Linear Model	1970-79[a] Logarithmic Model
Intercept	-1.848	9.830**
BQ/Workday	-.961**	- 1.524**
PQ/Workday	-.263**	-.327**
(DPI/POP)/IPD	2605.250**	3.523**
CER	-.0056**	-.579*
CPFQ	-10.350[b]	-.289**
IPD	.494**	1.049**
Monthly dummy variables:		
February	-3.865**	-.0358**
March	-1.851	-.0143*
April	-1.178	.0002
May	1.303	.0183
June	2.103	.0234
July	-.771	.0012
August	1.201	.0165
September	2.474	.0220
October	3.133[c]	.0305
November	-.461	-.0077
December	-2.884[c]	-.0289
R^2	.934	.931
D.W.	1.06	1.12

[a]Price and other variables, except dummies, in logs.
[b]Significantly different from zero at the .08 level.
[c]Significantly different from zero at the .10 level.
*Significantly different from zero at the .05 level.
**Significantly different from zero at the .01 level.

coefficients are underestimated with serial correlation, often causing a variable to be accepted as having a significant explanatory effect when it in fact does not.[2] Secondly, autoregressive models may offer additional forecasting accuracy. Comparisons between corrected and uncorrected models are presented in Chapter IV.

Autoregressive models were estimated using the SAS AUTOREG[3] routine, which is a variation of the Cochrane-Orcutt iterative procedure.[4] Models were initially specified using errors from the previous 15 periods. A second-order autoregressive process was identified and models were re-estimated using a 2 period error lag. A second-order autoregressive model, in which current errors are correlated to errors of the two previous periods, takes the following form:

$$Y_t = A + B*X_t + E_t$$

$$E_t = P_1E_{t-1} + P_2E_{t-2} + U_t$$

where E_t is the serially correlated error term, P_1 and P_2 are the serial correlation coefficients, and U_t is a normally distributed random error term.

Simple and complex autoregressive models are presented in Tables 2.4 and 2.5. Serial correlation coefficients are reported near the bottom of the tables.

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[2] Pindyck and Rubinfeld, 1981, pp. 152-153.
[3] Barr, et al., 1979, pg. 131.
[4] Pindyck and Rubinfeld, 1981, pp. 154-157.

Table 2.4

Simple Monthly Autoregressive Price Models

Independent Variables	Dependent Variable Omaha Choice Steer Price 900-1100 pounds, $/cwt. 1970-79 Linear Model	1970-79[a] Logarithmic Model
Intercept	-43.882**	7.550**
BQ/Workday	-.555**	-.892**
(DPI/POP)/IPD	3268.841**	3.035**
Monthly dummy variables:		
February	-1.973*	-.0169[b]
March	-3.202**	-.0296**
April	-1.363	-.0106
May	-.574	-.0040
June	-.266	-.0003
July	-.733	-.0014
August	-1.119	-.0070
September	-.555	-.0063
October	-.181	-.0024
November	-2.807**	-.0276**
December	-4.498**	-.0420**
P_1	.5871	.6037
P_2	.2035	.1935
R^2	.62	.62

[a]The price and all independent variables, except the monthly dummy variables, are in logarithms.
[b]Significantly different from zero at the .06 level.
*Significantly different from zero at the .05 level.
**Significantly different from zero at the .01 level.

Table 2.5

Complex Monthly Autoregressive Price Models

Independent Variables	Dependent Variable Omaha Choice Steer Price 900-1100 pounds, $/cwt. 1970-79 Linear Model	1970-79[a] Logarithmic Model
Intercept	-30.721**	8.257**
BQ/Workday	-.665**	-1.097**
(DPI/POP)/IPD	3571.904**	3.305**
CPFQ	-23.025**	-.412**
Monthly dummy variables:		
February	-1.688[b]	-.0124
March	-3.232**	-.0281**
April	-1.359	-.0091
May	-.937	-.0067
June	-.739	-.0050
July	-1.626	-.0108
August	-2.003	-.0167
September	-.841	-.0102
October	-.702	-.0094
November	-3.852**	-.0403**
December	-5.773**	-.0560**
P_1	.4143	.3849
P_2	.2893	.3230
R^2	.75	.77

[a]The price and all independent variables, except the monthly dummy variables, are in logarithms.
[b]Significantly different from zero at the .08 level.
**Significantly different from zero at the .01 level.

Key Findings

All models

As expected, commercial beef production per working day in the month and per capita real disposable income emerged as the key factors influencing steer prices during the 1970s. Both variables' coefficients had the anticipated signs and were highly significant in all models examined. Putting monthly production on a working day basis clearly improved the explanatory ability of the model, but no real differences surfaced among the several alternative workday measures examined. The simplest was selected for use in the model. In addition, percent fed cattle slaughter also had the expected sign and was significant[5] in most of the models estimated, including the autoregressive models.

Incorporating disposable personal income into the model yielded slightly better results than before tax personal income, as one might expect since most workers' spendable take-home pay has already had income taxes withdrawn. Total income and per capita nominal income were also examined, but per capita real income proved to be the income variable that did the best job of explaining past changes in demand for beef, and in forecasting 1980-81 price behavior. These results imply that individual consumers respond to the level of their income relative to the cost of goods and services,

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[5]Significant at the 5% level, unless stated otherwise.

not just absolute levels of money income, in making their spending decisions for beef. The GNP implicit price deflator proved to be preferable to the consumer price index in deflating the income variable.

Most of the monthly dummy variables were not significantly different from zero, and the signs varied some from model to model, indicating that seasonal fluctuations in demand from January levels are not strong. However, a seasonal pattern almost identical to the one identified by Hayenga and Hacklander (1970) persisted in all models. After accounting for price effects of other factors incorporated in the model, prices tend to be the highest during September and October, falling to a low in December, probably due to high holiday demand for turkeys and hams. In January, prices strengthen before falling to low levels during the late winter and early spring months. In May and June, prices again rebound slightly, before reaching July levels which are nearly as low as those of the December, February, and March.

<u>Simple models</u>

Models containing only a few explanatory variables explained 90% of the variability in choice steer prices from 1970-79. Linear models appear to have done as well as similar logarithmic models. Beef production per working day, pork production per working day, and per capita real disposable income were highly significant in the simpler models. Durbin-Watson statistics were low, indicating that there is a serial correlation problem in these models.

Complex models

The addition of several other explanatory factors to the simple models increased the proportion of steer price variability explained to about 93%, a modest improvement. Again, no real differences between the linear and logarithmic models stand out. The complex models also appear to have a serial correlation problem, though Durbin-Watson statistics are not as low as those of the simple models. Thus, the statistical significance of these coefficients should be viewed with caution.

In addition to beef production, pork production, and per capita real income, the variables having a significant impact upon prices in the complex models were consumer expenditures in restaurants, percent fed cattle slaughter, and the implicit price deflator. Interestingly, the sign for the restaurant expenditures variable was negative, verifying that consumers do tend to eat less beef when dining away from the home. As a separate independent variable, the implicit price deflator again gave better results than the consumer price index. In this model the implicit price deflator serves as a proxy for the cost of other consumer goods and services not otherwise incorporated in the model. Thus, the sign was positive as expected.

Omitted variables

Numerous other explanatory variables were examined and dropped from the complex models due to unexpected signs or lack of significance. Broiler production per working day was significant but consistently had a positive coefficient, as did the pork cold storage variable. The wage rate in the meat packing industry, the number of women in the work force, the unemployment rate, percent cow slaughter, and interest rates were all insignificant in most of the models considered. Both the prime rate and the 3-month treasury bill rate were investigated; neither had a significant impact upon prices.

The U.S. population was found to have an unreasonably high percentage price impact during the seventies, ranging from 10.8 to 11.3, when it was utilized as a separate explanatory variable in the price equation. This may have been due to spurious correlation with other trends occurring during 1970-79. Models incorporating population as a separate variable proved to be extremely inaccurate in forecasting 1980-81 prices.[6]

The net beef and veal imports variable was also insignificant throughout all the models estimated. In retrospect, this comes as no real surprise, since imports

[6]Using the average absolute error as a measure of accuracy.

are typically a constant 8-10% of total beef supplies. Since the two are highly correlated, imports fail to further explain price behavior after variability in beef production has been taken into account.

Total food program expenditures and food stamp payments were both examined and found to be marginally significant in most models. Total food program expenditures was significantly different from zero at the 4% level in a few of the models estimated. When these variables were included in the model the size of the income coefficient dropped considerably, which comes as no surprise since food program spending is really a component of income. These variables were not included in the final forecasting model primarily because of their difficulty of prediction relative to their contribution toward greater forecasting accuracy.

Autoregressive models

Similar autoregressive models were estimated to correct for the serial correlation found in the simple and complex models. R^2s were lower than those of the corresponding simple and complex models. However, because dependent variables are differences in the transformed equations used to estimate the revised autoregressive coefficients, the R^2 values can not be directly compared to those of uncorrected models.

As theory suggests, the standard error estimates of the coefficients for many explanatory variables increased. Consequently, it is not possible to conclude that pork production, consumer expenditures in restaurants, and the implicit price deflator had a significant impact on cattle prices during the 1970s. These variables were deleted, and revised autoregressive equations were re-estimated. Beef production, income, and percent fed cattle slaughter were found to be the key price influences during the 1970s. Note that the percentage price impact (flexibility) estimates for these key variables were also lowered considerably. Theoretically, coefficients from both the autocorrelated and autoregressive models are unbiased estimates of the true parameters. While the rationale for the changes in the percentage price impacts in the autoregressive models is not clear, all estimates were used in forecasting applications to see which performs the best (see Chapter IV).

Price Flexibilities

Numerous studies over the years have estimated and reported price flexibilities for beef, its substitutes, and income. Often these percentage price impacts were estimated for use in policy analysis, rather than for forecasting. While estimates of these important market relationships do vary some from study to study, most fall within a small range. One would not expect these findings to agree because of differences in the way the models were specified, i.e. on a total or per capita basis, as nominal or real income, or whether annual, quarterly, or monthly data was used.

Flexibilities from this study are reported in Table 2.6 and compared with earlier findings. Flexibilities from the simple and complex models are generally consistent with those reported in previous studies, while autoregressive estimates are considerably smaller. Since many of these earlier studies used annual data, there were probably no serial correlation problems. From a statistical standpoint, there should be no preference for either estimate, since coefficients from both corrected and uncorrected models are unbiased estimates of the true parameter. Forecasters should select those estimates which prove to be the best forecasting tool.

Direct beef price flexibilities (obtained from uncorrected models) have not changed a great deal from the previous estimates by Hayenga and Hackander in 1970 (the most closely related model), while the cross-flexibility for pork seems to have increased during the 1970s. Income percentage price impacts appear to be considerably larger than in the past. However, the size of the income coefficient can vary substantially depending upon whether it is estimated on a total or per capita basis, and whether it is real or nominal. The income coefficients reported in Table 2.6 are for real, per capita income. Coefficients

Table 2.6

Price Flexibilities

Model			The Percentage Change in Steer Prices Associated with a One Percent Change in: Beef	Other Meats	Income
This study: [a]					
Simple			-1.238	-.388	3.677
Complex			-1.524	-.327	3.523
Simple Autoregressive			-.892	--	3.035
Complex Autoregressive			-1.097	--	3.305
Previous studies:					
Study	Year	Data			
Fox[b]	1958	annual	-1.19	-.40	1.27
Brandow[c]	1961	annual	-1.59	-.279	--
Hayenga[d]	1970	monthly	-1.338	-.167	1.32
Farris[e]	1981	annual	-1.49	-.30	1.53
Good[f]	1981	quarterly	-1.895	-.368	1.13

[a] Beef prod. per workday in the month, pork prod. per workday, per capita real income.
[b] Per capita beef prod., per capita prod. of other meats, and per capita income.
[c] Beef prod. and prod. of other red meats and poultry.
[d] Beef prod. per workday, pork prod. per workday, and per capita income.
[e] Per capita beef cons., per capita cons. of other meats, per capita real income.
[f] Beef prod., pork prod., and real income.

obtained (but not reported) in this study for nominal disposable personal income were of the same magnitude as those cited from earlier studies.

CHAPTER III

SUPPLY MODEL

Model Specification

The results presented in Chapter II indicate that beef production is undoubtedly the key supply variable affecting steer price behavior. Beef production per working day had a highly significant price impact in every model estimated. Consequently, accurate forecasts of beef production are an essential step towards making accurate price forecasts.

This chapter outlines a method for forecasting monthly levels of commercial beef production as far as six months ahead using key USDA inventory reports. Throughout this chapter these various USDA inventory numbers, which are available quarterly or semi-annually, will be referred to as inventory figures. The month these figures are released will be termed release months. Quarterly cattle on feed and feeder cattle supply reports are released in January, April, July, and October, while semi-annual cow herd and bull inventory figures are commonly released in January and July.

In this procedure no attempt is made to identify the variables influencing production decisions regarding the placement of cattle on feed or herd culling decisions. Rather, it is assumed that current inventory reports reflect the sum of these past decisions. For instance, no attempt is made to explain or forecast current levels of cattle on feed. For whatever reason, these cattle were placed in feedlots and have the potential to be slaughtered as grain-fed cattle in the upcoming months. The approach taken is one of using these known inventory figures to forecast slaughter levels in the nearby future. The only "decision" variables included in the model are those which may alter the producers' plans after the release of the inventory figure. For instance, recent range conditions play a big role in determining if grass-fed cattle are placed on feed, slaughtered as non-fed cattle, or remain on pasture.

These inventory figures are clearly predetermined and are regarded as exogenous to the model. Thus, ordinary least-squares regression is appropriate and was used throughout this portion of the study.

Beef production estimates are obtained through a series of equations. Monthly fed steer and heifer slaughter (CFQ), non-fed steer and heifer slaughter (CNFQ), and cow and bull slaughter (CCBQ) are estimated individually, and then used to estimate total monthly commercial beef production (BQ). The general forms of these individual equations are shown below. Each will be discussed in more detail in following sections of this chapter.

BQ = f(CFQ, CNFQ, CCBQ, Monthly dummy variables)

CFQ = f(Appropriate cattle on feed categories, Prime interest rate, Change in steer prices, Quarterly release month dummy variables)

CNFQ = f(Feeder cattle supply, Range conditions, Prime interest rate, Feeder steer price, Monthly dummy variables)

CCBQ = f(Cow herd inventory, Bull inventory, Heifers held for beef cow replacement, Monthly dummy variables)

The beef production (BQ) equation translates slaughter for each category in thousands of head into total beef production in millions of pounds. A preferable method of forecasting beef production would be to estimate fed beef production, non-fed beef production, and cow and bull beef production in pounds and sum the three to arrive at total beef production for the month. However, only the number of fed and non-fed cattle slaughtered each month are available--monthly average carcass weights for the fed and non-fed slaughter categories are not reported. By regressing total beef production against the individual slaughter groups a constant carcass weight is assumed. Admittedly, this is a weak assumption, but the alternatives are limited by a lack of data. If individual forecasters have their own expectations of carcass weights, coefficients can be adjusted accordingly.

None of the explanatory variables in these slaughter models need to be forecasted. The supply model was designed so that all of the necessary information is known and available at the time the forecast is made.

Table 3.1

Variable Definitions and Sources

BQ	Total U.S. commercial beef production in the month, millions of pounds, carcass weight. Source: Livestock Slaughter
CFQ	Fed steer and heifer slaughter, thousands of head. See Appendix C for estimation of monthly data. Source: Livestock and Meat Situation for quarterly data.
CNFQ	Non-fed steer and heifer slaughter, thousands of head. See Appendix C for estimation of monthly data. Source: Livestock and Meat Situation for quarterly data.
CCBQ	Cow, bull, and stag slaughter, thousands of head. See Appendix C for estimation of monthly data. Source: Livestock and Meat Situation for quarterly data.
COFS1	Number of steers under 500 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed Livestock and Meat Situation
COFS2	Number of steers 500-700 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed Livestock and Meat Situation
COFS3	Number of steers 700-900 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed Livestock and Meat Situation
COFS4	Number of steers 900-1100 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed Livestock and Meat Situation
COFS5	Number of steers over 1100 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed Livestock and Meat Situation

Table 3.1 (cont.)

COFH1	Number of heifers under 500 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed; Livestock and Meat Situation
COFH2	Number of heifers 500-700 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed; Livestock and Meat Situation
COFH3	Number of heifers 700-900 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed; Livestock and Meat Situation
COFH4	Number of heifers over 900 pounds on feed in 23 states, beginning of quarter, thousands of head. Sources: Cattle on Feed; Livestock and Meat Situation
CPL7	Net placements of cattle on feed in 7 states during the month, thousands of head. Sources: Cattle on Feed; Livestock and Meat Situation
PR	Prime lending rate charged by banks on short-term loans, monthly average, in percent. Source: Federal Reserve Bulletin
CSP	Choice steer price in Omaha, 900-1100 pounds, monthly average in \$/cwt. Sources: Livestock and Meat Situation; Livestock Meat and Wool Market News
CSPDIF	The change in the choice steer price from the previous month's level. $CSP_t - CSP_{t-1}$.
CFSP	Choice feeder steer price, Kansas City, 400-500 pounds, monthly average in \$/cwt. Source: Livestock and Meat Situation; Livestock Meat and Wool Market News

Table 3.1 (cont.)

SHFS	The steer and heifer feeder cattle supply (on the farm, but not on feed), beginning of the month, thousands of head. Source: <u>Livestock and Meat Situation</u>
CCH	Number of cows and heifers that have calved, beef and dairy, January 1 or July 1, thousands of head. Source: <u>Cattle</u>
CB	Number of bulls over 500 lbs. on farms January 1 or July 1, thousands of head. Source: <u>Cattle</u>
BCR.	Heifers over 500 lbs. held for beef cow replacement, January 1 or July 1, thousands of head. Source: <u>Cattle</u>
PC	Index of average pasture and range feed conditions in 30 states, 80=normal. Source: <u>Crop Production</u>
PCDEV	Deviations of pasture conditions from the normal level, (PC-80). 0 if no index reported.
Dummy	Monthly or quarterly dummy variables (0,1), 1 if the figure is for that period, 0 otherwise.
R^2	The proportion of variation in the dependent variable explained by the independent variables; the coefficient of determination.
D.W.	The Durbin-Watson statistic, a measure of the degree of autocorrelation of the residuals.
P_1	The serial correlation coefficient for errors in the previous period (t-1).
P_2	The serial correlation coefficient for errors in time period t-2.
P_3	The serial correlation coefficient for errors in time period t-3.

Beef Production Equations

As mentioned in the previous section, monthly beef production is estimated from fed cattle slaughter, non-fed cattle slaughter, cow and bull slaughter, and monthly dummy variables. The following equation was estimated using 1970-79 data and ordinary least-squares regression.

$BQ_t = f(CFQ_t, CNFQ_t, CCBQ_t, Dummy_t)$

where: t = Month
Dummy = Monthly dummy variables (0,1) for February through December, with January serving as the base.

The monthly dummy variables serve to capture any seasonal variation in slaughter weights. When this equation is estimated without the intercept or dummy variables, slope coefficients should yield estimates of average dressed weights for each slaughter category during the 1970-79 period. Both versions are presented in Table 3.2. Coefficients from Table 3.2 indicate that average carcass weights are higher for fed cattle than for grass-fed cattle, as might be expected. However, the size of the cow and bull slaughter coefficient was considerably lower, which is difficult to explain. One would expect that carcass weights of older animals would equal or exceed those of fed steers and heifers. However, it may be that cow and bull slaughter includes a relatively large proportion of beef cow replacement heifers which were culled and slaughtered at a

Table 3.2

Simple Monthly U.S. Beef Production Equations

Independent variables	Dependent Variable Commercial Beef Production million pounds, 1970-79	
Intercept	--	119.830*
CFQ	.677**	.645**
CNFQ	.629**	.647**
CCBQ	.402**	.352**
Monthly dummy variables:		
February	--	-29.79*
March	--	-24.01
April	--	-30.91*
May	--	-24.92
June	--	-30.33*
July	--	-34.29*
August	--	-32.08*
September	--	-34.66*
October	--	-5.74
November	--	3.41
December	--	1.16
R^2	.96	.97
D.W.	.33	.31

*Significantly different from zero at the .05 level.
**Significantly different from zero at the .01 level.

young age. Another explanation is that in estimating this relationship using least-squares we have obtained parameter estimates which give the best fit rather than providing accurate estimates of average carcass weights. Despite this finding, this simpler equation can be a useful point of reference. Forecasters who have their own inclinations about carcass weights can adjust these coefficients accordingly, arriving at a modified estimate of beef production.

The Durbin-Watson statistics for these equations indicate that errors in adjacent time periods are highly correlated. An autoregressive beef production equation was estimated to correct for this correlation between error terms, and results are presented in Table 3.3. The R^2 for this corrected equation was approximately .99, though R^2s of autoregressive equations are not directly comparable to uncorrected equations. The P-values near the bottom are the serial correlation coefficients for errors in the two previous time periods. Chapter IV examines the usefulness of these two alternative models in forecasting applications. See Appendix A for an explanation of autoregressive forecasting procedures.

Table 3.3

Autoregressive Monthly U.S. Beef Production Equation

Independent variables	Dependent Variable Commercial Beef Production million pounds, 1970-79
Intercept	46.011
CFQ	.667**
CNFQ	.665**
CCBQ	.380**
Monthly dummy variables:	
February	-23.190**
March	-22.701**
April	-25.321**
May	-22.474**
June	-29.413**
July	-32.198**
August	-34.567**
September	-36.158**
October	-12.471
November	.953
December	-.468
P_1	.628
P_2	.247
R^2	.99

**Significantly different from zero at the .01 level.

Fed Steer and Heifer Slaughter Equations

The primary inventory figures used to explain fed slaughter levels are the quarterly USDA cattle on feed statistics, which can be found in the USDA Livestock and Meat Situation or Cattle on Feed publications. These reports, which contain the number of steers and heifers on feed by weight category, are also reported by many industry publications and market reporting services. Since cattle in the different weight groups do not reach slaughter at the same time, separate equations using different cattle on feed categories must be estimated for each forecast month following the release month. All of the following fed steer and heifer slaughter equations were estimated using 1970-79 data and the ordinary least squares estimation procedure.

The following is the general form of the equations for forecasting fed beef slaughter six months into the future. Fed slaughter is estimated using the number of cattle on feed in the relevant weight categories, the prime interest rate, the change in the choice steer price, and release month dummy variables.

$$CFQ_{m+i} = f(COFS_{w,m},\ COFH_{w,m},\ PR_m,\ CSP_m - CSP_{m-1},\ Dummy_m)$$

where:
- m = the release month--January, April, July, or October.
- w = the appropriate weight category.
- i = number of months after the release month: 1, . . .,6.

Dummy = Release month dummy variables (0,1) for April, July, or October, with January serving as the reference.

The prime interest rate and the change in the choice steer price during the release month are included in the equations since their impact upon future slaughter levels would not be captured by cattle on feed levels reported at the beginning of the month. Since the cost of carrying an animal increases as interest rates rise, the prime rate would be expected to have a negative effect on slaughter in the following months. Rising prices should result in higher fed cattle marketings, thus the change in steer prices is expected to have a positive coefficient. Quarterly release month dummy variables are added since environmental factors like weather affect the relationships between on-feed numbers in each weight category and subsequent slaughter in each season of the year.

Results of these equations are presented in Table 3.4. R^2 values range from .81 for two months later to .67 for six months after the USDA report, lower than those obtained in previous studies using cattle on feed statistics to forecast slaughter levels. This could be due to less accurate inventory reports, or producers may be more willing to alter normal feeding patterns to take advantage of expectations of higher prices due to low numbers of cattle on feed.

Table 3.4

Monthly Fed Steer and Heifer Slaughter Equations
for One to Six Month Forecasts

	Dependent Variable Fed Steer and Heifer Slaughter thousands of head		
Indep. Variables	m+1	m+2	m+3
Intercept	934.016**	1549.761**	942.057**
COFS4	.347**	.241**	--
COFS3	--	--	.180**
COFH3	.653**	.620**	.638**
LOG10(PR)	-637.709**	-797.007**	-224.033[a]
CSPDIF	--	--	10.513[b]
Release month dummies:			
April	204.256**	-4.822	84.111
July	-36.017	-235.498**	-33.071
October	-16.377	-206.710**	195.879**
R^2	.73	.81	.73
D.W.	1.61	1.43	1.86

[a]Significantly different from zero at the .21 level.
[b]Significantly different from zero at the .14 level.
**Significantly different from zero at the .01 level.

Table 3.4 (cont.)

	Dependent Variable Fed Steer and Heifer Slaughter thousands of head		
Indep. Variables	m+4	m+5	m+6
Intercept	935.158**	1808.06**	1115.536**
COFH2	.949**	.650**	.748**
LOG10(PR)	--	-551.220**	--
CSPDIF	26.379**	--	--
Release month dummies:			
April	-284.016**	-191.367**	-45.783
July	34.404	-29.035	278.542**
October	210.806**	283.866**	240.489**
R^2	.72	.73	.67
D.W.	1.30	2.17	2.03

The steers on feed inventory figures explained a high proportion of the variation in fed slaughter levels for three months following their release, but failed to have a significant influence beyond three months. This is most likely due to high intercorrelation with numbers of heifers on feed, which consistently had the strongest influence on slaughter levels in all equations. There does not appear to be any consistent pattern among the quarterly dummy variables, although many were significantly different from January (the base quarter) at the 1% level.

The relationship between fed cattle slaughter and the prime rate was found to be curvilinear. Interest rates during 1980-81 were consistently above the highest levels of the 1970-79 period. Consequently, equations using the standard (non-logarithmic) prime rate consistently underestimated actual fed cattle slaughter levels, sometimes by extremely large amounts. When the prime rate was specified in logarithmic form, its effect at higher levels was diminished and forecasting accuracy improved considerably. The average prime interest rate during the release month had the anticipated negative sign and was found to significantly affect fed slaughter levels in the following two months, as well as the fifth. The effect of interest rates in months three and four was marginal, perhaps due to the significant influence of changes in steer prices on fed beef slaughter in these two months. Results suggest that high interest rates during the release month cause producers to market fed cattle earlier and at lighter weights in an effort to reduce debt loads, thereby reducing fed slaughter levels in following months. High interest rates may also reduce placements of cattle on feed after the cattle on feed inventory is taken, thereby leading to reduced slaughter five months later.

Rising steer prices have the opposite effect of interest rates, causing producers to increase fed cattle marketings three to four months later, either due to delayed marketings in anticipation of higher prices or from increased placements of relatively heavy feeder cattle after the release of the inventory report.

Revised fed cattle slaughter forecasts can be made in the month following the release month by adding placements of cattle on feed in 7-states to the equation. Seven state placement data is available monthly and should provide a monitor of cattle feeding activity between releases of quarterly 23-state cattle on feed reports. The equations for making revised fed slaughter forecasts during month m+1 of fed beef slaughter for months m+3 to m+5 using 7-state placements of cattle on feed (CPL7) during month m are:

$$CFQ_{m+i} = f(COFS_{w,m}, COFH_{w,m}, CPL7_{m}, PR_{m+2}, Dummy_{m})$$

where: $i = 3,4,5.$

These equations appear in Table 3.5. The fit for the revised five month equation was noticeably improved, while fits of the three and four month revised equations were essentially the same. Placements of cattle on feed in 7 states during the release month (m) has its most significant

Table 3.5

Revised Monthly Fed Steer and Heifer Slaughter Equations Using 7-State Placements During Month m

		Dependent Variable Fed Steer and Heifer Slaughter thousands of head		
Indep. Variables	Month[a]	m+3	m+4	m+5
Intercept		650.130**	752.464**	1562.691**
COFS3	m	.193**	--	--
COFH2	m	--	.729**	.615**
COFH3	m	.531**	--	--
CPL7	m	.157*	.331**	.165*
LOG10(PR)	m+1	--	--	-506.436**
Release month dummies:				
April	m	92.839	-137.713*	-140.469
July	m	1.385	66.102	20.361
October	m	34.399	-149.869	146.885
R^2		.72	.73	.77
D.W.		1.58	1.63	2.02

[a]The appropriate data to use for forecasting with these equations. m is the release month for the 23-state cattle on feed report.
*Significantly different from zero at the .05 level.
**Significantly different from zero at the .01 level.

influence on slaughter four months later, when steers or heifers placed on feed at average weights come to slaughter.

Seven state placements during month m are not used to make revised forecasts for the sixth month following the release of the 23-state cattle on feed report because the majority of these cattle placed on feed have already reached slaughter weights within six months. A model for making revised m+6 fed cattle forecasts in month m+2 using 7-state placements during month m+1 is:

$$CFQ_{m+6} = f(COFS_{w,m}, COFH_{w,m}, CPL7_{m+1}, Dummy_{m})$$

Results of this revised equation may be found in Table 3.6. The R^2 for the six month forecast equation was improved, even though placements of cattle on feed in 7 states during month m+1 was only marginally significant. This variable was also used to estimate a second set of revised m+3 to m+5 forecasts, but it was not found to be significant and R^2s were not improved.

Non-Fed Steer and Heifer Slaughter Equations

The key figure used to estimate non-fed (i.e. grass-fed) steer and heifer slaughter is the quarterly feeder cattle supply, first reported by the USDA in 1973.

Table 3.6

Revised Monthly Fed Steer and Heifer Slaughter Equation Using 7-State Placements During Month m+1

		Dependent Variable Fed Steer and Heifer Slaughter thousands of head
Indep. Variables	Month[a]	m+6
Intercept		1114.712**
COFH2	m	.563**
CPL7	m+1	.209[b]
Release month dummies:		
April	m	-76.326
July	m	195.834**
October	m	66.819
R^2		.70
D.W.		1.81

[a]The appropriate data to use for forecasting with this equation. m is the release month for the 23-state cattle on feed report.
[b]Significantly different from zero at the .09 level.
**Significantly different from zero at the .01 level.

Previous studies have not utilized this information, most likely because of the limited number of observations available. This inventory figure represents all steer and heifers on the farm over 500 lbs. not being fed in a feedlot. It is from this group of cattle that non-fed slaughter in upcoming months must come. Because this figure is not broken into weight categories, it is not necessary to estimate separate equations for each of the six forecast months, as in the fed cattle slaughter equations. Two equations of the following form were estimated for making 1 to 3 and 4 to 6 month forecasts. Ordinary least squares regression and 1973-79 data were used.

<u>1 to 3 months</u>

$$CNFQ_{m+i} = f(SHFS_m, PR_m, CFSP_m, PCDEV_{m+i}, Dummy_{m+i})$$

where:
- m = the release month--January, April, July, or October.
- i = the number of months after the release month. 1, 2, or 3.
- Dummy = Monthly dummy variables (0,1) for February through December, with January serving as the base.

<u>4 to 6 months</u>

$$CNFQ_{m+i} = f(SHFS_m, PR_m, CFSP_m, PCDEV_{m+i}, Dummy_{m+i})$$

where: i = 4, 5, or 6.

The prime interest rate should have a positive effect on non-fed cattle slaughter, since higher interest rates will discourage placements of cattle on feed. These larger non-fed supplies, along with the pressure high interest rates place on feeder cattle producers to market animals early to reduce debt loads, should induce higher non-fed cattle slaughter. Conversely, higher feeder cattle prices should induce ranchers to sell feeder cattle for placement in feedlots rather than holding them for slaughter as non-fed cattle in upcoming months.

Good pasture conditions (PCDEV) during the forecast month should have a negative impact on non-fed cattle slaughter. If range conditions are below average and declining, producers would be expected to either sell these grass-fed cattle for placement in feedlots or slaughter them as non-feds. Since the feeder cattle supply figure is used to forecast slaughter in the next six months, monthly dummy variables are used to capture seasonal variation in non-fed steer and heifer slaughter associated with the availability of grass, feed supplies, etc.

Results of these equations appear in Table 3.7. R^2s are relatively low, which comes as no surprise since non-fed steer and heifer slaughter is considered the most random and unpredictable element of total commercial cattle slaughter. Equations for 4 to 6 month forecasts had a somewhat smaller R^2, as one might expect. The prime interest rate,

Table 3.7

Simple Monthly Non-Fed Steer and Heifer Slaughter Equations

Indep. Variables	Dependent Variable Non-Fed Steer and Heifer Slaughter thousands of head Months m+1 to m+3	 Months m+4 to m+6
Intercept	-199.679	-547.492**
SHFS	.068**	.037**
LOG10(PR)	309.883*	781.257**
CFSP	-7.702**	-9.163**
PCDEV	--	-8.373**
Monthly dummy variables:		
February	-392.438**	119.29*
March	-317.867**	199.29*
April	-376.01**	82.805
May	228.748**	90.408
June	262.891**	150.866*
July	263.32**	140.529*
August	-338.396**	481.132**
September	-387.396**	424.956**
October	-355.967**	475.522**
November	73.137	30.865
December	37.709	-21.309
R^2	.79	.76
D.W.	1.14	1.03

*Significantly different from zero at the .05 level.
**Significantly different from zero at the .01 level.

feeder steer prices, and the index of range conditions were all significant and had the anticipated signs. As in the fed cattle slaughter equations, the prime rate was specified as a logarithm, due to its non-linear relationship with slaughter levels. Seasonal non-fed slaughter patterns captured by the dummy variables were significant, as expected.

Durbin-Watson statistics were once again extremely low, indicating that errors in adjacent time periods are highly correlated. Autoregressive equations estimated to correct for this problem appear in Table 3.8. Serial correlation coefficients (P's) and R^2 terms are presented in the bottom portion of the table. A third-order autoregressive process was found, meaning that errors in the current month are partially correlated to errors in the previous three months. Since prices are expressed as differences in the transformed autoregressive equations used to estimate corrected coefficients, R^2s are usually smaller than those of uncorrected equations and are not comparable.

Cow and Bull Slaughter Equations

Even though they are reported separately, cow and bull slaughter levels are estimated jointly since they respond to many of the same influences and are highly correlated. Semi-annual USDA inventory reports are available to use in

Table 3.8

Autoregressive Monthly Non-Fed Steer and Heifer Slaughter Equations

	Dependent Variable Non-Fed Steer and Heifer Slaughter thousands of head	
Indep. Variables	Months m+1 to m+3	Months m+4 to m+6
Intercept	-149.722	-604.249*
SHFS	.037**	.035**
LOG10(PR)	558.764**	668.809**
CFSP	-8.141**	-5.417**
PCDEV	--	-8.102**
Monthly dummy variables:		
February	-264.181**	113.00
March	-183.868**	194.109
April	-245.064**	74.778
May	152.092**	78.203
June	187.727**	147.284*
July	186.921**	132.989*
August	-119.242	439.155**
September	-168.369*	386.191**
October	-137.915	434.681**
November	60.262	15.895
December	23.977	-35.356
P_1	.236	.243
P_2	.103	.108
P_3	.387	.413
R^2	.64	.62

*Significantly different from zero at the .05 level.
**Significantly different from zero at the .01 level.

estimating monthly cow and bull slaughter levels. They are the size of the beef and dairy cow herd, the number of bulls over 500 lbs., and heifers over 500 pounds held for beef cow replacement. Dairy cow herd numbers are included since dairy cows are an important component of cow slaughter statistics. The USDA began reporting July beef cow replacements, cow herd, and bull inventory figures in 1973. The following general equation was estimated using ordinary least squares regression and 1973-79 data.

$$CCBQ_{m+i} = f(CCH_m, CB_m, IBCR_m, CFSP_m, PCDEV_{m+i}, Dummy_{m+i})$$

where: m = the release month--January or July

$i = 1, \ldots, 6$

Dummy = Monthly dummy variables (0,1) for February through December, with January serving as the base.

Cow and bull inventory levels establish a limit on the number of cows and bulls available for slaughter and should explain a large portion of the variation in cow and bull slaughter from one six month period to the next. Handke and Futrell (1978) recognized that the portion of the cow inventory actually slaughtered varies as the cattle cycle moves from the accumulation phase to the liquidation phase, and vice versa. During accumulation, more cows are being retained and fewer are culled. As a result, cow slaughter levels are lower than they would be otherwise. Handke and

Futrell's approach was to estimate separate cow slaughter equations for each phase of the cycle, along with models that identify the current status of the cattle cycle. Using reported beef cow replacements is a simpler method for doing the same thing. Higher beef cow replacements indicate that we are currently in the accumulation phase, while falling replacements signal the liquidation phase. Thus, the number of heifers held for beef cow replacement should be inversely related to cow and bull slaughter levels over the following six months.

Feeder steer prices during the month following inventory reports should also have a negative impact on future cow and bull slaughter levels. Higher prices should raise producers' expectations of future feeder cattle prices, motivating them to reduce herd cullings and maintain higher output levels. As in the non-fed steer and heifer slaughter equations, poor range conditions during the forecasted month should increase cow and bull slaughter since the carrying capacity of the range is reduced. Monthly dummy variables are again essential to capture seasonal variation in cow and bull slaughter, since the same inventory figures are used to forecast slaughter during each of the following six months.

Results of the cow and bull slaughter equation are presented in Table 3.9. This equation was estimated

Table 3.9

Monthly Cow and Bull Slaughter Equation

Independent Variables	Dependent Variable Cow and Bull Slaughter thousands of head
Intercept	230.112
CB	.633**
BCR	-.117**
CFSP	-6.943**
Monthly Dummy Variables:	
February	-53.273
March	-48.273
April	-92.702**
May	-53.56
June	-39.273
July	-52.951
August	-28.552
September	-55.885
October	35.782
November	58.615
December	3.948
R^2	.89
D.W.	1.50

**Significantly different from zero at the .01 level.

using 1973-79 data, excluding July 1975 to January 1976. During this seven month period, cow and bull slaughter levels were extremely large relative to previous inventory levels. Consequently, when these outlying observations were not deleted estimated coefficients (and 1980-81 errors) were considerably larger than those of the equation presented in Table 3.9. R^2s are relatively high, indicating that a large proportion of the variability in cow and bull slaughter levels was explained by these equations. Deviations in range conditions were not found to be significant.

Surprisingly, the cow herd inventory failed to have a significant impact upon cow and bull slaughter, while the bull inventory was highly significant. Since these two variables are highly correlated (r=.92), either inventory figure should capture the variability of the other inventory as well. However, the cow herd inventory was expected to have the stronger influence. It may be that producers responding to USDA surveys do not know precisely how many cows they have on hand, and are unsure at what age young replacement heifers should be included as part of the cow herd. On the other hand, ranchers typically know exactly how many bulls they own, because they are fewer in number and more costly. As a result, the bull inventory report could be a more accurate figure than the cow herd inventory report, accounting for its higher explanatory power.

Beef cow replacements had the correct sign and was highly significant. It appears that this variable has worked well as a proxy for the cattle cycle's effect upon cow and bull slaughter levels. Monthly dummy variables indicate that seasonal cow and bull slaughter is lowest during the spring months as pastures become lush, and highest during October, November, and December when old and unproductive cows are culled as grass supplies deteriorate.

CHAPTER IV

FORECASTING WITH PRICE AND SUPPLY MODELS

In this chapter, a method of integrating the price and supply models of Chapters II and III into a useful price forecasting procedure is outlined. Then, the forecasting accuracy of the cattle slaughter, beef production, and price models, which vary in complexity, is examined for 1980-81.

Forecasting Procedure

Models presented in Chapter II identify the key variables influencing cattle price behavior and quantify their typical impact upon prices during the 1970s. However, before one can use these models to accurately forecast prices, reliable forecasts of the explanatory variables are needed. A model which can be used to forecast beef production and percent fed cattle slaughter--the key supply variables found to affect cattle price behavior--is outlined in Chapter III. A companion study at Iowa State University is currently developing similar procedures for forecasting monthly pork supplies. While it is beyond the scope of this study to estimate models for accurately predicting levels of disposable income and the implicit price deflator, numerous econometric forecasting firms, private businesses, and financial institutions routinely make forecasts of these key macroeconomic variables. These estimates are commonly published in major newspapers and business magazines such as The Wall Street Journal and Fortune. We would not expect individual firms to be able to consistently forecast these variables with any reasonable degree of precision, but over the years average expectations of leading firms has provided relatively accurate forecasts. Estimates of a variety of macroeconomic variables by 42 major firms are collected and reported monthly in the Blue Chip Economic Indicators. Many of the key figures from this report are printed in The Wall Street Journal.

Since the U.S. population typically grows at a fairly stable rate, recent trends can be extended to forecast future levels. Over the past one and a half years the U.S. population has consistently increased by 0.2 million people per month--a useful rule of thumb.

Beef supply forecasting procedure

The following section outlines the steps necessary to forecast total beef production and percent fed cattle slaughter, which in turn are used to make price forecasts. Appendix B contains a detailed forecasting example.

1. To forecast cow and bull slaughter levels for the following six months, collect the most recent reports (January or July) for the bull inventory and heifers held for beef cow replacements, along with the most recent month's average feeder steer price, and insert them into the

equation presented in Table 3.9. Sources and definitions for each variable are in Table 3.1.

2. To forecast non-fed steer and heifer slaughter levels for the upcoming six months, use either the simple equations in Table 3.7 or the autoregressive versions shown in Table 3.8. See Appendix A for an explanation of autoregressive forecasting procedures. The important figures needed are the most recent reports of the feeder cattle supply (January, April, July, or October), the range conditions index, prime interest rates, and recent choice feeder steer prices. Sources and specifications for each variable are shown in Table 3.1.

3. Use the equations of Table 3.4 to make fed steer and heifer slaughter forecasts for the next six months. The key figures needed are the number of steers and heifers on feed in the last <u>Cattle on Feed</u> report, the prime interest rate, and recent choice steer prices. Again, descriptions and sources for each of these variables are in Table 3.1. In addition, several revised forecasts may be made at the forecaster's discretion. During February, May, August, or November, forecasts of fed cattle slaughter levels three to five months beyond the original forecast month can be updated using the most recent 7-state placements of cattle on feed and the equations in Table 3.5. Revised forecasts for the sixth month beyond the original forecast month can be made in March, June, September, or December using 7-state

placements during the month following the Cattle on Feed report and the equation presented in Table 3.6.

4. Calculate the forecasted percent fed cattle slaughter for the next six months by dividing the fed cattle slaughter forecasts from step 3 by the sum of the cow and bull, non-fed, and fed cattle slaughter forecasts obtained in steps 1, 2, and 3.

5. Forecast beef production for the following six months by inserting slaughter estimates from steps 1, 2, and 3 into either the simple equations in Table 3.2 or the autoregressive equation in Table 3.3. These equations convert cattle slaughter forecasts in thousands of head into a total beef production estimate in millions of pounds.

Supply Forecasts

The slaughter and beef production equations presented in Chapter III were tested in forecasting applications over the 1980-81 period. Slaughter forecasts were made using only those inventory reports and forecasting errors which would have been available at the time each one to six month prediction was made. The accuracy of the beef production equations was tested using both actual and forecasted slaughter levels. Average absolute errors and average errors were calculated to measure the forecasting accuracy of each equation and to determine if forecasts were biased in either direction. The root mean square error (RMSE) of the forecast, which is the standard deviation of the forecast errors, is also presented. Approximately 2/3 of the 1980-81 forecasted values fell within +/- 1 standard deviation (RMSE) of the actual value. Errors were calculated as the actual value less the predicted value.

Cow and bull slaughter

Overall, cow and bull slaughter forecasts obtained using the equation in Table 3.9 were reasonably accurate (see Table 4.1). Errors ranged from 2.5 thousand head to as high as 129 thousand. The average absolute error was 6.2% of average 1980-81 cow and bull slaughter levels. Predictions based on January reports were more accurate and less biased than those based on the July report. Average absolute errors for February-July were 4.3% of the mean, compared to 7.5% for August-January. The average error during February-July was 9.68 thousand head, a slight downward bias. The August-January average error was -37.7 thousand, indicating that forecasted cow and bull slaughter was considerably higher than actual levels during these months.

Table 4.1

Accuracy of 1980-81 Cow and Bull Slaughter Forecasts

Release Month	Average Residual	Ave Abs Residual	Ave Abs Res as % of mean	RMSE
	thousands of head			
January	9.68	22.90	4.32%	29.27
July	-37.66	52.54	7.54%	64.82
1980-81 Average	-13.98	37.72	6.15%	50.29

Non-fed steer and heifer slaughter

Both the simple and autoregressive non-fed slaughter equations of Tables 3.7 and 3.8 were tested for 1980-81. Results are presented in Table 4.2. Errors were large, ranging from 26% to 59% of the 1980-81 mean. This comes as no surprise since monthly non-fed cattle slaughter can be extremely volatile, varying from a low of 30 thousand head to a high of 460 thousand--over 15 times greater. In light of this fact, these forecasting errors are as good as can be expected.

Non-fed steer and heifer slaughter forecasts made using autoregressive equations were a modest improvement over those from uncorrected equations. Average errors for two, three, and six months ahead were smaller, while those of the

Table 4.2

Accuracy of 1980-81 Non-Fed Steer and Heifer Slaughter Forecasts

Months Beyond Forecast Month	Average Residual (thousands of head)	Ave Abs Residual (thousands of head)	Ave Abs Res as % of mean	RMSE
Simple Equations (Table 3.7)				
1	12.39	59.63	25.8%	75.16
2	76.19	108.74	36.1%	131.21
3	100.05	107.27	36.8%	137.59
4	-65.18	114.04	49.4%	173.66
5	-6.80	103.47	34.4%	143.11
6	43.22	139.43	47.9%	151.44
1-3	62.88	91.88	33.5%	118.03
4-6	-9.59	118.98	43.4%	156.60
Autoregressive Equations (Table 3.8)				
1	-38.18	82.83	35.9%	108.79
2	2.90	105.66	35.1%	121.15
3	29.36	85.66	29.4%	91.30
4	-48.99	135.34	58.6%	182.33
5	-67.03	140.09	46.6%	158.2
6	-30.29	109.06	37.5%	130.16
1-3	-1.96	91.38	33.3%	107.78
4-6	-49.28	128.16	46.7%	158.34

remaining months were somewhat larger. As one might expect, the autoregressive equation for 4-6 month forecasts did not perform as well as the 1-3 month autoregressive equation, due to the fact that recent errors have a diminished impact upon forecasts further into the future.

Revised forecasts using updated range conditions and more recent errors were investigated, but average absolute errors were no lower than those of the original forecasts.

Fed steer and heifer slaughter

Both the fed cattle slaughter equations of Table 3.4 and the revised equations of Tables 3.5 and 3.6 were tested for forecasting accuracy using 1980-81 data. The results, which may be found in Table 4.3, are generally good. Average absolute errors range from 2.4% to 9.0% of the mean. Forecasts for three and six months beyond the base month were surprisingly accurate. All six equations' forecasts were clearly biased downward for the test period. Due to poor cattle feeding profitability, reported numbers of cattle on feed during 1980-81 were small relative to feeder cattle supplies. During this two year period, producers may have been more willing to place heavy feeder cattle in feedlots to capture potentially higher cattle prices. As a result, subsequent fed cattle slaughter was higher than otherwise indicated by the reported number of cattle on feed.

Revised forecasts using reports of 7-state placements of cattle on feed failed to substantially improve fed cattle slaughter forecasts, with the exception of revised estimates of slaughter four months beyond the base period. The average absolute error of the revised m+4 forecasts was over

Table 4.3

Accuracy of 1980-81 Fed Steer and Heifer Slaughter Forecasts

Months Beyond Forecast Month	Average Residual	Ave Abs Residual	Ave Abs Res as % of mean	RMSE
	thousands of head			
Release Month Equations (Table 3.4)				
1	72.46	87.16	4.5%	105.05
2	101.53	119.48	6.1%	130.71
3	8.04	49.36	2.4%	66.42
4	103.25	148.77	7.6%	189.14
5	166.23	177.69	9.0%	220.40
6	31.32	75.05	3.7%	91.89
Revised Forecasts During Month m+1 (Table 3.5)				
3	-66.06	79.32	3.9%	91.92
4	48.71	93.75	4.8%	112.14
5	160.36	169.81	8.6%	205.16
Revised Forecasts During Month m+2 (Table 3.6)				
6	5.95	69.82	3.4%	76.95

50 thousand head lower than average absolute errors of the original m+4 forecast. However, errors for revised m+3 forecasts were significantly larger.

Beef production

The simple and autoregressive equations in Tables 3.2 and 3.3 were used to forecast 1980-81 monthly beef production levels using both actual and forecasted slaughter. Results are presented in Table 4.4. When known slaughter levels were used, both the simple and autoregressive beef production equations were reasonably accurate. Average absolute errors for the simple and autoregressive beef production forecasts were 2.7% and 0.67% of the mean. When forecasted slaughter levels were used, average absolute errors ranged from 5.8% to 6.9% of the mean for the simple equation, and from 4.6% to 6.1% for the autoregressive equation.

Autoregressive beef production forecasts were more accurate than simple equation forecasts when known slaughter levels and errors of the previous period were used. When forecasted slaughter figures were used, the autoregressive beef production equation was more accurate than the simple equation for 1-3 month forecasts, but was less accurate for 4-6 month forecasts.

In addition, simple and autoregressive non-fed cattle slaughter and revised and unrevised fed cattle slaughter forecasts were tested in order to further evaluate the usefulness of these alternative forecasting equations. Beef production forecasts made using autoregressive non-fed cattle slaughter forecasts were more accurate than those obtained using simple non-fed slaughter forecasts. Average absolute errors were anywhere from 2 to 25 million pounds less when autoregressive non-fed cattle slaughter forecasts were used to make beef production forecasts. In general, revised fed cattle slaughter forecasts using 7-state

Table 4.4

Accuracy of 1980-81 Beef Production Forecasts

	Months Beyond Forecast Month	Average Residual (million pounds)	Ave Abs Residual (million pounds)	Ave Abs Res as % of mean	RMSE
Simple Equation (Table 3.2)					
-using known slaughter		48.48	48.48	2.7%	51.14
-using simple non-fed slaughter forecasts and the following fed slaughter forecasts:					
Base	1-3	123.03	125.55	6.9%	154.68
Revised	1-3	108.17	116.5	6.4%	144.83
Base	4-6	101.62	106.17	5.8%	132.79
Revised	4-6	83.16	108.23	6.0%	128.37
Autoregressive Equation (Table 3.3)					
-using known slaughter		7.05	12.44	0.7%	14.62
-using simple non-fed slaughter forecasts and the following fed slaughter forecasts:					
Base	1-3	77.67	107.74	5.9%	130.85
Revised	1-3	54.65	104.95	5.8%	127.86
Base	4-6	102.99	108.45	6.0%	135.62
Revised	4-6	80.04	111.17	6.1%	131.89
-using autoregressive non-fed forecasts and the following fed slaughter forecasts:					
Base	1-3	31.28	99.23	5.5%	120.57
Revised	1-3	39.99	102.40	5.6%	123.43
Base	4-6	64.56	82.89	4.6%	108.00
Revised	4-6	44.19	89.99	5.0%	110.02

placements data did not improve the accuracy of the beef production forecasts. In most cases, average absolute errors actually increased. Surprisingly, 4-6 month beef production forecasts were no less accurate than 1-3 month forecasts.

Price Forecasts

All of the simple, complex, and autoregressive price models of Chapter II were tested over the 1980-81 period using both known and forecasted levels of beef production and percent fed cattle slaughter. Actual levels of all other variables were used.

Using known levels of all explanatory variables

The results of 1980-81 price "forecasts" using actual levels of all explanatory variables, including beef production and percent fed cattle slaughter, are shown in Table 4.5. Average errors, average absolute errors, and the root mean square error (RMSE) of the forecast are reported for each of the simple, complex, and autoregressive price models presented in Tables 2.2, 2.3, 2.4, and 2.5. With the exception of the complex models, models specified as a linear relationship were more accurate than similar logarithmic models in forecasting 1980-81 cattle prices.

Table 4.5

Accuracy of 1980-81 Cattle Price Forecasts
Using Known Levels of Explanatory Variables

Model	Average Residual	Ave Abs Residual	Ave Abs Res as % of mean	RMSE
	$/cwt			
Simple Models (Table 2.2)				
Linear	3.82	4.12	6.3%	4.36
Logarithmic	4.56	4.90	7.5%	5.79
Complex Models (Table 2.3)				
Linear	-2.39	3.64	5.6%	4.56
Logarithmic	-0.49	3.11	4.8%	3.82
Simple Autoregressive Models (Table 2.4)				
Linear	1.04	2.00	3.1%	2.59
Logarithmic	1.14	2.44	3.7%	3.03
Complex Autoregressive Models (Table 2.5)				
Linear	0.97	2.02	3.1%	2.73
Logarithmic	0.93	2.41	3.7%	3.21

Simple vs. complex   Complex models not corrected for serial correlation were more accurate than simple uncorrected models. Autoregressive models were more accurate than similar uncorrected models, when errors of the previous period were known. Simple autoregressive models performed just as well as complex autoregressive models.

Using forecasted beef supply

Each price model in Chapter II was tested using both simple and complex beef production and percent fed cattle slaughter forecasts. Simple supply forecasts were made using the cow and bull slaughter equation from Table 3.9, simple non-fed cattle slaughter equations from Table 3.7, unrevised fed cattle slaughter equations from Table 3.4, and the simple beef production equation of Table 3.2 containing an intercept and dummy variables. Complex beef supply forecasts differed in that autoregressive non-fed cattle slaughter equations (from Table 3.8) and the autoregressive beef production equation (from Table 3.3) were used.

Results of 1980-81 price forecasts using forecasted beef production and percent fed cattle slaughter are presented in Table 4.6. Average absolute residuals ranged from $3.37 to $8.80. The following are the key findings of the various comparisons made between models:

Linear vs. logarithmic   Again, in almost every case linear price forecasting models were more accurate than similar logarithmic models.

Simple vs. complex price models   Contrary to the results obtained using known beef production and percent fed cattle slaughter levels, uncorrected simple models were more accurate than uncorrected complex models in forecasting 1980-81 cattle prices. When combined with downward

Table 4.6

Accuracy of 1980-81 Cattle Price Forecasts Using Forecasted Beef Production and Percent Fed Cattle Slaughter

	Months Beyond Forecast Month	Average Residual $/cwt.	Ave Abs Residual $/cwt.	Ave Abs Res as % of mean	RMSE
<u>Simple Price Models</u> (Table 2.2)					
-using simple supply forecasts:					
Linear	1-3	-.11	4.14	6.3%	4.91
Logarithmic	1-3	-1.11	5.31	8.1%	6.29
Linear	4-6	0.59	3.62	5.5%	4.61
Logarithmic	4-6	-0.09	4.62	7.1%	5.80
-using complex supply forecasts:					
Linear	1-3	2.86	4.91	7.5%	6.02
Logarithmic	1-3	3.07	6.00	9.2%	7.15
Linear	4-6	1.78	3.83	5.9%	4.90
Logarithmic	4-6	1.65	4.68	7.2%	5.83
<u>Complex Price Models</u> (Table 2.3)					
-using simple supply forecasts:					
Linear	1-3	-7.44	8.11	12.4%	9.71
Logarithmic	1-3	-7.95	8.80	13.5%	10.70
Linear	4-6	-6.74	7.45	11.4%	8.80
Logarithmic	4-6	-7.27	8.32	12.7%	9.81
-using complex supply forecasts:					
Linear	1-3	-3.74	6.26	9.6%	8.06
Logarithmic	1-3	-2.84	6.41	9.8%	8.65
Linear	4-6	-5.36	6.41	9.8%	7.92
Logarithmic	4-6	-5.39	6.92	10.6%	8.56

Table 4.6 (cont.)

	Months Beyond Forecast Month	Average Residual ($/cwt.)	Ave Abs Residual ($/cwt.)	Ave Abs Res as % of mean	RMSE
Simple Autoregressive Price Models (Table 2.4)					
-using simple supply forecasts:					
Linear	1-3	1.84	3.57	5.5%	4.34
Logarithmic	1-3	1.82	4.49	6.9%	5.14
Linear	4-6	3.18	4.03	6.2%	5.29
Logarithmic	4-6	2.14	3.96	6.1%	4.77
-using complex supply forecasts:					
Linear	1-3	3.09	4.16	6.4%	5.23
Logarithmic	1-3	3.40	4.95	7.6%	5.96
Linear	4-6	3.99	4.46	6.8%	5.77
Logarithmic	4-6	2.64	3.95	6.0%	4.85
Complex Autoregressive Price Models (Table 2.5)					
-using simple supply forecasts:					
Linear	1-3	0.55	3.85	5.9%	4.32
Logarithmic	1-3	-0.23	4.92	7.5%	5.54
Linear	4-6	0.74	3.37	5.2%	4.17
Logarithmic	4-6	-0.95	4.10	6.3%	5.00
-using complex supply forecasts:					
Linear	1-3	2.00	4.12	6.3%	5.06
Logarithmic	1-3	1.64	4.93	7.5%	5.96
Linear	4-6	1.42	3.48	5.3%	4.40
Logarithmic	4-6	-0.05	3.98	6.1%	4.90

biased supply forecasts, uncorrected complex models (which tended to overpredict 1980-81 prices using known supply levels) consistently forecasted cattle prices which were higher than actual levels. Average absolute errors for simple and complex autoregressive models were very similar.

Uncorrected vs. autoregressive price models   Models corrected for serial correlation were more accurate in forecasting 1980-81 steer prices than similar uncorrected models, expecially in the case of the complex models. In the simple models, autoregressive 1-3 month price forecasts were more accurate, while 4-6 month autoregressive forecasts tended to be slightly less accurate than those of uncorrected models.

1-3 month vs. 4-6 month forecasts   In general, 4-6 month price forecasts were no less accurate than similar 1-3 month forecasts.

Simple vs. complex supply forecasts   In most cases, simple beef production and percent fed cattle slaughter forecasts resulted in more accurate price forecasts than complex supply forecasts, despite the fact that complex beef production forecasts were more accurate. However, complex beef production and percent fed cattle slaughter forecasts did result in more accurate price forecasts than simpler production and slaughter forecasts in the complex uncorrected price models.

The linear complex autoregressive model forecasted 1980-81 prices more accurately than any model tested. Average absolute errors were \$3.85/cwt for 1-3 month forecasts and \$3.37/cwt for 4-6 month forecasts, with a slight downward bias of \$0.55 and \$0.74 respectively. The standard deviation of the forecast errors (RMSE) was \$4.32/cwt and \$4.17/cwt for 1-3 and 4-6 month forecasts, which means that 2/3 of the time forecasted prices fell within approximately +/- \$4.25 of the actual prices. However, the simple linear model was nearly as accurate over the same two year period, with average absolute errors of \$4.14/cwt and \$3.62/cwt for 1-3 and 4-6 month forecasts. The RMSE of the forecast was \$4.91/cwt and \$4.61/cwt respectively. Tables 4.7 and 4.8 compare actual 1980-81 cattle prices to values forecasted by these two models. Most of the forecasting error during 1980-81 was due to large errors throughout the late summer and early fall of 1980, particularly in August when prices were underpredicted by over \$10/cwt. Large forecast errors during this period were common to all models estimated. Although the exact cause is difficult to pinpoint, unusually hot weather during July and August which led to a well-publicized reduction in broiler production, and lower beef and pork production compared to prior expectations may have contributed to these unexpected high market prices.

Table 4.7

Simple Linear Model 1980-81 Cattle Price Forecasts
Using Simple Supply Forecasts

Date	Actual Price	1-3 Months	Residual	4-6 Months	Residual
		$/cwt			
1980:					
Jan.	66.32	73.38	-7.06	73.33	-7.01
Feb.	67.44	72.59	-5.15	72.59	-5.15
Mar.	66.80	66.58	0.22	66.23	0.57
Apr.	63.07	68.53	-5.46	66.74	-3.67
May	64.58	61.89	2.69	62.82	1.76
June	66.29	61.32	4.97	61.88	4.41
July	70.47	66.08	4.39	66.60	3.87
Aug.	73.31	61.29	12.02	61.40	11.91
Sept.	69.68	64.30	5.38	64.00	5.68
Oct.	67.18	62.92	4.26	60.30	6.88
Nov.	65.05	59.84	5.21	57.16	7.89
Dec.	64.29	66.44	-2.15	66.57	-2.28
1981:					
Jan	63.08	64.74	-1.66	63.66	-0.58
Feb.	61.50	66.38	-4.88	63.84	-2.34
Mar.	61.40	65.59	-4.19	62.32	-0.92
Apr.	64.92	70.27	-5.35	67.97	-3.05
May	66.86	63.70	3.16	63.10	3.76
June	68.26	67.96	0.30	68.19	0.07
June	67.86	66.30	1.56	67.42	0.44
Aug.	66.37	62.25	4.12	63.08	3.29
Sept.	65.37	66.53	-1.16	67.91	-2.54
Oct.	61.45	63.25	-1.80	63.63	-2.18
Nov.	59.81	64.23	-4.42	60.05	-0.24
Dec.	59.24	67.06	-7.82	65.71	-6.47
Average Error			-$0.11		$0.59
Average Absolute Error			$4.14		$3.62
% of mean			6.3%		5.5%
RMSE			4.91		4.61

Table 4.8

Complex Linear Autoregressive Model 1980-81 Cattle Price Forecasts Using Simple Supply Forecasts

		$/cwt			
Date	Actual Price	1-3 Months	Residual	4-6 Months	Residual
1980:					
Jan.	66.32	70.48	-4.16	70.05	-3.73
Feb.	67.44	69.04	-1.60	70.17	-2.73
Mar.	66.80	62.79	4.01	64.87	1.93
Apr.	63.07	66.47	-3.40	65.38	-2.31
May	64.58	62.57	2.01	62.95	1.63
June	66.29	60.93	5.36	62.12	4.17
July	70.47	65.15	5.32	64.99	5.48
Aug.	73.31	63.20	10.11	62.83	10.48
Sept.	69.68	65.34	4.34	65.47	4.21
Oct.	67.18	62.51	4.67	61.53	5.65
Nov.	65.05	63.39	1.66	56.97	8.08
Dec.	64.29	67.40	-3.11	65.15	-0.86
1981:					
Jan	63.08	64.91	-1.83	63.60	-0.52
Feb.	61.50	65.13	-3.63	64.47	-2.97
Mar.	61.40	64.76	-3.36	62.99	-1.59
Apr.	64.92	68.89	-3.97	67.26	-2.34
May	66.86	61.09	5.77	63.36	3.50
June	68.26	65.30	2.96	67.81	0.45
June	67.86	64.46	3.40	66.50	1.36
Aug.	66.37	63.16	3.21	63.97	2.40
Sept.	65.37	67.16	-1.79	68.89	-3.52
Oct.	61.45	62.94	-1.49	64.44	-2.99
Nov.	59.81	63.54	-3.73	60.59	-0.78
Dec.	59.24	66.71	-7.51	66.47	-7.27
Average Error			$0.55		$0.74
Average Absolute Error			$3.85		$3.37
% of mean			5.9%		5.2%
RMSE			4.32		4.17

Cattle prices were again affected by variations in poultry supplies in November and December of 1981. Industry sources suggest that several major processors began dumping large inventories of frozen turkeys on the market at bargain prices, which had a negative impact on steer prices. As a result, models overpredicted cattle prices by $4.50 to $7.50. Even though broiler production did not significantly influence cattle prices in models estimated using 1970-79 data, it appears that on occasions large variability in poultry supplies can have a substantial impact on choice steer prices. In periods of unusually high or low poultry slaughter forecasters may want to adjust price forecasts accordingly. In actual practice, models with poultry slaughter included as an explanatory variable probably would have been no more accurate, due to the unpredictable nature of the events which caused these major fluctuations in broiler and turkey supplies.

CHAPTER V

SUMMARY AND CONCLUSIONS

Price Models

The primary objective of this study was to identify the key factors influencing monthly cattle price behavior during the 1970s and incorporate this information into a relatively accurate and easy to use system for forecasting future price levels. The relationships between Omaha choice steer prices and beef production, pork production, and a variety of other demand influences were estimated using monthly 1970-79 data and ordinary least squares regression. Models were estimated in logarithmic form in order to directly obtain percentage price impacts (flexibilities). Models were also estimated as linear relationships to provide less complicated calculation procedures. Relatively simple and more complex models were estimated to match differing abilities and time-constraints of potential users. Where significant serial correlation between error terms was evident, similar autoregressive models were estimated as well.

The key variables found to affect monthly cattle prices during the 1970s were beef production per working day in the month, per capita real disposable income, and fed cattle slaughter as a percent of total commercial cattle slaughter. Pork production per working day failed to have a significant impact upon prices in models corrected for serial correlation. A one percent change in beef production typically resulted in a percentage price impact ranging from -1.24 to -1.52, while a one percent change in per capita real disposable income had a percentage price impact ranging from 3.52 to 3.68.

Supply Models

Since beef production was found to be the key supply variable influencing cattle prices, a series of beef supply equations were developed. Simple and autoregressive models relating beef production in millions of pounds to fed steer and heifer slaughter, non-fed steer and heifer slaughter, and cow and bull slaughter in thousands of head were estimated using 1970-79 data and ordinary least squares regression. Slaughter levels were in turn estimated using various USDA inventory reports such as the number of cattle on feed, the feeder cattle supply, and the cow herd and bull inventory.

The key factors found to influence monthly fed steer and heifer slaughter were the number of steers and heifers on feed in 23 states, the prime interest rate, and recent changes in choice steer prices. The prime interest rate was found to have a negative impact upon fed cattle slaughter rates. Higher interest rates cause producers to market cattle earlier and at lighter weights, and to reduce placements of cattle on feed. Revised equations using monthly 7-state placements of cattle on feed were also estimated. Since 7-state placements can be highly volatile from month to month, the number of cattle placed in a particular month may not be indicative of total numbers of cattle on feed. Consequently, revised forecasts using recent 7-state placements data were no more accurate than the original forecasts based on quarterly 23-state cattle on feed data.

Monthly non-fed steer and heifer slaughter, the most unpredictable element of commercial cattle slaughter, was estimated using the quarterly USDA steer and heifer feeder supply, the prime interest rate, choice feeder steer prices, and range conditions reports. The prime interest rate had a positive effect upon non-fed cattle slaughter. As interest rates rise, fewer cattle are placed on feed, and as a result, subsequent non-fed slaughter increases. Because of the serial correlation present, autoregressive equations were also estimated.

Cow and bull slaughter was best explained by semi-annual bull inventory levels, the number of heifers held for beef cow replacement, and the choice feeder steer price. The bull inventory, which is highly correlated to the cow herd inventory, served as a better index of the size of the beef herd in explaining cow and bull slaughter levels. The number of heifers held for beef cow replacement, included to capture variability in cow slaughter due to the cattle cycle, had the expected negative impact and was highly significant. Higher numbers of replacement heifers indicate that the cattle cycle is in the accumulation phase and that cow slaughter will be lower than normal.

Forecasting Results

All simple and complex price and supply models were tested for forecasting accuracy over the 1980-81 period. The root mean square error of the forecast and average absolute errors were calculated as a measure of accuracy, while average errors were used to show any forecast bias.

Supply forecasts

Overall, the supply model estimated did a relatively good job of forecasting 1980-81 monthly beef production levels. When known slaughter levels were used, average absolute errors for the beef production equation ranged from 2.7% of the mean to 0.7%. When forecasted slaughter levels were used, average absolute errors varied from 4.6% to 6.9% of the mean. All beef production forecasts were biased downward over the two year period. Autoregressive beef production forecasts were more accurate than those from the simple uncorrected beef production model. Four to six month forecasts were no less accurate than one to three month predictions.

When fed steer and heifer slaughter was forecast for 1980-81, average absolute errors varied from 2.4% to 9.0% of the mean. As expected, non-fed steer and heifer slaughter forecasts were the least accurate of all slaughter forecasts. Errors ranged from 25% to 58% of the 1980-81 mean. Autoregressive non-fed steer and heifer equations resulted in slightly more accurate forecasts. Cow and bull slaughter forecasts were off by an average of 6.2% of mean 1980-81 cow and bull slaughter levels.

Price forecasts

All of the simple, complex, and autoregressive price models estimated, including both linear and logarithmic forms, were tested for forecasting accuracy using 1980-81 data. Alternative forecasts were made using known levels of beef production, simple beef production forecasts, and complex beef production forecasts. Complex supply forecasts were obtained using the autoregressive non-fed steer and heifer slaughter and beef production equations. Major conclusions from these comparisons are:

1. Linear models gave more precise price forecasts in 1980-81 than similar logarithmic models.

2. Uncorrected simple price models were more accurate forecasting tools than uncorrected complex models. Simple

autoregressive models were nearly as accurate as complex autoregressive models.

3. Autoregressive price models resulted in lower forecast errors than similar uncorrected models.

4. Price forecasts made using simple beef production forecasts were just as accurate as those using complex beef supply forecasts.

The most accurate forecasts were obtained using the complex linear autoregressive price model and simple beef production forecasts. The average absolute error of forecasts made using this combination was $3.85/cwt for 1-3 month predictions and $3.37/cwt for 4-6 month forecasts, which is 5.9% and 5.2% of the 1980-81 mean cattle price. The root mean square error of the forecast was $4.32/cwt for 1-3 month forecasts and $4.17/cwt for 4-6 month forecasts. Average errors were $0.55 and $0.74 respectively, indicating that price forecasts were slightly downward biased.

Price forecasts made using the simple linear price model and simple beef production forecasts were nearly as accurate as those of the complex autoregressive price model. The average absolute error was $4.14/cwt for 1-3 month forecasts and $3.62/cwt for 4-6 month predictions. Root mean square errors were $4.91/cwt and $4.61/cwt respectively. Simple price forecasts had little bias; average errors for 1-3 and 4-6 month forecasts were -$.11

and $0.59 respectively.

In all of the models estimated, price forecasts for the summer of 1980 resulted in errors in excess of $10/cwt, partly due to low levels of broiler production caused by unusually hot weather. Similarly, large inventories of frozen turkeys during November and December of 1981 were probably the major factor causing forecasted prices to exceed actual cattle prices by $4.50 to $7.50. Forecasters may want to adjust price forecasts in response to major fluctuations in poultry supplies, even though broiler production was not found to have a significant impact upon prices during the 1970s.

Conclusions

Relatively simple price models were nearly as accurate in forecasting 1980-81 cattle prices as more complex autoregressive price models. Each model has its advantages. The simpler price model requires fewer calculations and is less complicated to use than an autoregressive model. However, pork production is included as an explanatory variable in models uncorrected for serial correlation, so in reality, autoregressive models may be more appealing simply because it is not necessary to forecast pork production. Individuals should select those models which best fit their needs, abilities, and time constraints.

A price forecasting example using the complex autoregressive price model and simple supply equations is presented in Appendix B. While none of the calculations required are particularly difficult, they can be time consuming--especially when six different sets of price forecasts are made. However, these models are easily adapted for microcomputer applications. All of the 1980-81 cattle price forecasts for the various models were obtained using an Apple microcomputer and the Visicalc software program. The entire analysis, which involved hundreds of calculations, was completed in two or three days--including the time required for programming.

If individuals find even the simple model forecasts to be too time-consuming and have no access to a microcomputer, then the price impact multiplier or flexibility approach should be considered. This short-cut method involves multiplying the expected percentage change in the explanatory variable by its price impact multiplier to determine the approximate price impact (see Figure 5.1). For instance, suppose that recently reported higher levels of cattle on feed lead you to believe that beef production in August will be 10% higher than the previous August. Using a price impact multiplier of -1.25 (refer to Table 2.6), we would expect this change to translate into a 12.5% reduction in steer prices compared to August levels a year ago, if other factors influencing cattle prices have not

	% change in:		Price Impact Multiplier		% Price Change
Beef Production	________	x	________	=	________
Pork Production	________	x	________	=	________
Income	________	x	________	=	________
Other	________	x	________	=	________
			Seasonal adjustment*	=	________
			Total % change	=	________

Base Period Price		1 + (% price change/100)		Forecast Price
________	x	________	=	________

---

* If year-to-year forecasts are made, ignore the seasonal effect. To find the percentage seasonal price adjustment between any pair of months, using logarithmic models, take the antilog of the difference in the seasonal dummy variable coefficients for the forecast and base periods.

Figure 5.1

Forecasting Worksheet

changed.

If forecasters choose to use models reported here, they can expect forecasts on the average to fall within $3-4 of the actual price, which at first glance, does not appear all too helpful. However, given the uncertainty about prices that prevailed during 1980 and 1981, these forecasts may have been extremely useful. In the spring of 1981, cattle prices were in the mid-60s range and there was a great deal of speculation about which direction they would move in the following months. The USDA was forecasting prices in the high 70s and possibly low 80s for the latter half of the year. The simple model presented in this paper indicated that prices would hold steady in the mid-60s during July-September and fall to $60 in November--which they did. Admittedly, these test "forecasts" were made using known levels of income and inflation, while the USDA prediction was based on expectations of rising real incomes. However, it is unlikely that these models would have forecasted prices as high as $80/cwt. The point is, even though simple model forecast errors still averaged nearly $3/cwt during this six month period, the information provided by these forecasts still would have been extremely valuable in determining the direction and general magnitude of cattle price movements.

Individuals may want to modify price forecasts obtained using these models in several ways. First, forecasters should consider adjusting predictions to account for recent forecast errors. Many variables influencing cattle prices, such as the level of government food program expenditures or the farm-retail margin, were not included in the models due to their unpredictable nature. Forecasters should attempt to identify the causes of recent errors, ascertain if they will continue, and adjust price forecasts accordingly. Secondly, individuals may want to "smooth" the forecast price pattern. Producers are able to make short-run production adjustments involving placements of heavy cattle on feed and the timing of cattle marketings in response to current marketing and price patterns. As a result, average monthly prices typically do not jump up and down in the sporadic fashion which occasionally shows up when each month's supply and price is forecast independently of the preceding or subsequent month. A subjective "smoothing" of the resulting price patterns often can improve the accuracy of independent monthly forecasts.

In addition to serving as a primary source of cattle price forecasts, predictions obtained using these models can be used in numerous other ways. Price forecasts can be used as a basis of comparison for evaluating predictions and recommendations by various market advisory or consulting firms. Many times a price forecast is based upon a key assumption which is not explicitly stated. Differing predictions may help individuals to pinpoint these assumptions and allow them to make more knowledgable decisions.

These price forecasts can also be used to determine if current live cattle futures prices are out of line, and if so, what likely direction they will move. This information can be integrated into a hedging strategy. If forecasted prices are significantly above current futures price levels, producers may want to defer hedging cattle placed on feed. However, if forecasted prices are far below futures prices, cattle feeders would be wise to place hedges immediately. Similarly, these cattle price forecasts can help individuals determine if forward contracting is advantageous.

In summary, the models estimated in this study provide a relatively simple and easy means of forecasting major cattle price movements and approximate price levels. This information can be useful as a primary source of cattle price forecasts, for comparison with other price forecasts and marketing recommendations, and for evaluating hedging and forward contract alternatives.

APPENDIX A

FORECASTING PROCEDURES FOR AUTOREGRESSIVE MODELS

While standard uncorrected models are relatively straight-forward, similar autoregressive models can be more difficult and time-consuming to use. In addition to estimating levels of explanatory variables for the period of concern, one must also calculate the errors from recent time periods. For instance, forecasts using a second-order autoregressive model would be made as follows:

$$Y_t = A + B*X_t + P_1E_{t-1} + P_2E_{t-2}$$

or

$$Y_t = A + B*X_t + P_1(Y_{t-1} - A - B*X_{t-1}) + P_2(Y_{t-2} - A - B*X_{t-2})$$

where E_{t-1} and E_{t-2} are the errors in the preceding two time periods and P_1 and P_2 are the serial correlation coefficients.

One must first forecast errors in the previous two periods using all of the coefficients presented in the autoregressive equation, with the exception of the serial correlation coefficients. Once these uncorrected errors are known, then the autoregressive equation may be used in its entirety (including serial correlation coefficients) to forecast future levels of the dependent variable. However, only in a one month ahead forecast are errors of the two periods preceding the forecasted month known. When forecasts for more than one month ahead are needed, it is necessary to use the most recently available error term in the following manner:

$$E_{t+2} = P*E_{t+1} = P^{2}*E_{t}$$
$$E_{t+3} = P*E_{t+2} = P^{3}*E_{t}$$
$$E_{t+s} = P^{s}*E_{t}$$

Suppose we are using a second-order model to forecast prices two months from now. The current price can be used to calculate the E_{t-2} residual, but since next month's price does not yet exist, E_{t-1} errors are unknown. In this case, the forecasted price would be:

$$Y_{t} = A + B*X_{t} + P_{1}{}^{2}E_{t-2} + P_{2}E_{t-2}$$

If we wish to forecast further into the future the information provided by serial correlation is less useful, since adjusted serial correlation coefficients become smaller and smaller[7].

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[7] Pindyck and Rubinfeld, 1981, pp. 215-216.

APPENDIX B

PRICE FORECASTING EXAMPLE

The following exercise illustrates the procedure and calculations required to make cattle price forecasts one to six months ahead. The models used are the simple slaughter and beef production equations of Chapter III and the linear complex autoregressive price model of Table 2.5. January 1982 cattle inventories and price levels are used to forecast expected prices for February through July of 1982. Note that because an autoregressive price model is used it is also necessary to estimate December and January levels of all explanatory variables in order to calculate forecast errors for those two months. All of the information used in this example would have been available by the last week of January.

1. Forecast cow and bull slaughter (Table 3.9).

Necessary data

July 1 1981 bull inventory (CB) = 2640
July 1 1981 beef cow replacements (BCR)= 6243
Ave. July 1981 feeder steer price (CFSP) = $63.22
January 1 1982 bull inventory (CB) = 2619
January 1 1982 beef cow replacements (BCR) = 6623
Ave. January 1982 feeder steer price (CFSP) = $60.00

Calculation procedure

December 1981 CCBQ	= 230.112 + .633(2640) - .117(6243) - 6.943(63.22) + 3.948	
	= 731.865 + 3.948 =	735.813
January 1982 CCBQ	= 731.865 + 0 =	731.865

```
February 1982 CCBQ = 230.112 + .633(2619) - .117(6623)
                     - 6.943(60) - 53.273
                   = 696.468 - 53.273 =               643.195
March 1982 CCBQ    = 696.468 - 48.273 =               648.195
April 1982 CCBQ    = 696.468 - 92.702 =               603.766
May 1982 CCBQ      = 696.468 - 53.560 =               642.908
June 1982 CCBQ     = 696.468 - 39.273 =               657.195
July 1982 CCBQ     = 696.468 - 52.951 =               643.517
```

2. Forecast non-fed steer and heifer slaughter (Table 3.7).

Necessary data

October 1 1981 feeder cattle supply (SHFS) = 7853
October 1981 prime interest rate (PR) = 18.45%
Ave. October 1981 feeder steer price (CFSP) = $64.07
January 1 1982 feeder cattle supply (SHFS) = 12,748
January 1982 prime interest rate (PR) = 15.75%
Ave. January 1982 feeder steer price (CFSP) = $60.00
Pasture conditions are not reported for
January, so pasture conditions deviations (PCDEV) = 0

Calculation procedure

```
December 1981 CNFQ = -199.679 + .068(7853) + 309.883
          x (LOG10(18.45)) - 7.702(64.07) + 37.709
                   =  233.169  +  37.709 =            270.878
January 1982 CNFQ  =  233.169  +    0    =            233.169

February 1982 CNFQ = -199.679 + .068(12748) + 309.883
          x (LOG10(15.75)) - 7.702(60) - 392.438
                   =  576.082 - 392.438 =             183.644
March 1982 CNFQ    =  576.082 - 317.867 =             258.215
April 1982 CNFQ    =  576.082 - 376.01  =             200.072

May 1982 CNFQ    = -547.492 + .037(12748) + 781.257
      x (LOG10(15.75)) - 9.163(60) - 8.373(0) + 90.408
                 =  309.788 + 90.408  =               400.196
June 1982 CNFQ   =  309.788 + 150.866 =               460.654
July 1982 CNFQ   =  309.788 + 140.529 =               450.317
```

3. Forecast fed steer and heifer slaughter (Table 3.4)

Necessary data

October 1 1981 steers 900-1100# on feed (COFS4) = 2173
October 1 1981 steers 700-900# on feed (COFS3) = 2085

October 1 1981 heifers 700-900# on feed (COFH3) = 1229
October 1981 prime interest rate (PR) = 18.45%
Ave. September 1981 choice steer price (CSP) = $65.37
Ave. October 1981 choice steer price (CSP) = $61.45
October 1981 change in steer prices (CSPDIF) = -$3.92

January 1 1982 steers 900-1100# on feed (COFS4) = 2544
January 1 1982 steers 700-900# on feed (COFS3) = 2115
January 1 1982 heifers 700-900# on feed (COFH3) = 1230
January 1 1982 heifers 500-700# on feed (COFH2) = 882
January prime interest rate (PR) = 15.75%
Ave. December 1981 choice steer price (CSP) = $59.24
Ave. January 1982 choice steer price (CSP) = $60.25
January 1982 change in steer prices (CSPDIF) = $1.01

<u>Calculation procedure</u>

December 1981 CFQ = 1549.761 + .241(2173) + .62(1229) - 797.007(LOG10(18.45)) - 206.710 = 1619.716

January 1982 CFQ = 942.057 + .18(2085) + .638(1229) -224.033(LOG10(18.45)) + 10.513(-3.92) + 195.879 = 1972.502

February 1982 CFQ = 934.016 + .347(2544) + .653(1230) - 637.709(LOG10(15.75) = 1856.457

March 1982 CFQ = 1549.761 + .241(2544) + .62(1230) - 797.007(LOG10(15.75)) = 1971.224

April 1982 CFQ = 942.057 + .18(2115) + .638(1230) - 224.033(LOG10(15.75)) + 10.513(1.01) = 1849.885

May 1982 CFQ = 935.158 + .949(882) + 26.379(1.01) = 1798.819

June 1982 CFQ = 1808.06 + .65(882) - 551.22(LOG10(15.75)) = 1721.395

July 1982 CFQ = 1115.536 + .748(882) = 1775.272

4. Forecast percent fed cattle slaughter.

<u>Calculation procedure</u>

Using the slaughter estimates from steps 1, 2, and 3 percent fed cattle slaughter is calculated by dividing fed steer and heifer slaughter by the sum of all three slaughter categories.

Percent fed cattle slaughter (CPFQ) = CFQ/(CFQ+CNFQ+CCBQ)

December 1981 CPFQ = 1619.716/(1619.716 + 270.878
+ 735.713) = .6167
January 1982 CPFQ = 1972.502/(1972.502 + 233.169
+ 731.865) = .6715
February 1982 CPFQ = 1856.457/(1856.457 + 183.644
+ 643.195) = .6919
March 1982 CPFQ = 1971.224/(1971.224 + 258.215
+ 648.195) = .6850
April 1982 CPFQ = 1849.885/(1849.885 + 200.072
+ 603.766) = .6971
May 1982 CPFQ = 1798.819/(1798.819 + 400.196
+ 642.908) = .6330
June 1982 CPFQ = 1721.395/(1721.395 + 460.654
+ 657.195) = .6063
July 1982 CPFQ = 1775.272/(1775.272 + 450.317
+643.517) = .6188

5. Forecast beef production (Table 3.2)

<u>Calculation procedure</u>

Using fed steer and heifer slaughter (CFQ), non-fed steer and heifer slaughter (CNFQ), and cow and bull slaughter (CCBQ) estimates from steps 1, 2, and 3:

December 1981 BQ = 119.83 + .645(1619.716) + .647(270.878)
+ .352(735.813) + 1.16 = 1599.971

January 1982 BQ = 119.83 + .645(1972.502) + .647(233.169)
+ .352(731.865) = 1800.571

February 1982 BQ = 119.83 + .645(1856.457) + .647(183.644)
+ .352(643.195) - 29.79 = 1632.677

March 1982 BQ = 119.83 + .645(1971.224) + .647(258.215)
+ .352(648.195) - 24.01 = 1762.489

April 1982 BQ = 119.83 + .645(1849.885) + .647(200.072)
+ .352(603.766) - 30.91 = 1624.068

May 1982 BQ = 119.83 + .645(1798.819) + .647(400.196)
+ .352(642.908) - 24.92 = 1740.379

June 1982 BQ = 119.83 + .645(1721.272) + .647(460.654)
+ .352(657.195) - 30.33 = 1729.176

July 1982 BQ = 119.83 + .645(1775.272) + .647(450.317)
+ .352(643.517) - 34.29 = 1748.464

6. Compute the number of working days in the month.

Refer to the Workdays definition in Table 2.1.

Calculation procedure

December 1981 Workdays = 22 normal weekdays + .5(1 weekday holiday) + .33(4 Saturdays) =	23.82
January 1982 Workdays = 20 normal weekdays + .5(1 weekday holiday) + .33(5 Saturdays) =	22.15
February 1982 Workdays = 20 normal weekdays + .33(4 Saturdays) =	21.32
March 1982 Workdays = 23 normal weekdays + .33(4 Saturdays) =	24.32
April 1982 Workdays = 21 normal weekdays + .5(1 weekday holiday) + .33(4 Saturdays) =	22.82
May 1982 Workdays = 20 normal weekdays + .5(1 weekday holiday) + .33(5 Saturdays) =	22.15
June 1982 Workdays = 22 normal weekdays + .33(4 Saturdays) =	23.32
July 1982 Workdays = 22 normal weekdays + .33(5 Saturdays) =	23.65

7. Forecast the U.S. population.

Necessary data

November 1981 population (POP) = 228.5

Calculation procedure

Using the 0.2 million/month growth rule:

December 1981 POP =	228.7
January 1982 POP =	228.9
February 1982 POP =	229.1
March 1982 POP =	229.3
April 1982 POP =	229.5
May 1982 POP =	229.7
June 1982 POP =	229.9
July 1982 POP =	230.1

8. Forecast disposable personal income.

Necessary data

November 1981 disposable personal income (DPI) = 2089.9

Calculation procedure

Assuming that disposable personal income will grow at an annual rate of 10% over the following months:

10% / 12 = 0.83% increase per month.

For simplicity, income is compounded at the rate of .83% per month to approximate a 10% annual growth rate.

December 1981 DPI =	1.0083 * 2089.9 =	2107.32
January 1982 DPI =	1.0083 * 2107.32 =	2124.88
February 1982 DPI =	1.0083 * 2124.88 =	2142.58
March 1982 DPI =	1.0083 * 2142.58 =	2160.44
April 1982 DPI =	1.0083 * 2160.44 =	2178.44
May 1982 DPI =	1.0083 * 2178.44 =	2196.60
June 1982 DPI =	1.0083 * 2196.60 =	2214.83
July 1982 DPI =	1.0083 * 2214.83 =	2233.21

9. Forecast the implicit price deflator index.

Necessary data

October 1981 implicit price deflator (IPD) = 198.4

Calculation procedure

Assuming that prices will increase at an annual rate of 8% over the following months:

8% / 12 = 0.67% increase per month

For simplicity, the price index is compounded at the rate of .67% per month to approximate an 8% annual inflation rate.

November 1981 IPD =	1.0067 * 198.4 =	199.73
December 1981 IPD =	1.0067 * 199.73 =	201.07
January 1982 IPD =	1.0067 * 201.07 =	202.42
February 1982 IPD =	1.0067 * 202.42 =	203.77
March 1982 IPD =	1.0067 * 203.77 =	205.14
April 1982 IPD =	1.0067 * 205.14 =	206.51
May 1982 IPD =	1.0067 * 206.51 =	207.89

June 1982 IPD =	1.0067 * 207.89 =	209.29
July 1982 IPD =	1.0067 * 209.29 =	210.69

10. Forecast Omaha choice steer prices (Table 2.5)

The linear complex autoregressive price model of Table 2.5 was used for this example, although individuals are free to use any of the price models presented in Chapter II which best suit their needs. The one to six month estimates of percent fed slaughter (CPFQ), beef production (BQ), the number of working days (Workdays), population (POP), disposable personal income (DPI), and the implicit price deflator (IPD) from steps 4-9 are used to forecast choice steer prices for the following six months. In addition to these variables, December and January forecast errors are needed since an autoregressive model is used. Recent errors are obtained by using the model in Table 2.5 <u>without the serial correlation coefficients</u> (P's) to estimate December and January prices, which are then subtracted from actual steer prices. See Appendix A for an explanation of autoregressive forecasting procedures.

<u>Necessary data</u>

December 1981 choice steer price (CSP) = $59.24
January 1982 choice steer price (CSP) = $60.25

<u>Calculation procedure</u>

Estimated December 1981 CSP = -30.721 - .665(1599.971/23.82)
+ 3571.904((2107.32/228.7)/201.07) - 23.025(.6167)
- 5.773 = $68.33

Estimated January 1982 CSP = -30.721 - .665(1800.571/22.15)
+ 3571.904((2124.88/228.9)/202.42) - 23.025(.6715) =
\$63.57

December 1981 forecast error = 59.24 - 68.33 = -9.09
January 1982 forecast error = 60.25 - 63.57 = -3.32

Once these recent errors are known, the linear equation of Table 2.5 can be used in its entirety to forecast future price levels.

February 1982 CSP = -30.721 - .665(1632.677/21.32)
+ 3571.904((2142.58/229.1)/203.77) - 23.025(.6919)
- 1.688 + .4143(-3.32) + .2893(-9.09) = \$60.66

March 1982 CSP = -30.721 - .665(1762.489/24.32)
+ 3571.904((2160.44/229.3)/205.14) - 23.025(.685)
- 3.232 + $(.4143)^2$(-3.32) + .2893(-3.32)
= \$64.61

April 1982 CSP = -30.721 - .665(1624.068/22.82)
+ 3571.904((2178.44/229.5)/206.51) - 23.025(.6971)
- 1.359 + $(.4143)^3$(-3.32) + $(.2893)^2$(-3.32)
= \$68.21

May 1982 CSP = -30.721 - .665(1740.379/22.15)
+ 3571.904((2196.6/229.7)/207.89) - 23.025(.633)
- .937 + $(.4143)^4$(-3.32) + $(.2893)^3$(-3.32)
= \$65.65

June 1982 CSP = -30.721 - .665(1729.176/23.32)
+ 3571.904((2214.83/229.9)/209.29) - 23.025(.6063)
-.739 + $(.4143)^5$(-3.32) + $(.2893)^4$(-3.32)
= \$69.63

July 1982 CSP = -30.721 - .665(1748.464/23.65)
+ 3571.904((2233.21/230.1)/210.69) - 23.025(.6188)
- 1.626 + $(.4143)^6$(-3.32) + $(.2893)^5$(-3.32)
= \$68.74

APPENDIX C

ESTIMATION OF SLAUGHTER DATA

Commercial cattle slaughter by class is not available monthly, so it was necessary to estimate all of the slaughter data used in this analysis, with the exception of total monthly commercial cattle slaughter. Since federally inspected slaughter represents roughly 95% of commercial slaughter, it is reasonable to assume that total commercial cattle slaughter (CAQ) has the same proportion of steers, heifers, cows, and bulls as does federally inspected slaughter (FIQ).

Commercial cow slaughter (CCQ) =

(federally inspected cow slaughter/FIQ) x CAQ

Commercial bull slaughter (CBQ) =

(federally inspected bull slaughter/FIQ) x CAQ

Commercial steer slaughter (CSQ) =

(federally inspected steer slaughter/FIQ) x CAQ

Commercial heifer slaughter (CHQ) =

(federally inspected heifer slaughter/FIQ) x CAQ

Commercial cow and bull slaughter (CCBQ) = CCQ + CBQ

Commercial steer and heifer slaughter (CSHQ) = CSQ + CHQ

Federally inspected steer and heifer slaughter is not separated into fed and non-fed components, so monthly fed steer and heifer slaughter (CFQ) must be estimated by distributing quarterly fed slaughter data over the corresponding months using 7-state fed cattle marketings (CMK7), as in the following example:

CMK7	% of quarter		Quarterly CFQ		Monthly CFQ
1589	(1589/4682)	x	6360	=	2158
1488	(1488/4682)	x	6360	=	2022
1605	(1605/4682)	x	6360	=	2180
4682					

Monthly non-fed steer and heifer slaughter (CNFQ) is calculated as the residual of total steer and heifer slaughter (CSHQ) less fed steer and heifer slaughter (CFQ):

Non-fed steer and heifer slaughter (CNFQ) = CSHQ - CFQ

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