

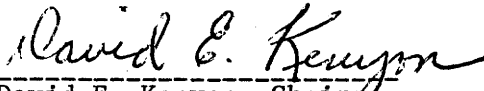
ONE, TWO AND THREE QUARTER FORECASTING
MODELS FOR BROILER PRICE,

by

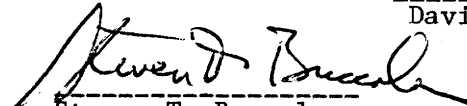
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CHAPTER I

INTRODUCTION

Wide fluctuations in price and net returns have been more nearly the rule than the exception in the broiler industry. Average quarterly net returns for broilers ranged from 11.6 cents per pound in the third quarter of 1975 to a low of -5.3 cents per pound in the fourth quarter of 1976.

The large variation in net returns is accounted for by volatile prices for iced broilers as well as volatile input costs. Between 1973 and 1976, average quarterly iced broiler prices on the Chicago market have been as low as 35 cents per pound and as high as 53 cents per pound while corn prices, the major input, have ranged from \$1.59 to \$3.56 per bushel.

A number of problems which are fairly unique to the broiler industry contribute to the wide price ranges faced by integrated broiler firms. The high perishability of iced broilers usually entails rapid disposal of production. This gives the integrator little time to wait for a higher price and although some storage occurs, the quantity is small and does little to even out price.

Seasonality in the demand for broilers is another problem facing integrators. Since broilers lend themselves well to summer use, there is generally a greater demand and higher prices during the second and

third quarter of each year. During winter, broilers have to compete more directly with turkey and roasting fowl largely because of special holidays during that period. In addition, pork has its strongest demand during the first and fourth quarters.

The production line technology associated with the broiler industry makes it hard to start and stop production in response to changing demand. This adds to price instability.

Another important factor governing broiler prices is their close relationship to pork prices which also fluctuate widely.

Problem

Since 1973 price fluctuations in the broiler industry have been even greater than in previous years. This creates problems for the integrators who produce 95% of commercial broilers marketed. Price fluctuation makes it difficult to plan production especially since a minimum of ten months is required to produce marketable broilers. Important decisions would be easier to make if the integrator had some idea of future price, or at least an indication of whether price would go up or down.

Having a predicted price to work with would also help the integrator plan hedging strategies. Through hedging, it may be possible for the integrator to lock in a profit for his final output; however, the futures market does not always provide an accurate indication of what future broiler prices will be. An integrator who hedges for a guaranteed profit of 2 cents per pound when actual profits are 5 cents per pound might be hesitant to hedge again. If he had a fairly accurate

predicted price to use, he would be better able to hedge at a price which would be advantageous. The further in advance he had a price to use, the longer he would have to wait for a futures price which would be beneficial.

Objective

The objective of this study is to develop a price forecasting model to predict quarterly prices for iced broilers at the Chicago market one, two, and three quarters in advance.

All data used in this study are readily accessible from government publications. The models are true forecasting models in that they predict outside the data base. The models were analyzed by making actual forecasts as someone using the models would have done. The models are developed as user models and all steps in using the models to make a forecast are outlined with examples. The sources of data used to make a forecast are given to make it easy for the model user to understand.

CHAPTER II

REVIEW OF LITERATURE AND STRUCTURE

Literature Review

The importance of seasonality in the demand for broilers has been established in a number of studies. Stanton examined seasonal demand for beef, pork and broilers. Quarterly observations of deflated retail price and per capita consumption of each of the commodities were used to estimate the relationships between them.

The relationships among the variables were estimated by regression with the analysis based on data expressed in logarithms. The regression coefficients, sometimes called "price flexibility" coefficients, indicate the percentage change in price associated with a one percent change in the quantity consumed, other factors constant. The price flexibility coefficient for broiler consumption during summer was found to be $-.568$ while the "cross quantity" coefficients for pork and beef were -2.26 and $+.329$, respectively. This suggests that the relatively high level of broiler consumption during the summer months is not much affected by changes in the prices of other meats. During winter, broiler consumption had a coefficient of $-.577$ while beef was $-.348$ and pork $-.338$, suggesting greater competition during this period. Seasonal changes in demand were also found in the study with quarters 2 and 3 being the greater demand period.

A quarterly simulation model of the livestock and poultry subsectors was performed by Rahn. Since Rahn assumes 95 percent of all commercial broilers are grown under contract or by integrated firms themselves, fundamental production decisions are initiated at the hatchery level. Broiler integrators first express their future production desires through the number of birds tested for pullorum disease and therefore become potential breeders. Breeders are put in the replacement flock at 26 days old and begin laying at about 200 days old. The testing is done sometime during this period since many of the young chicks hatched from infected breeder hens die within a few days.

Using this hypothesis Rahn developed a broiler chick hatch equation which was defined as a function of the present hatchery supply flock, the lagged value of a profitability indicator, seasonal dummy variables and trend. The sum of broiler type chicks tested for pullorum in the three quarters preceding the current quarter was used to indicate the size of the hatchery supply flock. The profitability indicator used was a ratio of wholesale broiler prices to broiler grower feed prices.

From the broiler hatch equation a broiler production equation was developed. Broiler production was found to be a function of the broiler hatch variable lagged one quarter, the profitability indicator lagged one quarter and seasonal dummies. The market age of broilers is eight to ten weeks, so broiler production in any quarter is closely related to broiler hatch in the previous quarter.

Also presented in the Rahn study was an interdependent demand system of price equations, the variables of which are grouped into six

categories. They are those which relate to: (1) prices and supplies of the competing products, (2) the level and distribution of consumer incomes, (3) the general price level, (4) food marketing costs, (5) quality composition changes in the competing meat supplies, and (6) shifts in the level of the functional relation over time.

Broiler price was defined as a function of beef price, pork price, lamb price, turkey price, per capita broiler consumption, the consumer price index, food marketing cost, disposable income, unemployment, trend and seasonal dummies. Pork was by far the most important competing product in determining broiler price. Seasonality was significant in the second, third and fourth quarters with positive t values of 6.82, 6.20 and 3.10, respectively.

The model presented later in this paper basically follows Rahn's development.

Structure

The remainder of this study is organized as follows: Chapter III provides the stages of production, presentation of the models, definitions of the variables, estimation of equations and a description of the procedure used. It includes a summary of other models tried as well as a review of the mechanics of price forecasting. The fourth chapter is devoted to an analysis of the predictive ability of the model and to a comparison of the results with those of previous studies. Chapter IV summarizes the conclusions of the study.

CHAPTER III

PRESENTATION OF THE MODELS

Stages in Production

The time required to grow out a marketable broiler is only about 8 weeks, but the decision making process on production begins long before this. The time frame starts with planning the purchase of replacement breeder chicks and extends 18 months into the future when the last of the broilers are ready for market. From the time replacement chicks are ordered from basic breeders, 10 months is the minimum time required to produce marketable broilers. The decisions made at this point place a maximum constraint on production.

Although the magnitude of the egg supply from the hatchery flock places a ceiling on future output, there is relatively little cost of having excess capacity. This gives a large degree of production flexibility on the down side so that later, during the production process, adjustments can be made. The stages of production and the time required for each are shown in Figure 3-1.

The size of the hatchery flock ultimately determines future broiler hatch. The first problem in estimating future production is to estimate the size of the flock. The proxy variable used to indicate the size of the hatchery supply flock is the sum of pullorum testing in the previous three quarters. When a flock is examined for pullorum, normally

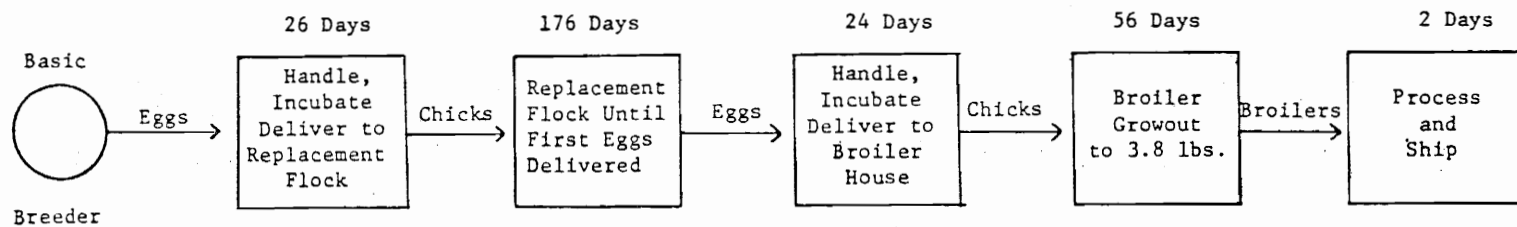


Figure 3-1. Stages of Production.

about 5% of the chicks in the flock are tested.

After the new breeders are in the replacement flock, certain practices can be put into effect to increase or decrease future output depending on what the manager believes to be in the best interest of the firm. The time at which pullet eggs are regarded as suitable for incubation can be increased or decreased. The quality of feed can be raised or lowered. The normal production period of the hatchery supply flock can be lengthened or shortened. Eggs used for hatching can be augmented or diverted by relaxing or tightening grading standards. The size of the broiler chick hatch depends on the size of the hatchery supply flock and decisions made during that stage.

From the receipt of the broiler hatching egg to the delivery of the chick to the broiler house requires a period of 24 days. At this point, decisions are again made which are reflected in future output. The number of chicks to be grown out can be increased or decreased by relaxing or tightening sorting standards.

About 56 days are required from the placing of the chick in the broiler house to the delivery of a 3.8-4.0 pound bird to the dressing plant. Even during this stage, some adjustments in final output can be made. The normal growth period can be extended or reduced. The quality of feed can be modified. The time period in disposing of breeder flocks can be increased or decreased, deciding when the older breeders reach the market.

Thus at the various stages of production managers make a number of decisions which affect final output. Generally the adjustments mention-

ed above have a negative effect on production performance, increasing the marginal cost for each stage. Decisions to increase or decrease output during a particular stage are based on such variables as net returns, input prices, seasonality, expected broiler prices, and prices of competing meats.

The Models

Three models were developed in this study to predict broiler price one, two, and three quarters in advance. Figures 3-2, 3-3, and 3-4 are flow charts of the three models showing the variables and inter-relationships between equations used to forecast broiler price. The models were developed using the time sequence in Figure 3-1, knowledge of the industry and economic theory. Figure 3-2 shows broiler price to be a function of corn price, estimated broiler quantity, estimated pork price and second and third quarter dummy variables. Broiler quantity is predicted using second and third quarter dummy variables, broiler hatch lagged one quarter and a trend variable. Pork price is predicted by using corn price, predicted pork quantity, a fourth quarter dummy variable and a trend variable. Pork quantity is specified as a function of sow farrowing lagged two and three quarters, second, third, and fourth quarter dummy variables and the hog/corn ratio. Figures 3-3 and 3-4 are read in the same manner. The lags on the independent variables in Figures 3-2, 3-3, and 3-4 are relative to the dependent variable in that equation.

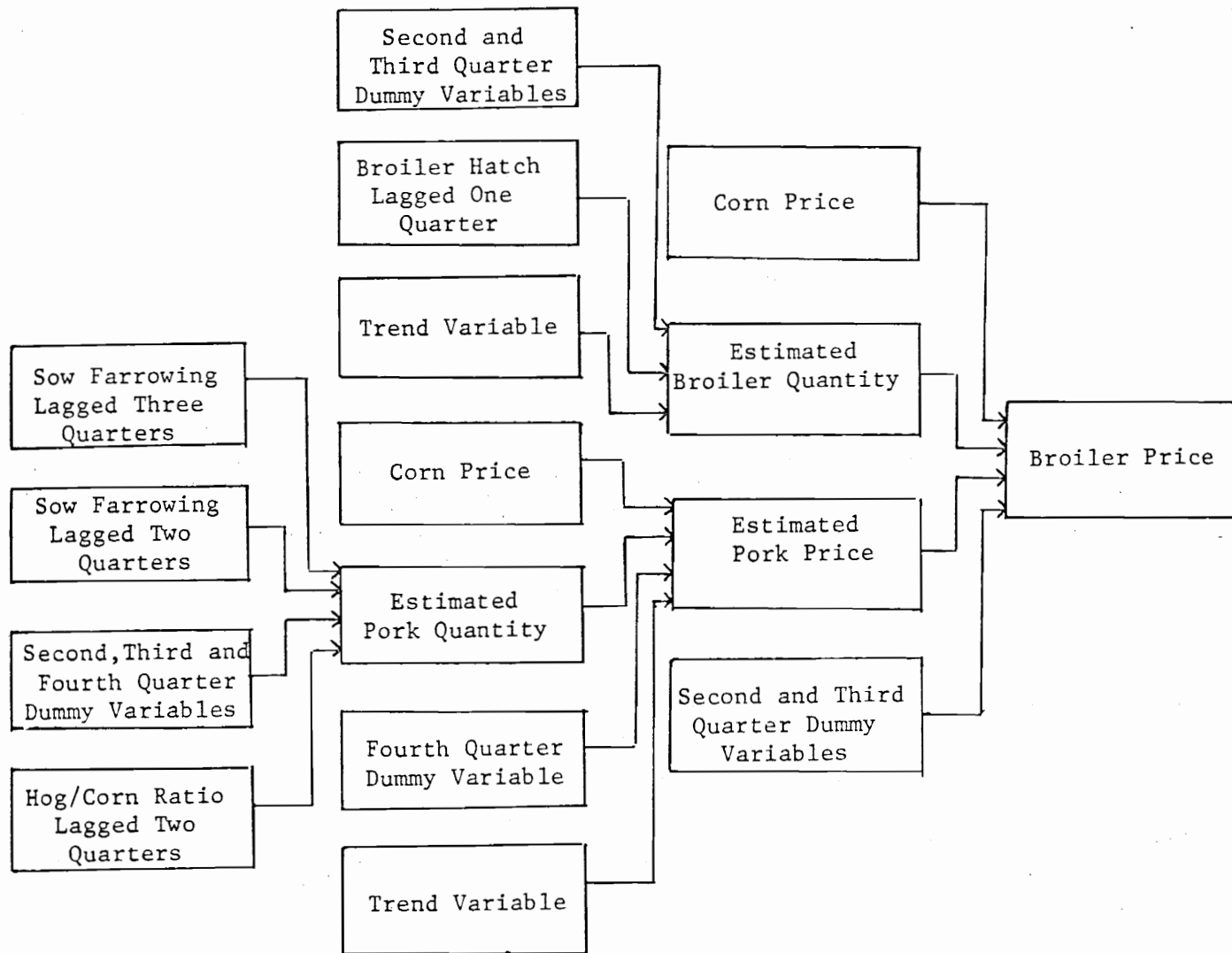


Figure 3-2. One Quarter Broiler Price Forecasting Model.

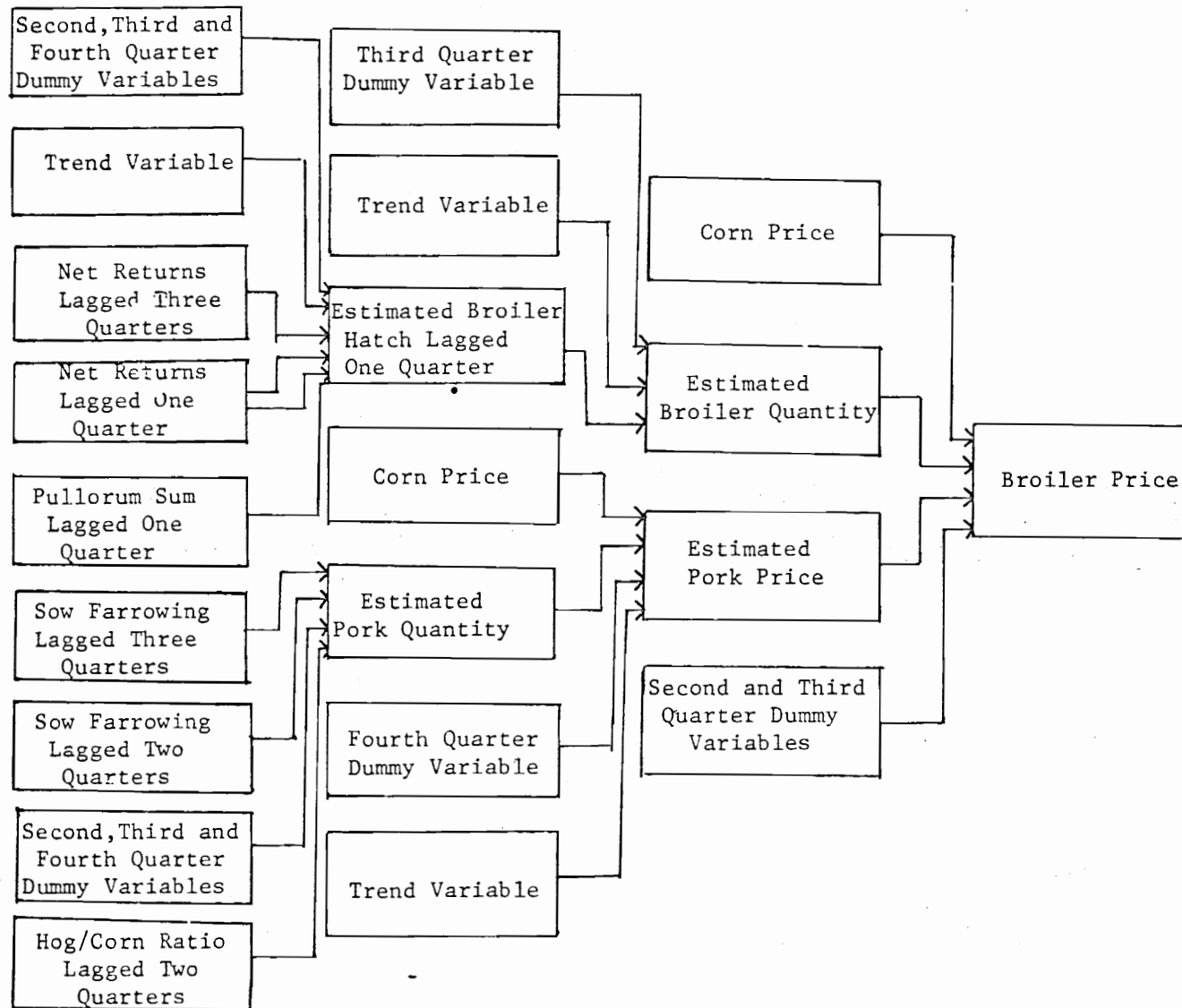


Figure 3-3. Two Quarter Broiler Price Forecasting Model.

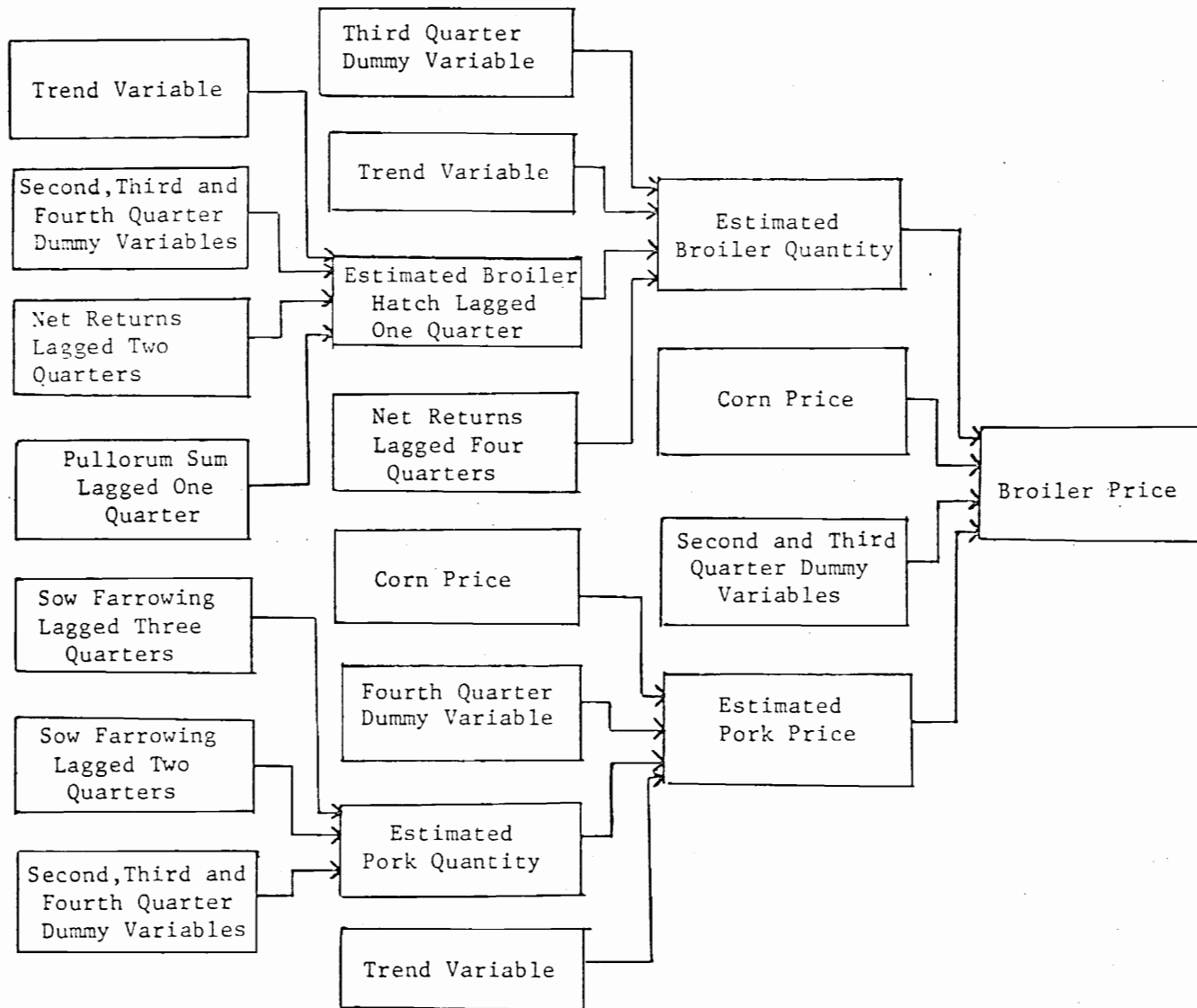


Figure 3-4. Three Quarter Broiler Price Forecasting Model.

Definition of Variables

A short section defining the variables used in the models is presented to clarify and facilitate later discussion.

The following standard notation will be used:

- X(I) - a variable measured quarterly
- EX - the estimated value of X
- X2 - a variable which is different from zero only in the second quarter.
- X3 - a variable which is different from zero only in the third quarter.
- X4 - a variable which is different from zero only in the fourth quarter.
- TV - a trend variable measured yearly; one in 66, two in 67, ... eleven in 77.

Table 3-1 gives the notation used to designate each variable, a short description of each, and the unit of measure.

The quarters in this study have been defined as follows:

- Quarter one - January, February, March
- Quarter two - April, May, June
- Quarter three- July, August, September
- Quarter four - October, November, December

The time period used to estimate the coefficients in the models extended from the first quarter of 1967 through the first quarter of 1977. Data used in this study are given in Appendix B. The following methods were used to put the data on a quarterly basis. Broiler price was calculated as an average of the three months in a given quarter weighted by monthly slaughter. Corn and pork prices are simple averages

Table 3-1. Variable Definitions

Variable	Unit of Measure	Description
BH	Mil.	Broiler Type Chick Hatch
BRP	\$	Price Per Lb., Iced Broiler, Chicago, Trucklot Sales
BRQ	Mil. lb.	Chicken Certified as Wholesome in Federally Inspected Plants, R.T.C. Weights
CRP	\$	Corn Price, Chicago, No. 2 Yellow, Per Bushel
D2	....	One in the Second Quarter, Zero Otherwise
D3	....	One in the Third Quarter, Zero Otherwise
D4	....	One in the Forth Quarter, Zero Otherwise
EBH	Mil.	Est. Broiler Type Chick Hatch
EBRQ	Mil. lb.	Est. Pork Price
EPP	\$	Est. Pork Price
EPQ	Mil. lb.	Est. Pork Slaughter
HCR	....	Hog/Corn Price Ratio, U.S. Basis
NR	¢	Net Returns, Per Pound on Farm Cost Converted to Wholesale Market Values for R.T.C. Broilers
PP	\$	Pork Price, Farm, Per Cwt.
PQ	Mil lb.	Pork Slaughter, Liveweight
PS	Thous.	Sum of Broiler Type Chicks Tested For Pullorum Disease During the Three Quarters Preceding the Indicated Quarter
SF	Thous.	Sows Farrowing, 14 States
TV	....	Trend Variable, One in 1967, Two in 1968,, Eleven in 1977

Source: Taken and calculated from Appendix B.

of the three months in each quarter. Broiler quantity, broiler hatch, pullorum testing and pork quantity are sums of the months in each quarter. Each hog/corn ratio refers to the last month of its quarter, i.e., quarter one uses the March ratio, quarter two the June ratio, and so forth. This is the number of bushels of corn equal in value to 100 lbs. of hog liveweight. If the published ratio is not available at the time the user wishes to make a prediction an estimate can be made using hog and corn prices from the Wall Street Journal. Government reports on sow farrowings are published quarterly but they do not correspond exactly to the quarters defined in this study. Sow farrowings are used in this study as follows:

Quarter one - March-May

Quarter two - June-August

Quarter three - September-November

Quarter four - December-February

Net returns used in the data base are taken from the Poultry and Egg Situation. Published net returns are not always available as soon as the model user wants to make a prediction. Hence, the following formula for deriving net returns is provided to allow the model user to generate this figure. The formula given is the U.S. Department of Agriculture formula and the variable values given are those used for 1977. These values are updated yearly although the variable values used in 1977 are the same as those used in 1976. The formula and variable values were provided by Gerald R. Rector of the Economic Research Service, U.S.D.A.

The formula

$$\text{Fcst} = [([\text{Sbm} \cdot \text{Psbm} + (\text{Corn}/56) \cdot 2000 \cdot \text{Pcorn}] \cdot \text{Fprcun}) \\ + (\text{Fmill} \cdot 100)] / 2000 \cdot \text{Fcun}$$

$$\text{Rcst} = (\text{Fcst} + \text{Acost}) / \text{Dp}$$

$$\text{Tdcst} = \text{Rcst} + \text{Pcost}$$

$$\text{Nr} = \text{Price} - \text{Tdcst} \qquad \text{Eq. 3-1.}$$

Variables

- Acost - Additional production costs, 6.30 cents, difference between total production costs liveweight and feed cost as given in Poultry and Egg Situation
- Corn - Corn price per bushel, No. 2 Yellow Chicago, add 10¢ per bushel delivery cost
- Dp - Dressing percentage, .73, i.e., ready-to-cook weight is 73% of liveweight
- Fcst - Feed cost to produce one pound of liveweight broiler, lagged two months, i.e., feed costs in February are calculated from December prices
- Fcun - Feed conversion rate, 2.10, i.e., 2.10 pounds of feed are needed to produce one pound of liveweight broiler
- Fmill - Feed milling charge, 14.50 dollars per ton
- Fprcun - Variable to account for micro ingredients, 1.05
- Pcorn - Percentage of corn in ration, 70.86
- Pcost - Processing cost ready-to-cook, 11.00 cents per pound
- Price - Price of broilers, nine-city weighted average, cents per pound
- Psbm - Percentage of soybean meal in ration, 29.14
- Rcst - Ready-to-cook cost, cents per pound
- Sbm - Soybean meal 49-50%, price per ton Decatur, add \$12 per ton delivery cost
- Tdcst - Total cost, cents per pound

Net returns are calculated on a monthly basis and are weighted by monthly broiler slaughter.

Example:

Estimate January 1977 net returns.

$$\text{Sbm (in November 1976)} = 193 + 12 = 205$$

$$\text{Corn (in November 1976)} = 2.33 + .10 = 2.43$$

$$\text{Price} = 38.78$$

$$\begin{aligned} \text{Fcst} &= [([205 \cdot 29.14 + (2.43/56) \cdot 2000 \cdot 70.86] \cdot 1.05) \\ &\quad + (14.50 \cdot 100)] / 2000 \cdot 2.10 = 14.89 \end{aligned}$$

$$\text{Rcst} = (14.89 + 6.30) / .73 = 29.03$$

$$\text{Tdcst} = 29.03 + 11.00 = 40.03$$

$$\text{Nr} = 38.78 - 40.03 = -1.25$$

Net returns for January 1977 are -1.25 cents per pound.

Estimation of Equations

Throughout this study an attempt has been made to make the model as easy to use as possible. Consequently, a number of models were tried before the final was arrived at. The criteria used in selecting the final model were the availability of the data and the ability to predict as evidenced by actual prediction behavior.

Broiler quantity can be predicted fairly accurately up to three quarters in advance by predicting broiler hatch for the previous quarter. The first model attempted to predict broiler price as a function of estimated broiler quantity, corn price, seasonal dummies, and trend. This was done in an effort to avoid having to predict the price of competing meats. Unfortunately, this model proved a poor predictor. The predic-

tions made often indicated turning points which did not occur and had a high average error. Actual pork and cattle prices were added to the model to test their significance. Cattle price had an insignificant t - statistic and was eliminated. Predictions were then made using actual pork prices. The predicting ability of the model was greatly improved, both in terms of turning point errors and average error, when pork prices were included.

Several alternative methods of including the impact of the pork sector on broiler prices were tried. Since pork quantity might be easy to predict, it was tried in the broiler price equation. That proved unsuccessful, so futures prices of hogs were tried instead. The futures market proved to be a poor predictor of pork prices and therefore of no help in predicting broiler prices. Finally, a simple pork quantity and price model was developed which improved broiler price predictions.

The coefficients in the equations were estimated by ordinary least squares and are presented in the order they are used in the models. The t - statistics are given below the coefficients.

The decision whether or not to retain a variable in the models was based on a combination of economic theory and of statistical significance as determined by t - values. Since the models are updated quarterly, the t - values constantly changed. What may be insignificant in the 1967-1976 data base may have been significant in the 1967-1974 and were therefore left in the equation. As a general rule, any coefficient that consistently had a t value greater than one was retained.

The forecasts in this study are assumed to have been made during

the last week of the quarter, i.e. forecasts are made during the last week of March, June, September and December.

One Quarter Forecasting Model

This model is intended to forecast broiler price one quarter ahead of the quarter in which the prediction is being made.

Pork Quantity Equation

To predict pork slaughter, two different methods were tried. One method used number of hogs in the various weight classes as published by the U.S.D.A. while the other used sow farrowings. Sow farrowings proved to be a much better predictor of future slaughter. The final model specifies pork quantity to be a function of sow farrowing lagged two and three quarters, the hog/corn ratio lagged two quarters, and seasonal dummies. A trend variable was tried but proved insignificant.

$$\begin{aligned}
 PQ(I) = & 947.392 + .876 SF(I-3) + .818(SF I-2) - 19.673 HCR(I-2) \\
 & [2.94] \quad [5.61] \quad [5.20] \quad [-2.70] \\
 & - 379.799 D4 - 660.879 D3 + 252.593 D2 \\
 & [-2.57] \quad [-3.47] \quad [2.61]
 \end{aligned}$$

$$R^2 = .910 \qquad \text{Eq. 3-2.}$$

The sow farrowing coefficient of the three quarter lag indicates that an increase of 1000 sow farrowings will increase final slaughter by .876 million pounds while the two quarter lag indicates an increase of .818 million pounds per 1000 farrowings. For every increase of 1 in the hog/corn ratio lagged two quarters, there is a decrease of 19.673 million pounds of final slaughter in the quarter being predicted. A possible explanation is that when the hog/corn ratio is high, more animals are

held for breeding.

Pork Price Equation

Pork price is specified to be a function of the estimated pork quantity, corn price, a fourth quarter dummy, and a trend variable. Seasonal dummy variables were tried for the second and third quarters, but were found to be insignificant.

$$\begin{aligned}
 PP(I) &= 69.355 - .012 EPQ(I) + 3.720 CRP(I) + 5.470 D4 \\
 &\quad [7.62] \quad [-7.23] \quad [2.49] \quad [3.38] \\
 &\quad + 1.642 TV(1977) \\
 &\quad [3.82] \\
 R^2 &= .906 \qquad \qquad \qquad \text{Eq. 3-3.}
 \end{aligned}$$

This equation indicates that an increase of a million pounds of hog slaughter decreases the price by 1.2 cents per hundredweight. A one dollar increase in the price of corn per bushel is associated with a \$3.72 increase in pork price. The fourth quarter dummy variable indicates a \$5.47 increase in price during the fourth quarter, while the trend variable indicates that price would go up about \$1.64 per year if slaughter quantity and corn price were to remain constant.

Broiler Quantity Equation

Broiler quantity was found to be a function of broiler hatch lagged one quarter, seasonal dummies for the second and third quarters and a trend variable.

Since the market age of broilers is about eight weeks, the broiler quantity in any given quarter is closely related to the broiler hatch in the previous quarter. A seasonal dummy was tried for the fourth

quarter but proved insignificant. The trend variable was added to account for technological advances in the industry.

$$\begin{aligned} \text{BRQ}(I) &= 30.836 + 2.149 \text{ BH}(I-1) - 75.321 \text{ D3} + 50.430 \text{ D2} \\ &\quad [.30] \quad [13.74] \quad [-3.57] \quad [17.42] \\ &+ 48.935 \text{ TV}(1977) \\ &\quad [17.42] \\ R^2 &= .983 \end{aligned} \quad \text{Eq. 3-4.}$$

The coefficient for the broiler hatch variable indicates an increase in slaughter of 2.15 pounds for every chick hatched. The trend variable indicates an annual increase of 48.935 million pounds. Much of this is probably a result of fewer chicks being lost due to better technology.

Broiler Price Equation

Broiler price is specified to be a function of estimated broiler quantity, estimated pork price, corn price, and seasonal dummy variables for the second and third quarters. A seasonal dummy for the fourth quarter was tested but was statistically insignificant at the 5% level.

$$\begin{aligned} \text{BRP}(I) &= .214 - .000046 \text{ EBRQ}(I) + .005\text{EPP}(I) + .032 \text{ CRP}(I) \\ &\quad [3.42] \quad [-1.13] \quad [4.12] \quad [2.30] \\ &+ .018 \text{ D3} + .017 \text{ D2} \\ &\quad [1.23] \quad [1.11] \\ R^2 &= .834 \end{aligned} \quad \text{Eq. 3-5.}$$

The estimated broiler quantity coefficient indicates that an increase in estimated slaughter of 217.4 million pounds causes the price of broilers to drop one cent. A one dollar per cwt. increase in the price of pork is estimated to increase broiler price by .5 cents per

pound, while a one dollar increase in corn price per bushel would raise broiler price 3.2 cents per pound. Broiler price was found to increase during the second and third quarter.

Two Quarter Forecasting Model

This model attempts to predict broiler price two quarters ahead of the quarter in which the prediction is being made.

Pork Quantity Equation

The variables used in estimating pork quantity in the two quarter forecasting model are the same as those in the one quarter model, therefore the equations are identical.

Pork Price Equation

As in the pork quantity equation, pork price is estimated using the same variables in the two quarter model as the one quarter model, therefore the equations will be the same.

Broiler Chick Hatch Equation

The broiler chick hatch equation is a variation of an equation developed by Rahn. Chick hatch is specified to be a function of the present hatchery supply flock, lagged net returns, seasonal dummy variables, and trend. Rahn [p. 88] specifies the sum of broiler type chicks tested for pullorum in the three quarters preceding the current quarter as the proxy variable to indicate the egg laying flock. If broiler hatch for period (I) is being estimated, the pullorum sum used by Rahn would include chicks tested in quarters (I-1), (I-2), and (I-3). In

this study, the pullorum sum has been lagged one quarter. There is a period of 175 days between the time a breeder is delivered to the replacement flock and the time the first eggs are ready to be incubated. In addition, 24 days are required after the breeder hen begins to lay until the first eggs are hatched. Since the breeder can be tested for pullorum anytime before she starts to lay, it is quite conceivable that some breeders tested in quarter (I-1) will not produce chicks in quarter (I). While it is granted that some breeders will produce chicks in quarter (I), a tradeoff seems justified since it will allow the model to predict further in advance. Over the range of the data a slightly higher R^2 was obtained by using the pullorum sum of quarters (I-2), (I-3), and (I-4) to estimate broiler hatch in quarter (I).

Broiler hatch in this study is specified to be a function of the pullorum sum lagged one quarter, net returns lagged one and three quarters, seasonal dummy variables, and a trend variable. Net returns lagged two quarters proved insignificant when tested and was not included. The trend variable was included to reflect technological advances which have resulted in more chicks per breeder over time. The seasonal dummies reflect seasonality in broiler production.

$$\begin{aligned}
 \text{BH(I)} &= 406.843 + 5.344 \text{ NR(I-3)} + 4.268 \text{ NR(I-1)} + .013 \text{ PS(I-1)} \\
 &\quad [9.21] \quad [4.54] \quad [3.60] \quad [7.16] \\
 &- 63.079 \text{ D4} - 34.526 \text{ D3} + 48.346 \text{ D2} + 23.676 \text{ TV(1977)} \\
 &\quad [-6.52] \quad [-3.46] \quad [5.17] \quad [11.71] \\
 R^2 &= .932 \qquad \qquad \qquad \text{Eq. 3-6.}
 \end{aligned}$$

The coefficient of the three quarter lagged net returns associates

an increase of 5.34 million birds with a one cent increase in profit, while the one quarter lagged net returns indicates an increase of 4.268 million birds with a one cent increase in profit. The pullorum sum variable indicates an increase of 13,000 birds for every additional thousand tested for pullorum. The trend variable indicates that approximately 23.68 million breeders could be removed from the hatchery flock yearly and still maintain a constant level of chick hatch over time.

Broiler Quantity Equation

Broiler quantity for the two quarter forecasting model is specified to be a function of the estimated broiler hatch lagged one quarter, a third quarter seasonal dummy, and a trend variable.

$$\begin{aligned} \text{BRQ}(I) &= -239.407 + 2.551 \text{EBH}(I-1) - 131.638 \text{D3} + 45.298 \text{TV}(1977) \\ &\quad [-1.70] \quad [12.52] \quad [-5.13] \quad [11.96] \\ R^2 &= .967 \end{aligned} \quad \text{Eq. 3-7.}$$

The coefficient for the estimated broiler hatch indicates that broiler slaughter is increased by 2.55 pounds for every chick hatched. The third quarter seasonal dummy indicates lower production during this quarter and the trend variable is associated with a yearly increase in broiler slaughter of about 45.30 million pounds.

Broiler Price Equation

Broiler price is specified to be a function of the estimated broiler quantity, estimated pork price, corn price and seasonal dummy variables for the second and third quarters.

$$\begin{aligned}
 \text{BRP}(I) &= .226 - .000053 \text{ EBRQ}(I) + .005 \text{ EPP}(I) + .035 \text{ CRP}(I) \\
 &\quad [3.62] \quad [-1.32] \quad [4.18] \quad [2.42] \\
 &+ .017 \text{ D3} + .015 \text{ D2} \\
 &\quad [1.19] \quad [1.04] \\
 R^2 &= .829 \qquad \qquad \qquad \text{Eq. 3-8.}
 \end{aligned}$$

The estimated broiler quantity coefficient indicates that an increase in slaughter of 188.7 million pounds is required in order for broiler price to drop one cent. A rise in pork price of one dollar per cwt. is associated with a .5 cent rise per pound in broiler price, while a one dollar per bushel increase in corn price is associated with a 3.5 cent increase in broiler price. As in the first model, broiler price was found to be higher during the second and third quarters, which was expected due to increased demand during the summer. The first quarter is the base season used in this study.

Three Quarter Forecasting Model

Pork Quantity Equation

Pork quantity in the three quarter forecasting model is specified to be a function of sow farrowing lagged two and three quarters and seasonal dummies.

Since farrowing intentions are published by the U.S.D.A., it is possible to use sow farrowing lagged two quarters in the three quarter model. The hog/corn ratio lagged three quarters proved insignificant and was not included.

$$\begin{aligned}
 \text{PQ(I)} &= 574.537 + 1.006 \text{ SF(I-3)} + .697 \text{ SF(I-2)} - 468.854 \text{ D4} \\
 &\quad [1.80] \quad [6.19] \quad [4.23] \quad [-2.98] \\
 &\quad - 532.088 \text{ D3} + 220.272 \text{ D2} \\
 &\quad [-2.64] \quad [2.10] \\
 R^2 &= .889 \qquad \qquad \qquad \text{Eq. 3-9.}
 \end{aligned}$$

The coefficient of the three quarter lagged sow farrowing indicates that an increase of 1000 sow farrowings will increase final slaughter by 1.006 million pounds three quarters later, while the two quarter lag indicates an increase of .697 million pounds per 1000 additional farrowings two quarters later.

Pork Price Equation

As in the two quarter forecasting model, pork price is specified to be a function of estimated pork quantity, corn price, a fourth quarter dummy variable, and a trend variable.

$$\begin{aligned}
 \text{PP(I)} &= 68.520 - .012 \text{ EPQ(I)} + 3.236 \text{ CRP(I)} + 5.386 \text{ D4} \\
 &\quad [6.56] \quad [-6.21] \quad [1.96] \quad [3.02] \\
 &\quad + 1.753 \text{ TV(1977)} \\
 &\quad [3.75] \\
 R^2 &= .888 \qquad \qquad \qquad \text{Eq. 3-10.}
 \end{aligned}$$

An additional million pounds of hog slaughter is associated with a 1.2 cent per pound decrease in price while a one dollar increase in corn price per bushel is associated with a \$3.236 increase in pork price. The demand for pork is generally stronger during winter, which accounts for the price increase during the fourth quarter. The trend variable indicates that pork price would increase \$1.753 per hundredweight if pork quantity and corn price were to remain constant.

Broiler Chick Hatch Equation

Broiler hatch is specified to be a function of the net returns lagged two quarters, pullorum sum lagged one quarter, seasonal dummies, and a trend variable.

$$\begin{aligned} \text{BH(I)} &= 407.872 + 6.511 \text{ NR(I-2)} + .012 \text{ PS(I-1)} - 42.552 \text{ D4} \\ &\quad [8.37] \quad [5.01] \quad [6.26] \quad [-42.5] \\ &- 27.860 \text{ D3} + 86.058 \text{ D2} + 23.764 \text{ TV(1977)} \\ &\quad [-2.78] \quad [7.79] \quad [10.98] \end{aligned}$$

$$R^2 = .913$$

Eq. 3-11.

The coefficient of net returns lagged two quarters indicates an increase of 6.511 million birds per one cent increase in profit. The pullorum sum coefficient indicates an increase of 12,000 birds hatched for every additional thousand breeders tested for pullorum. The trend variable indicates that approximately 23.764 million breeders could be removed from the hatchery flock yearly and still maintain a constant level of chick hatch over time.

Broiler Quantity Equation

Broiler quantity is specified to be a function of net returns lagged four quarters, estimated broiler hatch lagged one quarter, a third quarter seasonal dummy, and a trend variable.

$$\begin{aligned} \text{BRQ(I)} &= -187.374 + 4.548 \text{ NR(I-4)} + 2.494 \text{ EBH(I-1)} \\ &\quad [-1.20] \quad [1.63] \quad [10.99] \\ &- 138.008 \text{ D3} + 43.566 \text{ TV(1977)} \\ &\quad [-5.18] \quad [10.92] \end{aligned}$$

$$R^2 = .967$$

Eq. 3-12.

The estimated coefficient for net returns lagged four quarters indicates that broiler slaughter is increased by 4.548 million pounds for every additional cent of profit. The coefficient for estimated broiler hatch associates an increase in broiler slaughter quantity of 2.494 pounds with every chick hatched. The seasonal dummy indicates a decrease in production during the third quarter as in the two previous models and the trend variable shows an annual increase of 43.566 million pounds.

Broiler Price Equation

As in the first two models, broiler price is specified to be a function of estimated broiler quantity, estimated pork price, corn price, and seasonal dummy variables for the second and third quarters.

$$\begin{aligned} \text{BRP}(I) &= .218 - .000047 \text{ EBRQ}(I) + .004 \text{ EPP}(I) + .037 \text{ CRP}(I) \\ &\quad [3.33] \quad [-1.11] \quad [3.65] \quad [2.36] \\ &+ .018 \text{ D3} + .015 \text{ D2} \\ &\quad [1.18] \quad [.95] \end{aligned}$$

$$R^2 = .813 \qquad \text{Eq. 3-13.}$$

The estimated broiler quantity coefficient associates a one cent drop in broiler price with an increase in slaughter of 212.8 million pounds. The pork price coefficient indicates that a one dollar per cwt. rise in pork price will raise broiler price by .4 cents per pound while a one dollar rise in corn price per bushel is associated with a 3.7 cents per pound increase in broiler price. The seasonal dummies indicate a higher price in the second and third quarters as in the previous models. All equations and t - statistics are summarized in Appendix C.

The Mechanics of Making A Forecast

For the purpose of demonstration, a forecast using all three models will be made. The equations have been estimated using data from the first quarter of 1967 with the first quarter of 1977 being the last observation in the model. The quarters to be predicted are the second, third, and fourth quarters of 1977.

Often the model user will want to make a prediction before the results of the last month of the quarter are available for some variables. This would be particularly true of quantities which often are not available as soon as price data. When this situation occurs, the user must make his best estimate for that month. By using past data, a relatively accurate estimate can usually be made. The forecasts presented as examples in this study were made during the last week in March.

The corn price used to estimate the coefficients in the models is the actual corn price in the quarter being predicted. It is the only variable in any of the models for which no published value is available at the time a prediction is made. When making a price forecast for broilers, the model user must select a corn price to be used in the prediction based on what the user believes the corn price will be in the quarter for which the broiler price prediction is being made. Possibilities include basing the corn price prediction on present price, the futures market price and the model user's knowledge of the commodity. All corn price predictions in this study were made as follows: when broiler price was forecast three quarters ahead, the corn price used

was the price in the quarter the prediction was made. For example, at the end of quarter one if broiler price for quarter four was being predicted, the corn price used was the corn price in quarter one. When broiler price was predicted two quarters ahead, an average of the corn price in the quarter the forecast is being made and the previous quarter's corn price was used. For example, if broiler price for quarter four was being predicted at the end of quarter two, the corn price used was an average of the corn price in quarters one and two. If broiler price was being predicted one quarter in advance, the corn price used was an average of the corn price in the quarter the prediction was made and the two previous quarters. For example, if the fourth quarter broiler price was being predicted at the end of the third quarter, the corn price used would be an average of the corn price in quarters one, two and three.

The method of forecasting corn price as outlined above was used in making all forecasts presented in this study. The analysis required a standardized procedure and therefore the forecast corn price often missed the actual price by more than would have been the case by someone using the model and making their own corn price forecast.

One Quarter Forecasting Model Prediction

The quarter to be predicted with this model is the second quarter of 1977. We are now at the end of the first quarter, 1977. Table 3-2 defines the lags, where the data is taken from and when it is available.

Table 3-2. One Quarter Forecasting Model Lags, Sources and Release Date.

<u>Variable</u>	<u>Definition</u>	<u>Source</u>	<u>Release Date</u>
SF(III)	Sow Farrowing, September-November, 1976	Hogs and Pigs	March, June, Sept., Dec.
SF(IV)	Sow Farrowing, December-February, 1976-77	Hogs and Pigs	March, June, Sept., Dec.
HCR(IV)	Hog/Corn ratio, December, 1976	Feed Situation	Feb., May, Sept., Nov.
EPQ(II)	Pork quantity for Quarter Two, 1977	Estimated by the pork quantity equation	
CRP(II)	Corn price forecast for Quarter Two, 1977	Average of corn price in Quarter One 1977 and Quarters Three and Four of 1976	
D4	Fourth Quarter seasonal dummy variable	Zero in every quarter except the fourth	
TV(1977)	Trend variable	One in 1967, Two in 1968,...Eleven in 1977	
BH(I)	Broiler hatch in Quarter One, 1977	Eggs, Chickens and Turkeys	Monthly
D3	Third Quarter seasonal dummy variable	Zero in every quarter except the third	
D2	Second Quarter seasonal dummy variable	Zero in every quarter except the second	
EBRQ(II)	Broiler quantity in Quarter Two, 1977	Estimated by the broiler quantity equation	
EPP(II)	Pork price in Quarter Two, 1977	Estimated by the pork price equation	

Present Quarter: Quarter One, 1977

Predicted Quarter: Quarter Two, 1977

Source: Calculated by using U.S.D.A. data.

Step 1

The first step in making a forecast of future broiler price is to predict pork quantity.

$$\begin{aligned} \text{PQ(II)} &= 947.392 + .876 \text{ SF(III)} + .818 \text{ SF(IV)} - 19.673 \text{ HCR(IV)} \\ &\quad - 379.799 \text{ D4} - 660.879 \text{ D3} + 252.593 \text{ D2} \end{aligned}$$

$$\begin{aligned} \text{PQ(II)} &= 947.392 + 876 (2520) + .818 (2289) - 19.673 (16.2) \\ &\quad + 252.593 = 4961.2 \end{aligned}$$

In the pork quantity equation SF(III), SF(IV) and HCR(IV) refer to 1976 quarters.

Step 2

Utilizing the estimated pork quantity, the prediction of pork price for the second quarter of 1977 is made.

$$\begin{aligned} \text{PP(II)} &= 69.355 - .012 \text{ EPQ(II)} + 3.720 \text{ CRP(II)} + 5.470 \text{ D4} \\ &\quad + 1.642 \text{ TV(1977)} \end{aligned}$$

$$\begin{aligned} \text{PP(II)} &= 69.355 - .012 (4961.2) + 3.720 (2.62) + 1.642 (11) \\ &= 37.63 \end{aligned}$$

The corn price used, \$2.62, is an average of corn price in quarter one of 1977 and quarters three and four of 1976.

Step 3

This step involves predicting broiler quantity.

$$\begin{aligned} \text{BRQ(II)} &= 30.836 + 2.149 \text{ BH(I)} - 75.321 \text{ D3} + 50.430 \text{ D2} \\ &\quad + 48.935 \text{ TV(1977)} \end{aligned}$$

$$\text{BRQ(II)} = 30.836 + 2.149 (888.2) + 50.430 + 48.935 (11) = 2528.3$$

Step 4

The last step uses the previously estimated pork price, corn price, and broiler quantity to predict broiler price.

$$\begin{aligned} \text{BRP(II)} &= .214 - .000046 \text{ EBRQ(II)} + .005 \text{ EPP(II)} + .032 \text{ CRP(II)} \\ &+ .018 \text{ D3} + .017 \text{ D2} \end{aligned}$$

$$\begin{aligned} \text{BRP(II)} &= .214 - .00046 (2528.3) + .005 (37.63) + .032 (2.62) \\ &+ .017 = .3867 \end{aligned}$$

The second quarter 1977 broiler price prediction is 38.67 cents per pound.

Two Quarter Forecasting Model Prediction

The quarter to be predicted with this model is the third quarter of 1977. This prediction is being made at the end of the first quarter. Table 3-3 defines the lags, the source of the data used to make a prediction and when it is available.

Step 1

$$\begin{aligned} \text{PQ(III)} &= 947.392 + .876 \text{ SF(IV)} + .818 \text{ SF(I)} - 19.673 \text{ HCR(I)} \\ &- 379.799 \text{ D4} - 660.879 \text{ D3} + 252.593 \text{ D2} \end{aligned}$$

$$\begin{aligned} \text{PQ(III)} &= 947.392 + .876 (2289) + .818 (2999) - 19.673 (15.8) \\ &- 660.879 = 4434 \end{aligned}$$

The SF(IV) in this equation refers to the fourth quarter of 1976.

Step 2

The result of the pork quantity equation is then used in the pork price equation.

Table 3-3. Two Quarter Forecasting Model Lags, Sources and Release Date

<u>Variable</u>	<u>Definition</u>	<u>Source</u>	<u>Release Date</u>
SF(IV)	Sow Farrowing, December-February, 1976-77	Hogs and Pigs	March, June, Sept., Dec.
SF(I)	Sow Farrowing, March-May, 1977	Hogs and Pigs	March, June, Sept., Dec.
HCR(I)	Hog/Corn ratio, March, 1977	Calculated from data in the Wall Street Journal	Daily
D4	Fourth Quarter seasonal dummy variable	Zero in every quarter except the fourth	
D3	Third Quarter seasonal dummy variable	Zero in every quarter except the third	
D2	Second Quarter seasonal dummy variable	Zero in every quarter except the second	
EPQ(III)	Pork quantity in Quarter Three, 1977	Estimated by the pork quantity equation	
CRP(III)	Corn price forecast for Quarter Three, 1977	Average of corn price in Quarter One, 1977 and Quarter Four of 1976	
TV	Trend Variable	One in 1967, Two in 1968,...Eleven in 1977	
NR(II)	Net returns in Quarter Two, 1976	Poultry and Egg Situation	March, June, Sept., Dec.
NR(I)	Net returns in Quarter One, 1977	Calculated from formula in text	
PS(I)	Sum of pullorum testing in Quarters Two, Three and Four, 1976	Eggs, Chickens and Turkeys	Monthly
EBH(II)	Broiler hatch in Quarter Two, 1977	Estimated by the broiler hatch equation	
EBRQ(III)	Broiler quantity in Quarter Three, 1977	Estimated by the broiler quantity equation	
EPP(III)	Pork price in Quarter Two, 1977	Estimated by the pork price equation	

Present Quarter: Quarter One, 1977
 Source: Calculated by using U.S.D.A. data.

Predicted Quarter: Quarter Three, 1977

$$\begin{aligned} \text{PP(III)} &= 69.355 - .012 \text{ EPQ(III)} + 3.720 \text{ CRP(III)} + 5.470 \text{ D4} \\ &+ 1.642 \text{ TV(1977)} \end{aligned}$$

$$\text{PP(III)} = 69.355 - .012 (4434) + 3.720 (2.50) + 1.642 (11) = 43.51$$

Step 3

Since broiler quantity for the third quarter is being estimated, the broiler hatch to be predicted is for the second quarter.

$$\begin{aligned} \text{BH(II)} &= 406.843 + 5.344 \text{ NR(III)} + 4.268 \text{ NR(I)} + .013 \text{ (PS(I)} \\ &- 63.079 \text{ D4} - 34.526 \text{ D3} + 48.346 \text{ D2} + 23.676 \text{ TV(1977)} \end{aligned}$$

$$\begin{aligned} \text{BH(II)} &= 406.843 + 5.344 (-0.7) + 4.268 (-0.3) + .013 (16702) \\ &+ 48.346 + 23.676 (11) = 927.7 \end{aligned}$$

The NR(III) in the broiler hatch equation refers to quarter three of 1976 and is predicted using the formula presented earlier in this chapter. The PS(I) is the sum of broiler type chicks tested for pullorum in quarters four, three and two of 1976.

Step 4

The predicted broiler hatch is utilized in estimating broiler quantity for quarter three of 1977.

$$\text{BRQ(III)} = -239.407 + 2.551 \text{ EBH(II)} - 131.638 \text{ D3} + 45.298 \text{ TV(1977)}$$

$$\begin{aligned} \text{BRQ(III)} &= -239.407 + 2.551 (927.7) - 131.638 + 45.298 (11) \\ &= 2493.8 \end{aligned}$$

Step 5

Broiler price is predicted using the estimated pork and corn prices and estimated broiler quantity.

$$\begin{aligned} \text{BRP(III)} &= .226 - .000053 \text{ EBRQ(III)} + .005 \text{ EPP(III)} \\ &+ .035 \text{ CRP(III)} + .017 \text{ D3} + .015 \text{ D2} \end{aligned}$$

$$\begin{aligned} \text{BRP(III)} &= .226 - .000053 (2493.8) + .005 (43.51) \\ &+ .035 (2.50) + .017 = .4159 \end{aligned}$$

The predicted broiler price for the third quarter of 1977 is 41.59 cents per pound.

Three Quarter Forecasting Model Prediction

The quarter to be predicted with this model is the fourth quarter of 1977. Table 3-4 defines the lags, the source of the data and when it is available.

Step 1

Both figures used for sow farrowing are intentions, since actual farrowing has not occurred at the time the prediction is made.

$$\begin{aligned} \text{PQ(IV)} &= 574.537 + 1.006 \text{ SF(I)} + .697 \text{ SF(II)} - 468.854 \text{ D4} \\ &- 532.088 \text{ D3} + 220.272 \text{ D2} \end{aligned}$$

$$\text{PQ(IV)} = 574.537 + 1.006 (2999) + .697 (2637) - 468.854 = 4960.666$$

Step 2

Utilizing the estimated pork quantity, the prediction of pork price for the fourth quarter of 1977 is made.

$$\begin{aligned} \text{PP(IV)} &= 68.520 - .012 \text{ EPQ(IV)} + 3.236 \text{ CRP(IV)} + 5.386 \text{ D4} \\ &+ 1.753 \text{ TV(1977)} \end{aligned}$$

$$\begin{aligned} \text{PP(IV)} &= 68.520 - .012 (4960.666) + 3.236 (2.55) + 5.386 \\ &+ 1.753 (11) = 41.91 \end{aligned}$$

Table 3-4. Three Quarter Forecasting Model Lags, Sources and Release Date

<u>Variable</u>	<u>Definition</u>	<u>Source</u>	<u>Release Date</u>
SF(I)	Sow Farrowing, March-May, 1977	Hogs and Pigs	March, June, Sept., Dec.
SF(II)	Sow Farrowing, June-August, 1977	Hogs and Pigs	March, June, Sept., Dec.
D4	Fourth Quarter seasonal dummy variable	Zero in every quarter except the fourth	
D3	Third Quarter seasonal dummy variable	Zero in every quarter except the third	
D2	Second Quarter seasonal dummy variable	Zero in every quarter except the second	
EPQ(IV)	Pork Quantity in Quarter Four, 1977	Estimated by the pork quantity equation	
CRP(IV)	Corn price forecast for Quarter Four, 1977	Used corn price in Quarter One, 1977	
TU(1977)	Trend variable	One in 1967, Two in 1968,... Eleven in 1977	
NR(I)	Net returns in Quarter One, 1977	Calculated from formula in text	
PS(II)	Sum of pullorum testing in Quarter One, 1977 and Quarters Three and Four, 1976	Eggs, Chickens and Turkeys	Monthly
NR(IV)	Net returns in Quarter One, 1977	Poultry and Egg Situation	March, June, Sept., Dec.
EBH(III)	Broiler hatch in Quarter Three, 1977	Estimated by the broiler hatch equation	
EBRQ(IV)	Broiler quantity in Quarter Four, 1977	Estimated by the broiler quantity equation	
EPP(IV)	Pork Price in Quarter Four, 1977	Estimated by the pork price equation	

Present Quarter: Quarter One, 1977 Predicted Quarter: Quarter Four, 1977
 Source: Calculated by using U.S.D.A. data.

Step 3

Since broiler quantity is to be estimated for the fourth quarter, the broiler hatch predicted will be that of the third quarter.

$$\begin{aligned} \text{BH(III)} &= 407.872 + 6.511 \text{ NR(I)} + .012 \text{ PS(II)} - 42.552 \text{ D4} \\ &\quad - 27.860 \text{ D3} + 86.058 \text{ D2} + 23.764 \text{ TV(1977)} \end{aligned}$$

$$\begin{aligned} \text{BH(III)} &= 407.872 + 6.511 (-.3) + .012 (16870) - 27.860 \\ &\quad + 23.764 (11) = 841.9027 \end{aligned}$$

PS(II) is the sum of chicks tested for pullorum in quarter one of 1977 and quarters three and four of 1976.

Step 4

Using the estimated broiler hatch, a forecast of broiler quantity in the fourth quarter can be made. In this equation NR(IV) refers to the fourth quarter net returns of the previous year.

$$\begin{aligned} \text{BRQ(IV)} &= -187.374 + 4.548 \text{ NR(IV)} + 2.494 \text{ EBH(III)} - 138.008 \text{ D3} \\ &\quad + 43.566 \text{ TV(1977)} \end{aligned}$$

$$\begin{aligned} \text{BRQ(IV)} &= -187.374 + 4.548 (-5.7) + 2.494 (841.9027) + 43.566 (11) \\ &= 2365.6337 \end{aligned}$$

Step 5

The last step uses the previously estimated pork and corn prices and the estimated broiler quantity to predict broiler price.

$$\begin{aligned} \text{BRP(IV)} &= .218 - .000047 \text{ EBRQ(IV)} + .0045 \text{ EPP(IV)} \\ &\quad + .037 \text{ CRP(IV)} + .018 \text{ D3} + .015 \text{ D2} \end{aligned}$$

$$\begin{aligned} \text{BRP(IV)} &= .218 - .000047 (2365.6337) + .0045 (41.91) \\ &\quad + .037 (2.55) = .3898 \end{aligned}$$

The four quarter 1977 broiler price prediction is 38.98 cents per pound.

CHAPTER IV

ANALYSIS OF THE MODELS

In the evaluation of these models, all analysis has been done by making actual predictions outside the data base used to estimate the model being examined. For example, the three quarter model prediction for the first quarter of 1975 was made by using data through the second quarter of 1974.

Because 1973 and 1974 were particularly volatile years for the broiler industry, evaluation started with 1975. Predictions were made with the three models for all four quarters of 1975 and 1976 and the first quarter of 1977 for a total of nine actual predictions each.

Stekler's [438] account of forecasting with econometric models gives three basic criteria to use in the evaluation of a model. An evaluation should include (1) the percentage of turning points in business activity that are forecast correctly, (2) the degree to which the model's rate of change corresponds to the direction and extent of the observed changes, and (3) the performance of the model relative to some naive method of forecasting.

Many of the methods used in this study to evaluate the performance of the models are those suggested by Theil. The first method used was to graph the actual and predicted results to look for underestimation, overestimation, and turning point errors.

The quality of a set of forecasts can be measured by the mean square prediction error which is given by

$$\frac{1}{N} \sum_{t=1}^N (P_t - A_t)^2, \quad \text{Eq. 4-1.}$$

where (p_t, A_t) are predicted and realized percentage changes.

In this study P_t is defined as $p_t - p_{t-1}/p_{t-1}$ where p_t is the predicted price in quarter t and p_{t-1} is the predicted price in the previous quarter. A_t is defined as $a_t - a_{t-1}/a_{t-1}$ where a_t is the actual price in quarter t and a_{t-1} is the actual price in the previous quarter. These definitions will be used throughout the analysis.

The square root of the mean square prediction error gives the measure of error as a percentage. The root-mean-square prediction error is abbreviated as RMS prediction error. It is used to obtain a measure which has the same dimension as the predictions and realizations.

Another method used by Theil is the inequality or U coefficient. If the RMS prediction error is divided by the square root of the mean square successive difference of the realizations, the result is

$$U = \frac{\sqrt{\sum (P_t - A_t)^2 / \sum A_t^2}}{\quad} . \quad \text{Eq. 4-2.}$$

The U value or inequality coefficient will equal zero if all predictions are perfect and one if the forecasts have the same RMS prediction error as no-change extrapolation. The inequality coefficient gives the percentage of the RMS prediction error that would have been observed if the forecasting procedure used has been no-change extrapolation. Since the U coefficient has no finite upper bound, it is possible to do considerably worse than no-change extrapolation.

The square of the numerator of the inequality coefficient can be broken down into a number of terms, each referring to a particular type of prediction error. This decomposition sheds some light on the nature of forecast errors. It is given as

$$\frac{1}{N} \sum (P_t - A_t)^2 = (\bar{P} - \bar{A})^2 = (\bar{P} - \bar{A})^2 + (s_p - s_a)^2 + 2(1-r) s_p s_a$$

Eq. 4-3.

where \bar{P} , \bar{A} , s_p , s_a are the means and standard deviations of the series P_t , A_t respectively and r is their correlation coefficient. These are defined as follows:

$$\bar{P} = \frac{1}{N} \sum P_t \qquad \bar{A} = \frac{1}{N} \sum A_t$$

$$s_p^2 = \frac{1}{N} \sum (P_t - \bar{P})^2$$

$$s_a^2 = \frac{1}{N} \sum (A_t - \bar{A})^2$$

$$r = \frac{1}{N} \sum (P_t - \bar{P}) (A_t - \bar{A}) / s_p s_a$$

The first term, $(\bar{P} - \bar{A})^2$, is zero if and only if the average predicted change coincides with the average realized change. Errors leading to a positive value for this term are called errors in central tendency. If this term is large, the average predicted change deviates substantially from the average realized change, clearly a serious error. The bias proportion is indicated by

$$U^m = (\bar{P} - \bar{A})^2 / \frac{1}{N} \sum (P_t - A_t)^2 \qquad \text{Eq. 4-4.}$$

In fact, each of the terms in Eq. 4-3 is divided by $\frac{1}{N} \sum (P_t - A_t)^2$ to put them on a percentage basis. Their sum will equal 1 or 100%.

If the second term, $(s_p - s_a)^2$, is greater than zero, then the predicted and realized percentage changes have unequal variances. Large values for this term suggest that certain important variables have been omitted from the predicting equation causing a large stochastic error component. The variance proportion is given by

$$U^S = (s_p - s_a)^2 / \frac{1}{N} \Sigma (P_t - A_t)^2 \quad \text{Eq. 4-5.}$$

If the last term, $2(1-r) s_p s_a$, is greater than zero, then r is less than one. Prediction errors which lead to a positive value for this term are called errors due to incomplete covariation. Since it cannot be expected that forecasters will be able to predict such that their points are all located on a straight line, little can be done about this measure. The covariance proportion is given by

$$U^C = 2(1-r) s_p s_a / \frac{1}{N} \Sigma (P_t - A_t)^2 \quad \text{Eq. 4-6.}$$

Another method of testing the accuracy of a model's predictions is by measuring the average error. In this study the average error is defined as

$$AE = \frac{1}{N} \Sigma |p_t - a_t| \quad \text{Eq. 4-7.}$$

where (p_t, a_t) are the predicted and actual prices.

One Quarter Forecasting Model

The first step in testing the model was to graph actual and predicted prices. This is given in Figure 4-1. Except for the first quarter of 1977, the model did a good job of following the trend of

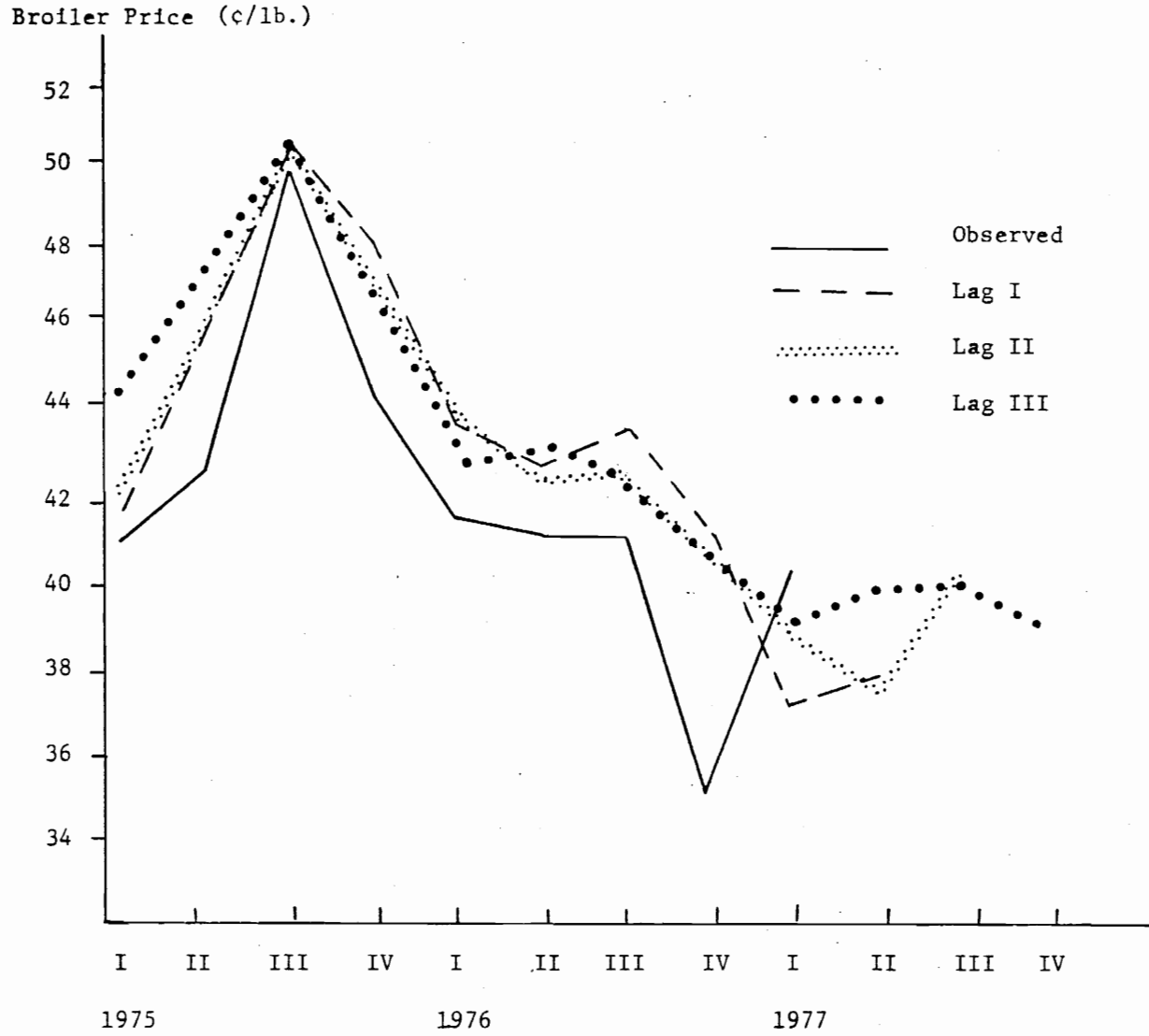


Figure 4-1. Actual and Predicted Broiler Prices.

broiler prices. The model consistently overestimated actual price, however this is not necessarily a problem if the model user is aware of it and can adjust accordingly. The single underestimation came after missing a major turning point in which the model greatly overestimated price. Graphs of the estimated broiler quantity and pork prices were drawn in an attempt to find the source of the overestimation. These are given in Figures 4-2 and 4-3 respectively. It appears that at least part of the overestimation is due to overestimated pork price. However, even in quarters where pork price is underestimated, broiler price is still overestimated. Estimated pork quantity (Figure 4-4) showed no pattern of under or overestimation which might effect pork price and hence broiler price. Estimated broiler quantity showed no evidence of underestimation which might cause broiler price to be overestimated. A comparison of actual and predicted broiler prices over the entire data base indicated no systematic overestimation bias (Figure 4-5). The method of forecasting corn price used in this study often led to corn price being overestimated. This proved to be a partial cause of the overestimation of broiler price. Figure 4-6 shows the predictions made using actual corn prices. Someone using the model who has a knowledge of the market for corn should be able to make more accurate corn price forecasts than the method used in this study. Appendix A gives the actual and estimated values of the above mentioned variables.

In the case of predicted and actual change, no pattern of over or underestimation appears. Given eight observed and predicted changes,

Broiler Quantity (Mil. lb.)

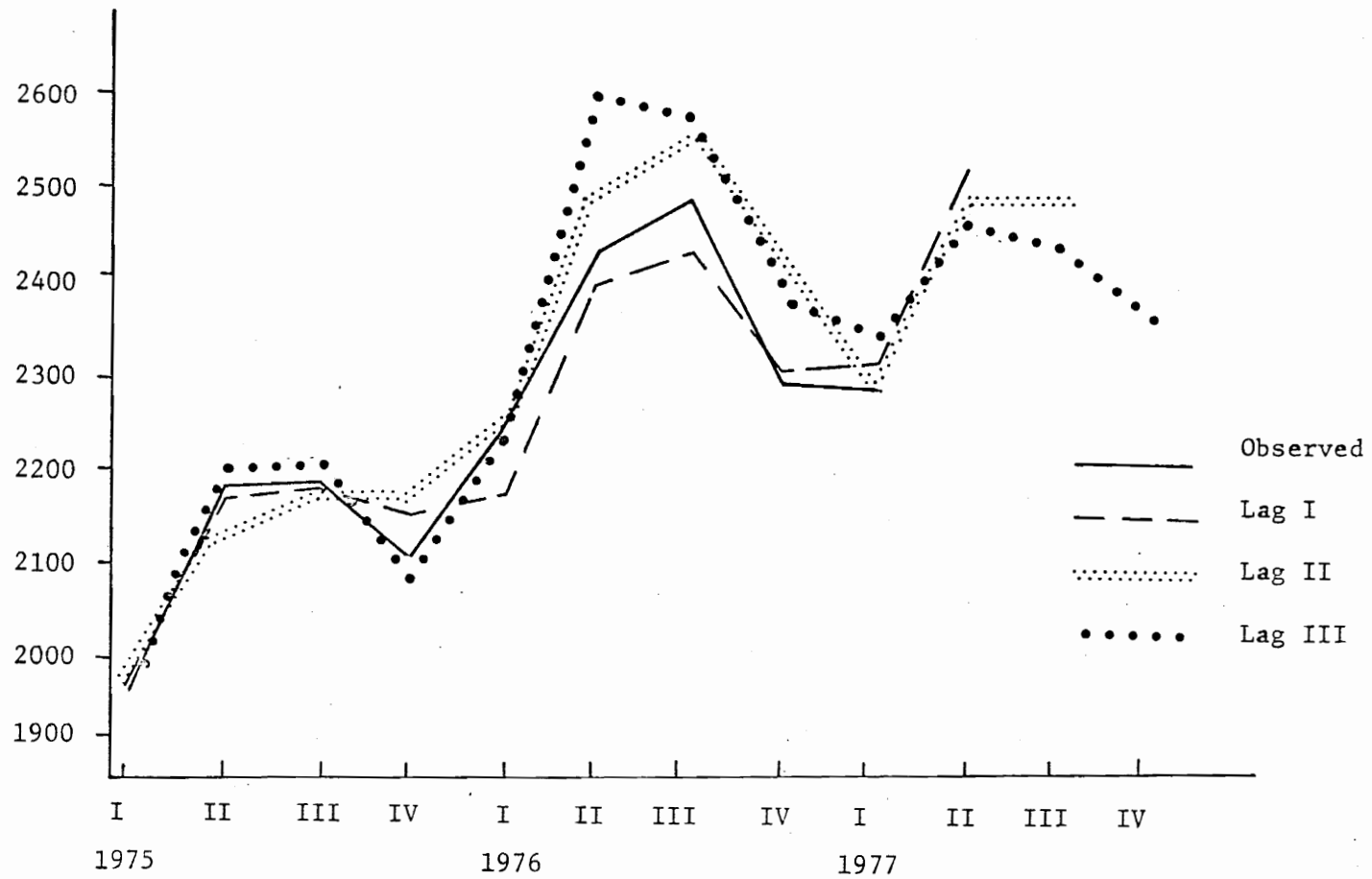


Figure 4-2. Actual and Predicted Broiler Quantity.

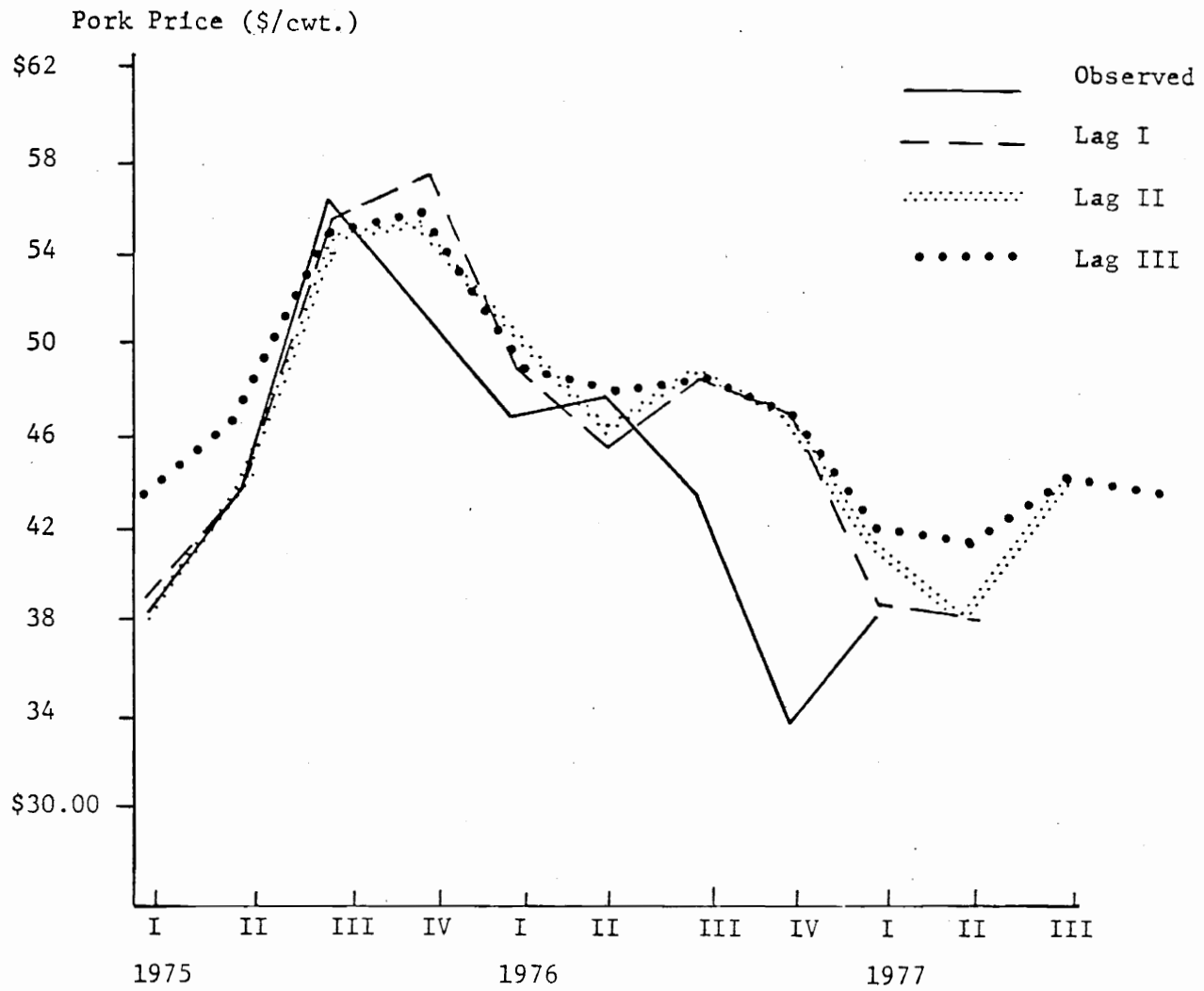


Figure 4-3. Actual and Predicted Price.

Pork Quantity (mil.lb.)

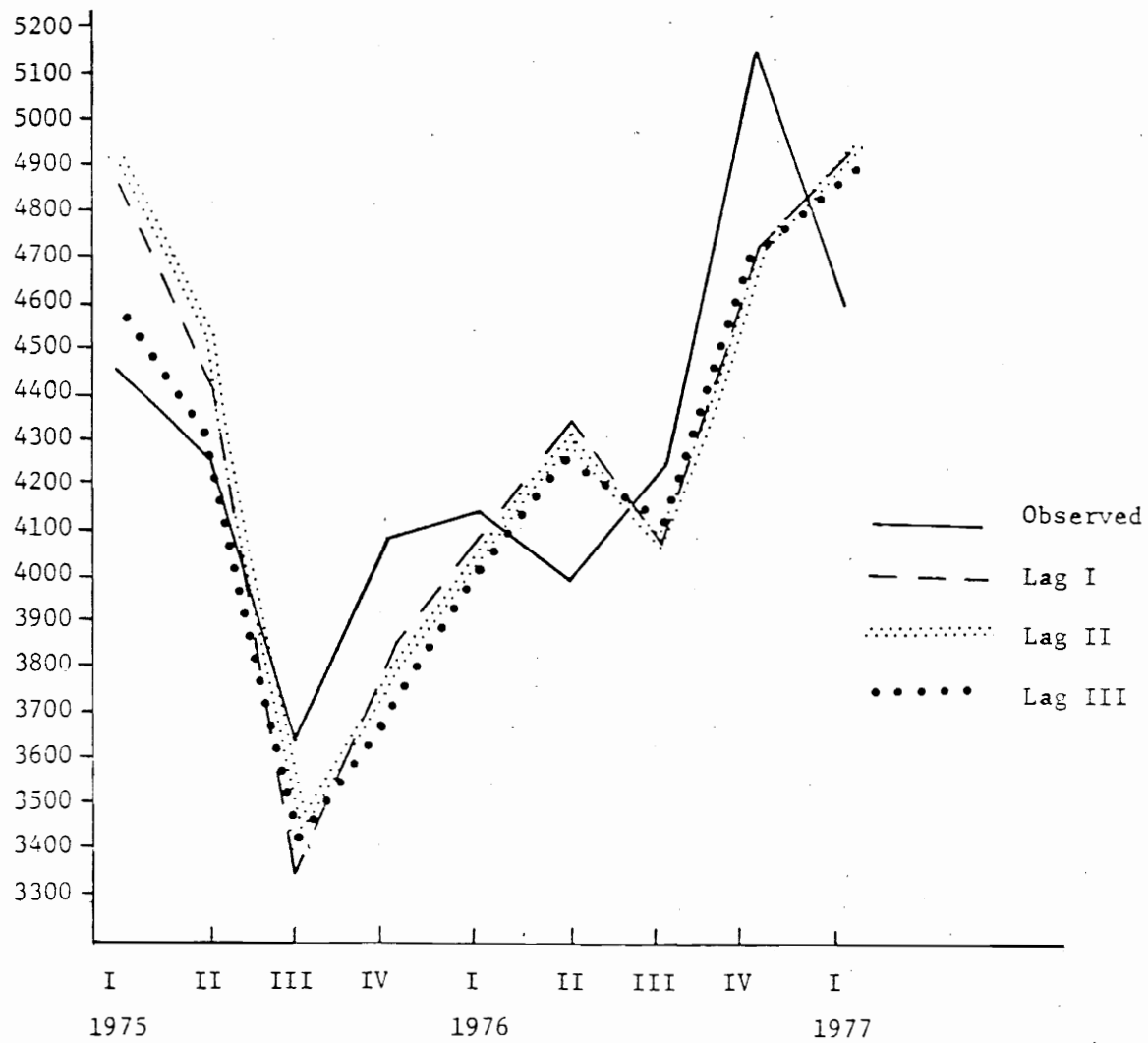


Figure 4-4. Actual and Predicted Pork Quantity.

Broiler Price (c/lb.)

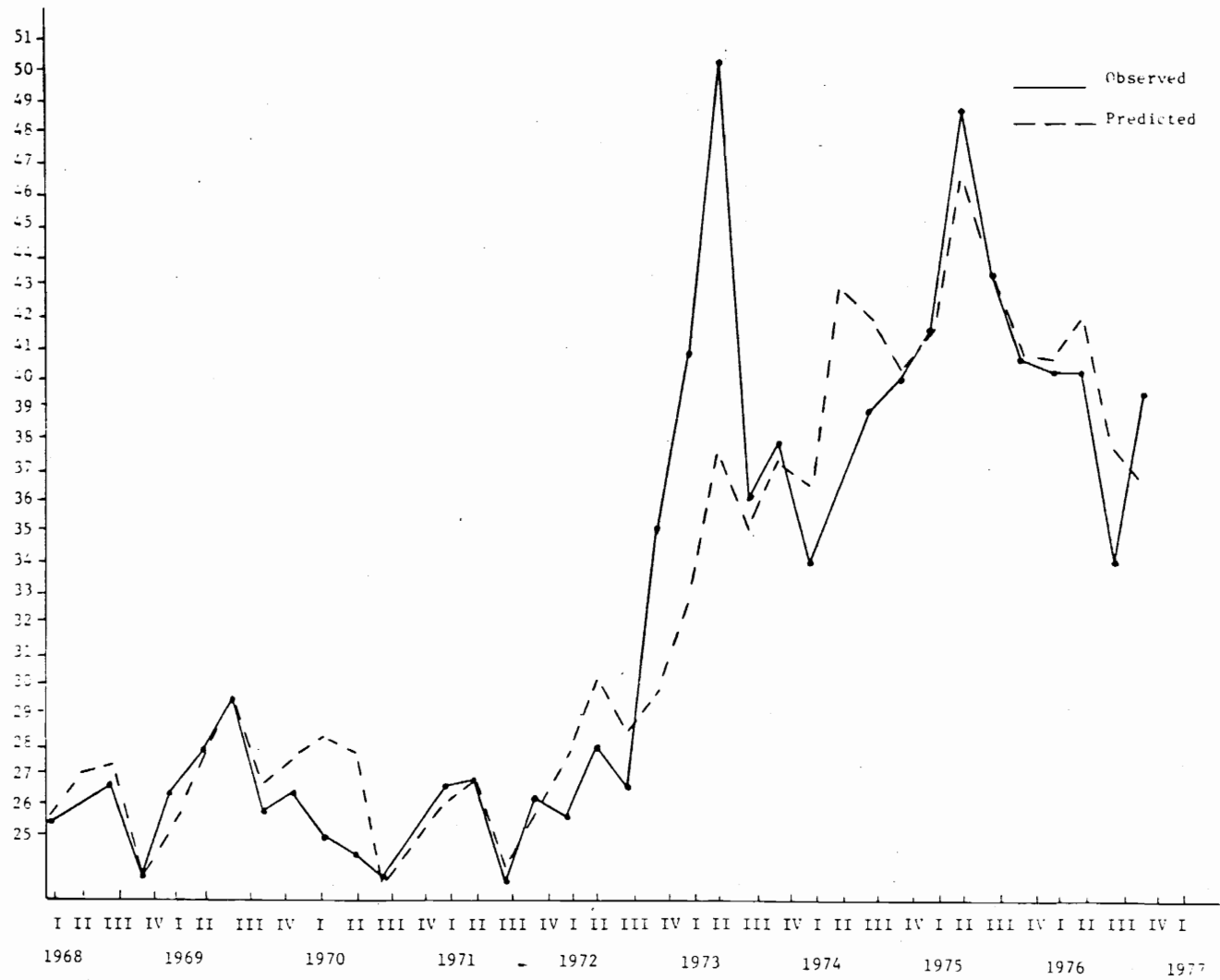


Figure 4-5. Actual and Predicted Broiler Price Over the Data Base.

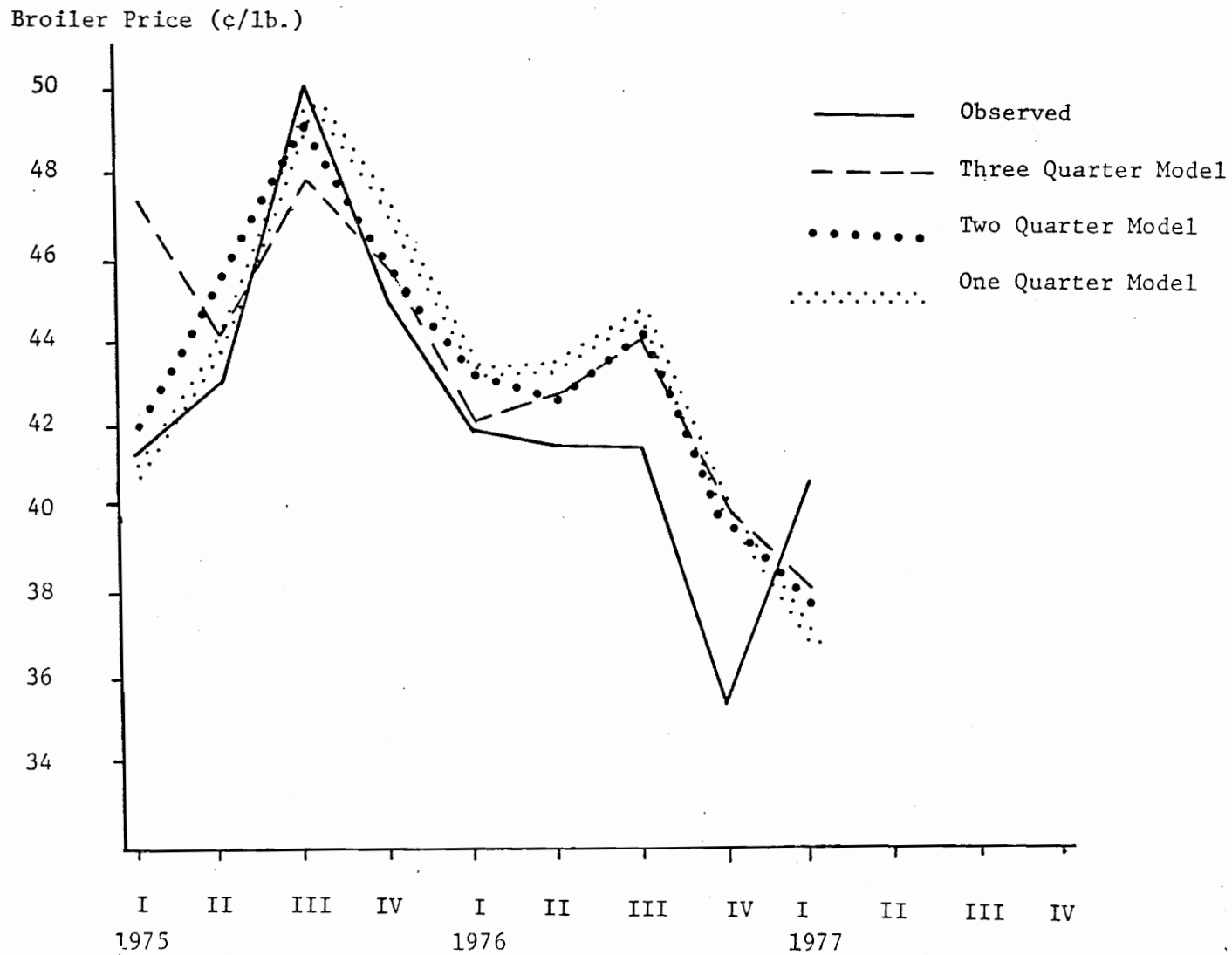


Figure 4-6. Broiler Price Predicted With Actual Corn Price.

there were three cases each of overestimation and underestimation and two cases of missed turning points. These are shown in Table 4-1.

The missed turning point in the fourth quarter of 1976 had a serious effect on the results of the analysis, particularly on the one quarter lag model which missed the change by more than the other two models. The mean square prediction error (Eq. 4-1) for the 9 predictions which involved 8 changes was 108.3074, while the first 7 changes had a mean square prediction error of 32.9158. The RMS prediction error for the 7 changes was 5.7372, while the 8 changes had a RMS prediction error of 10.4071. The U coefficient (Eq. 4-2) was also seriously affected by the fourth quarter 1976 prediction. The prior inequality coefficient of the first 7 changes is .5960, while the 8 change coefficient is .9954. This says that the RMS prediction error is 99.54 percent of the RMS error that would have been observed if the forecaster had used no-change extrapolation.

The square of the numerator of the U coefficient was decomposed (Eq. 4-3) to examine the nature of the errors using all 8 observed changes. The means were found to be $\bar{P} = -1.164$ and $\bar{A} = .352$. The standard deviations were $s_p = 7.12$ and $s_a = 10.45$ and the correlation coefficient $r = .3631$.

The bias proportion U^m (Eq. 4-4) was found to be .021. This means that 2.1 percent of the error is due to errors in central tendency. While errors in central tendency are serious, this amount is not large enough to create a major problem. The variance proportion given by U^s (Eq. 4-5) is .102 or 10.2 percent. The errors due to un-

Table 4-1. Actual and Predicted Broiler Price Changes

Year	Quarter	A_t	P_t One	P_t Two	P_t Three
1975	II	3.97	9.72	8.81	5.38
	III	16.45	9.47	9.30	6.03
	IV	-10.41	- 3.67	-6.77	-6.11
1976	I	- 6.49	- 9.04	-5.76	-8.91
	II	- 0.93	- 2.33	-4.14	0.95
	III	- 0.26	1.74	0.77	-1.61
	IV	-14.58	- 5.01	-4.10	-4.18
1977	I	15.03	-10.19	-5.08	-4.04

Underestimation and Overestimation of Changes and Turning Point Errors

<u>Model</u>	<u>Overestimation</u>	<u>Underestimation</u>	<u>Turning Point Errors</u>	<u>Total</u>
One	3	3	2	8
Two	2	4	2	8
Three	3	3	2	8

Source: Calculated from data in Appendix A.

equal variation do not seem to be a large problem. The largest proportion, 87.5 percent is due to incomplete covariation which little can be done about. This is given by U^C (Eq. 4-6).

The average error (Eq. 4-7) of the one quarter model was found to be 2.63 cents per pound which, except for one observation, was due entirely to overestimation. The observed and estimated values for all three models are given in Appendix A.

Two Quarter Forecasting Model

The two quarter lag model constantly overestimated actual price in all quarters except the last (Figure 4-1). In estimating the 8 observed changes, the model overestimated twice, underestimated four times, and missed two turning points (Table 4-1).

Like the one quarter forecasting model, the results of the tests suggested by Theil were affected by the missed turning point in the fourth quarter of 1976 but not as much as the one quarter model. The missed change raised the mean square prediction error (Eq. 4-1) from 29.8409 to 76.6623 and the RMS prediction error from 5.4627 to 8.7557. The inequality coefficient (Eq. 4-2) went from .5675 to .8374, which means that the RMS prediction error is 83.74 percent of the RMS prediction error that would have occurred using no-change extrapolation.

When the square of the numerator was decomposed (Eq. 4-3), the mean was found to be $\bar{P} = -.871$, the standard deviation $s_p = 6.121$, and the correlation coefficient $r = .5559$.

The bias proportion (Eq. 4-4) was observed to be .019 or 1.9 percent, which is not a serious error. The variance proportion (Eq. 4-5)

was found to be .244 or 24.4 percent, which is somewhat higher than the one quarter lag model. This suggests the possibility that certain important variables may have been left out of the equation. However, the largest portion of the error, 74.1 percent, is due to incomplete covariation (Eq. 4-6) as in the one quarter lag model.

The average error (Eq. 4-7) of the two quarter model was 2.24 cents per pound and again, except for one observation, was due to overestimation.

Three Quarter Forecasting Model

The three quarter model also overestimated price in every quarter except the last (Figure 4-1). In estimating change, it overestimated and underestimated three times each and missed two turning points (Table 4-1).

Although the three quarter model also missed the turning point in the fourth quarter of 1976, its prediction was the best of the three models. Its results were affected the least by the missed turning point. The mean square prediction error (Eq. 4-1) went from 35.3489 to 76.3883 and the RMS prediction error went from 5.9455 to 8.7400. The inequality coefficient (Eq. 4-2) went from .6176 to .8359.

When the square of the numerator was decomposed, (Eq. 4-3), the mean was found to be $\bar{P} = -1.561$, the standard deviation $s_p = 4.918$, and the correlation coefficient $r = .5983$.

The bias proportion, U^m , (Eq. 4-4) was found to be 4.8 percent. While this is slightly higher than the other two models, it is not

high enough to be a serious problem. The variance proportion (Eq. 4-5) was observed to be 40.1 percent, which is much higher than either of the other two models. This is higher than expected and suggests that certain important variables may have been omitted from the equation. The largest proportion, 54.1 percent, is the covariance proportion (Eq. 4-6).

The three quarter model had an average error (Eq. 4-7) of 2.55 cents per pound. A summary of the results of the analysis is given in Appendix D.

As another method of analyzing the model, it was compared with the futures market's ability to forecast price. For purposes of analysis it was assumed that the price forecast was made during the last week of each quarter, i.e., the last week of March, June, September and December. The futures price of broilers in the upcoming quarters was then averaged for the entire week. For example, during the last five days of March, the futures price for April, May and June is averaged for a one-quarter-ahead prediction, July, August and September for a two-quarter-ahead prediction and November for a three-quarter-ahead prediction. In a case where only one or two months of a given quarter were traded, that was the average used.

When futures prices were graphed (Figure 4-7) they showed a tendency to be erratic, particularly when predicting from two and three quarters out. In order to see how well the models presented in this study compare with the futures market's ability to forecast change, U coefficients were calculated for the futures market. In

Broiler Price (¢/lb.)

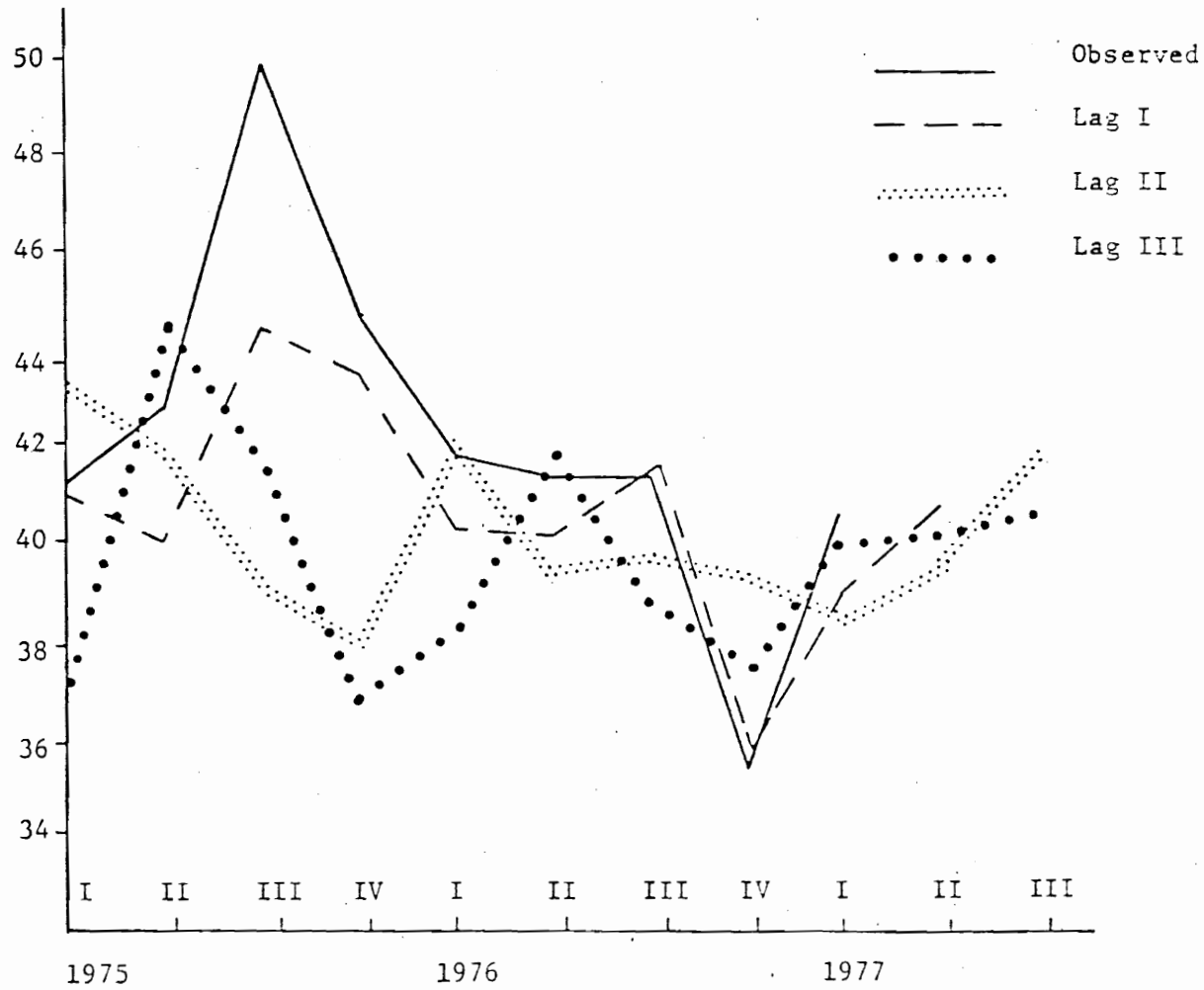


Figure 4-7. Actual Broiler Price vs. Futures Price.

Table 4-2 these are compared with the U coefficients for the models in this study. In ability to predict change one quarter back, the futures market is superior. When predicting two and three quarters back, the models do considerably better. In Table 4-3 the futures predictions are given. F_t refers to the change predicted by the futures market and corresponds to P_t in Table 4-1. The futures market appears to have a tendency to underestimate more often than overestimate change and, except for a one quarter lag, has more turning point errors.

The average error for the futures market when predicting one quarter ahead was 1.66 cents per pound compared to 2.63 cents per pound for the one quarter forecasting model presented in this study. The futures market predicting two quarters ahead had an average error of 3.45 cents per pound, while the two quarter forecasting model's average error was 2.24 cents per pound. The average error for the futures market predicting three quarters ahead was 3.41 cents per pound, while the three quarter forecasting model in this study had an average error of 2.55 cents per pound.

Comparison of Results

The pork quantity and pork price equations given by Rahn are substantially different from those developed in this study; however, some comparisons with the present study can be made. Rahn [80] develops a barrow and gilt slaughter equation which is similar to the pork quantity equations in this study (Eqs. 3-2 and 3-9). Rahn defines barrow and gilt slaughter as a function of sow farrowing lagged

Table 4-2. Inequality Coefficients (U) of the Models Broiler Price Predictions vs. Futures Market Predictions

Quarters Ahead Forecast	Model	Futures
One	0.9954	0.4633
Two	0.8374	1.2898
Three	0.8359	1.1676

Source: Calculated from Broiler Price Changes Predicted by the Models, by the Futures Market and Actual Changes.

Table 4-3. Actual Changes and Futures Predicted Broiler Price Changes

Year	Quarter	A_t	F_t LAG I	F_t LAG II	F_t LAG III
1975	II	3.97	- 2.71	- 3.51	20.33
	III	16.45	11.24	- 6.40	- 6.13
	IV	-10.41	- 2.04	- 3.06	-11.95
1976	I	- 6.49	- 7.40	10.82	3.82
	II	- 0.93	- 0.30	- 6.19	9.04
	III	- 0.26	3.31	0.36	- 6.50
	IV	-14.58	-14.16	- 0.70	- 4.01
1977	I	15.03	9.31	- 2.42	7.41

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Underestimation and Overestimation of Changes and Turning Point Errors

<u>LAG</u>	<u>Overestimation</u>	<u>Underestimation</u>	<u>Turning Point Errors</u>	<u>Total</u>
I	1	5	2	8
II	1	2	5	8
III	3	2	3	8

Source: Calculated from data in Appendix A.

two and three quarters, a profitability indicator and its first difference, seasonal dummies, and trend. He found sow farrowing lagged three quarters to be more significant than sow farrowing lagged two quarters. Similar results were found in this study; however, numerical comparisons cannot be made since Rahn's dependent variable is number slaughtered while this study has total pounds slaughtered as the dependent variable. Rahn had a positive coefficient for the second, third and fourth quarter dummy variables, while this study found negative coefficients for the third and fourth quarter and positive for the second. Since pork slaughter is normally greatest during the fourth quarter, it would be expected to have a positive coefficient; however, sow farrowing is by far greatest during the first quarter. The negative coefficient is the model's correction procedure since an inspection of the data verifies that slaughter is normally greater during quarter four. Rahn's data base is 1956-1970, so some contradictions can be expected.

The pork price equation developed by Rahn [112] is much more complicated than the equations presented in this study (Eqs. 3-3 and 3-10). Rahn's equation uses per capita consumption of pork instead of slaughter and the only common variable between his equation and the equations presented in this study is a trend variable. The three equations in this study have an average R^2 of .900 as compared to .621 for Rahn's equation.

The broiler chick hatch equation used in this study is a variation of an equation developed by Rahn [88]. Rahn's equation indicates

an increase of 2.1 million birds per quarter for every additional million birds in the hatchery laying flock. The two equations in this study (Eqs. 3-6 and 3-11) show an average increase of 12.5 million birds for every additional million in the laying flock. Rahn's equation had a negative coefficient for the fourth quarter seasonal dummy and positive coefficients for the second and third. This study found a negative coefficient for the third and fourth and a positive coefficient for the second quarter. The trend variable in Rahn's study indicates that approximately 29.6 million birds could be removed from the hatchery supply yearly and still maintain a constant level of chick hatch over time. The trend variable in this study found that 23.7 million birds could be removed yearly without affecting chick hatch.

The estimated coefficient for the one period lagged broiler hatch variable in Rahn's [90] broiler quantity equation indicates that slaughter increases 2.74 pounds for every additional chick hatched. This is ready-to-cook weight. The three equations in this study (Eqs. 3-4, 3-7, and 3-12) indicate an average increase of 2.40 pounds per additional chick hatched. Rahn's equation has a negative coefficient for the third and fourth quarter seasonal dummy variables and a positive coefficient for the second quarter. This study found a negative coefficient for the third quarter and a positive coefficient for the second quarter. A fourth quarter seasonal dummy variable was found to be insignificant in this study and was not used. Normally a negative coefficient would not be expected for the third quarter, however, in this case the model is adjusting to the second quarter broiler

hatch, which since 1967 has always had the largest broiler hatch of any quarter every year.

The broiler price equation developed by Rahn [113] is considerably different from the ones developed in this study (Eqs. 3-5, 3-8, and 3-13). Rahn's equation contains other broiler substitutes besides pork and a number of general economic indicators. His equation also uses per capita consumption of broiler meat where this study uses broiler quantity. In spite of this, some comparisons can be made. Rahn found that the price of pork was the most significant of the broiler substitutes. His study found that if the wholesale price per 100 pounds of pork cuts at the Chicago market increases by one dollar, that broiler price increases by .27 cents per pound. This study found that a one dollar per hundredweight increase in the farm price of pork increases broiler price by an average of .47 cents per pound. Rahn's price equation found positive coefficients for the second, third, and fourth quarter seasonal dummy variables. This study found positive coefficients for the second and third quarters, but a fourth quarter dummy variable when tried proved insignificant. Rahn's broiler price equation had an $R^2 = .695$ while the average R^2 of the three equations in this study is .825.

The data base in Rahn's study was 1955 through 1970, while this study used a data base of 1967 through the first quarter of 1977. It was not expected that the results would be the same, since changes have occurred in the industry. Prices of broilers and inputs were much more volatile during the 70's than in previous years. In addi-

tion, the mixture of price freezes and changes in government programs during the years since Rahm's study have had an effect on the industry.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study presents models to predict broiler price one, two and three quarters in advance. The two and three quarter models have a system of five equations while the one quarter model has a system of four equations. Normally, one would expect the prediction for a given quarter to increase in accuracy as additional information is included. In this study, no significant difference could be observed between the predictive ability of the models based on graphical and numerical investigation. A possible explanation is that some important variable in determining broiler price was left out of one or more of the models.

From the beginning, an effort was made to keep the models as easy to use as possible. For the most part, this has been successful. All data used in this study comes from readily available sources all published by the U.S. Department of Agriculture. After the data has been collected and the coefficients estimated, future broiler price can be forecast by the use of a hand calculator. Examples were presented and the data base is supplied so that anyone interested in using the models can easily duplicate the results.

Broiler price was found to be a function of broiler quantity, pork price, corn price and seasonality. Except for trend and season-

ality, all independent variables for a given quarter must be estimated. Pork price was found to be the most difficult to predict. It also proved the most significant in determining broiler price. For every dollar per hundredweight pork price increased, broiler price was found to increase by .5 cents per pound. This means that in order to make an accurate prediction of broiler price, an accurate estimate of pork price must usually be made. This being the case, some risk is obviously involved in using the model since pork price has proved difficult to forecast. If a pork price is forecast which the model user believes to be too high or too low then the user's estimate may be substituted. A missed forecast of corn price will also influence the broiler price prediction.

When analyzed for predictive ability all three models had inequality (U) coefficients less than one which means they all predict change better than no-change extrapolation. The models were compared with the ability of the futures market to predict future price. The futures market was found to be a better predictor of broiler price when predicting one quarter ahead both in terms of the inequality coefficient and average error. Forecasting two and three quarters ahead the models in this study proved superior with lower inequality coefficients and lower average errors.

While forecasting is by no means an exact science, it can prove a useful tool in planning. Anyone using a forecasting model should be aware that there is always some risk involved and the models presented here are no exception. However, this should not diminish their

usefulness since some element of risk is involved in most business decisions. Since the models presented in this study have a regular tendency to overestimate actual price, the user can account for this in the course of prediction and therefore should be able to reduce considerably the average error reported in this study. A better forecast of corn price should correct much of this error.

It is hoped that the models presented in this study prove useful to broiler integrators in decision making or to anyone interested in understanding more about the broiler industry.

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APPENDIX A

Table A-1. Estimated and Observed Values for all Predicted Variables

Year and Quarter	Pork Quantity				Pork Price				Broiler Hatch			Broiler Quantity				Broiler Price			
	Model One	Model Two	Model Three	Obs.	Model One	Model Two	Model Three	Obs.	Model Two	Model Three	Obs.	Model One	Model Two	Model Three	Obs.	Model One	Model Two	Model Three	Obs.
1975 I	4861	4912	4567	4455	38.94	38.51	43.79	38.43	766.1	794.1	770.8	1964	2002	1988	1964	.4198	.4257	.4515	.4134
II	4429	4527	4301	4267	43.47	43.34	46.59	43.93	839.1	862.4	835.1	2164	2130	2201	2182	.4606	.4632	.4758	.4298
III	3332	3395	3416	3642	55.35	55.06	55.05	56.20	779.8	753.5	786.7	2178	2168	2205	2187	.5042	.5063	.5045	.5005
IV	3821	3814	3693	4094	57.31	55.53	56.27	51.63	797.6	780.9	776.4	2158	2166	2083	2106	.4857	.4720	.4737	.4484
1976 I	4094	4042	4041	4148	49.27	50.46	48.89	46.97	898.8	924.6	855.1	2177	2258	2219	2249	.4418	.4448	.4315	.4193
II	4359	4355	4264	4002	45.69	46.07	47.75	47.87	969.0	960.8	929.5	2400	2504	2596	2438	.4315	.4264	.4356	.4154
III	4096	4083	4126	4245	48.49	48.66	48.41	43.33	852.0	826.2	831.2	2435	2568	2583	2493	.4390	.4297	.4286	.4143
IV	4724	4736	4737	5171	46.94	47.18	47.12	33.43	788.5	804.2	815.9	2312	2408	2397	2300	.4170	.4118	.4107	.3539
1977 I	4954	4948	4896	4627	38.59	40.59	41.93	38.13	874.9	857.9	888.2	2327	2291	2346	2294	.3745	.3907	.3941	.4071

Source: Taken and Calculated from Appendix B.

APPENDIX B

Table B-1. Data Base Used to Estimate the Coefficients.

Broiler										
	Chicago Price <u>a</u> /	Total Quantity <u>a</u> /	Net Re- turns <u>a</u> /	Chick Hatch <u>b</u> /	Pullorum Sum <u>b</u> /	Pork Prices <u>c</u> /	Pork Slaughter <u>d</u> /	Chicago Corn Prices <u>e</u> /	Sows Farrowing <u>f</u> /	Hog/Corn Ratio <u>e</u> /
	\$/lb.	Mil. lb.	c/lb.	Mil.	Thous.	\$/cwt.	Mil. lb.	\$/bu.	Thous.	
1967 I	.2581	1486.7	0.0	699.0	21448	14.57	5144	1.41	3644	10.3
II	.2519	1684.2	-0.3	752.3	23987	15.87	4607	1.38	2544	11.5
III	.2545	1679.7	0.0	675.1	23175	17.77	4622	1.25	2513	14.2
IV	.2297	1542.3	-1.8	632.1	21412	16.93	5407	1.14	2133	16.2
1968 I	.2677	1481.6	2.1	695.5	20255	17.73	5042	1.15	3644	17.5
II	.2733	1622.9	2.4	762.0	20339	17.40	4972	1.17	2701	18.1
III	.2799	1701.1	2.7	680.0	19165	19.53	4754	1.10	2601	19.3
IV	.2490	1589.8	0.0	654.2	18166	17.47	5601	1.13	2190	17.0
1969 I	.2769	1588.1	2.3	732.3	18523	17.83	5224	1.18	3352	18.3
II	.2912	1791.4	3.4	814.7	20344	18.83	4900	1.29	2467	20.3
III	.3075	1823.6	4.4	735.3	20822	21.57	4706	1.28	2420	21.7
IV	.2707	1735.5	1.5	742.6	20433	23.03	5171	1.19	2259	23.7
1970 I	.2771	1798.3	1.4	818.3	21016	23.40	4750	1.25	3902	22.7
II	.2636	2030.8	0.0	879.0	22481	19.77	4860	1.32	2930	19.2
III	.2577	2005.2	-0.9	750.2	23103	16.90	4909	1.45	2966	14.3
IV	.2494	1843.4	-2.5	734.0	22634	12.13	6099	1.46	2483	11.1
1971 I	.2663	1851.5	-0.9	783.5	22643	17.10	5718	1.57	3762	11.8
II	.2793	1978.3	0.5	851.6	23198	16.80	5689	1.53	2683	12.2
III	.2817	2046.0	0.6	776.8	22639	18.47	5290	1.31	2699	16.1
IV	.2464	1929.1	-1.4	756.1	21065	19.33	5840	1.13	2177	18.2
1972 I	.2750	2009.2	0.6	838.0	20094	23.90	5265	1.22	3412	21.2
II	.2688	2184.1	-0.7	860.5	19373	24.33	5152	1.26	2546	22.7
III	.2922	2125.7	1.1	785.9	18370	27.87	4611	1.33	2596	23.0
IV	.2787	2022.2	-1.2	759.1	17736	27.93	5220	1.41	2266	20.8

Table B-1. (Continued)

Broiler										
	Chicago Price <u>a/</u>	Total Quantity <u>a/</u>	Net Re- turns <u>a/</u>	Chick Hatch <u>b/</u>	Pullorum Sum <u>b/</u>	Pork Prices <u>c/</u>	Pork Slaughter <u>d/</u>	Chicago Corn Prices <u>e/</u>	Sows Farrowing <u>f/</u>	Hog/Corn Ratio <u>e/</u>
	\$/lb.	Mil. lb.	c/lb.	Mil.	Thous.	\$/cwt.	Mil. lb.	\$/bu.	Thous.	
1973 I	.3640	1990.9	3.0	791.0	17439	34.50	4802	1.59	3325	27.9
II	.4207	2126.8	5.4	870.1	18094	35.90	4700	2.03	2521	18.7
III	.5195	2099.1	6.3	775.1	17249	47.13	4068	2.63	2562	20.4
IV	.3725	2090.8	-4.3	770.9	16345	39.87	4956	2.52	2258	16.0
1974 I	.3919	2101.0	-1.2	828.2	15415	38.13	4922	3.01	3245	13.1
II	.3524	2254.1	-3.9	862.3	15349	27.03	5162	2.77	2424	09.4
III	.3749	2175.9	-0.7	716.0	14915	34.63	4800	3.51	2280	10.2
IV	.4022	1920.8	-2.3	698.0	14381	37.40	5091	3.56	1778	11.7
1975 I	.4134	1963.5	0.0	770.8	13485	38.43	4455	3.02	2428	14.6
II	.4298	2182.1	5.0	835.1	13578	43.93	4267	2.89	2088	17.7
III	.5005	2186.8	11.6	786.7	13144	56.20	3642	3.02	2103	21.2
IV	.4484	2106.3	5.8	776.4	13919	51.63	4094	2.64	2049	20.0
1976 I	.4193	2249.2	3.8	855.1	13853	46.97	4148	2.67	2910	18.2
II	.4154	2438.2	2.8	929.5	15317	47.87	4002	2.83	2523	17.9
III	.4143	2493.4	-0.7	831.2	15455	43.33	4245	2.87	2520	15.3
IV	.3539	2300.4	-5.7	815.9	16564	33.43	5171	2.44	2289	16.2
1977 I	.4071	2293.9	-0.3	888.2	16702	38.13	4627	2.55	2999	15.8
II					16870				2637	

Source: a/ Poultry and Egg Situation, U.S.D.A., 1969-1977 issues.
b/ Current Poultry Trends, U.S.D.A., 1967-1977 issues.
c/ Livestock and Meat Situation, U.S.D.A., 1969-1977 issues.
d/ Livestock Slaughter, U.S.D.A., 1969-1977 issues.
e/ Feed Situation, U.S.D.A., 1973-1977 issues.
f/ Hogs and Pigs, U.S.D.A., 1973-1977 issues.

APPENDIX C

Table C-1. Table of Equations

One Quarter Forecasting Model

$$\begin{aligned}
 \text{PQ(I)} &= 947.392 + .876\text{SF(I-3)} + .818\text{SF(I-2)} - 19.673\text{HCR(I-2)} \\
 &\quad [2.94] \quad [5.61] \quad [5.20] \quad [-2.70] \\
 &- 379.799\text{D4} - 660.879\text{D3} + 252.593\text{D2} \\
 &\quad [-2.57] \quad [-3.47] \quad [-2.61]
 \end{aligned}$$

$$\begin{aligned}
 \text{PP(I)} &= 69.355 - .012\text{EPQ(I)} + 3.720 + 5.470\text{D4} + 1.642\text{TV(1977)} \\
 &\quad [7.62] \quad [-7.23] \quad [2.49] \quad [3.38] \quad [3.82]
 \end{aligned}$$

$$\begin{aligned}
 \text{BRQ(I)} &= 30.836 + 2.149\text{BH(I-1)} - 75.321\text{D3} + 50.430\text{D2} + 48.935\text{TV(1977)} \\
 &\quad [.30] \quad [13.74] \quad [-3.57] \quad [3.39] \quad [17.42]
 \end{aligned}$$

$$\begin{aligned}
 \text{BRP(I)} &= .214 - .000046\text{EBRQ(I)} + .005\text{EPP(I)} + .032\text{CRP(I)} \\
 &\quad [3.42] \quad [-1.13] \quad [4.12] \quad [2.30] \\
 &+ .018\text{D3} + .017\text{D3} \\
 &\quad [1.23] \quad [1.11]
 \end{aligned}$$

Two Quarter Forecasting Model

$$\text{PQ (I)} = \text{Same as One Quarter Forecasting Model}$$

$$\text{PP(I)} = \text{Same as One Quarter Forecasting Model}$$

$$\begin{aligned}
 \text{BH(I)} &= 406.843 + 5.344\text{NR(I-3)} + 4.268\text{NR(I-1)} + .013\text{PS(I-1)} \\
 &\quad [9.21] \quad [4.54] \quad [3.60] \quad [7.16] \\
 &- 63.079\text{D4} - 34.526\text{D3} + 48.346\text{D2} + 23.676\text{TV(1977)} \\
 &\quad [-6.52] \quad [-3.46] \quad [-5.17] \quad [11.71]
 \end{aligned}$$

$$\begin{aligned}
 \text{BRQ(I)} &= -239.407 + 2.551\text{EBH(I-1)} - 131.638\text{D3} + 45.298\text{TV(I)} \\
 &\quad [-1.70] \quad [12.52] \quad [-5.13] \quad [11.96]
 \end{aligned}$$

$$\begin{aligned}
 \text{BRP(I)} &= .226 - .000053\text{EBRQ(I)} + .005\text{EPP(I)} + .035\text{CRP(I)} \\
 &\quad [3.62] \quad [-1.32] \quad [4.18] \quad [2.42] \\
 &+ .017\text{D3} + .015\text{D2} \\
 &\quad [1.19] \quad [1.04]
 \end{aligned}$$

Three Quarter Forecasting Model

$$\begin{aligned}
 \text{PQ(I)} &= 574.537 + 1.006\text{SF(I-3)} + .697\text{SF(I-2)} - 468.854\text{D4} \\
 &\quad [1.80] \quad [6.19] \quad [4.23] \quad [-2.98] \\
 &- 532.088\text{D3} + 220.272\text{D2} \\
 &\quad [-2.64] \quad [2.10]
 \end{aligned}$$

$$\begin{aligned}
 \text{PP(I)} &= 68.520 - .012\text{EPQ(I)} + 3.236\text{CRP(I)} + 5.386\text{D4} \\
 &\quad [6.56] \quad [-6.21] \quad [1.96] \quad [3.02] \\
 &+ 1.753\text{TV(1977)} \\
 &\quad [3.75]
 \end{aligned}$$

$$\begin{aligned}
 \text{BH(I)} &= 407.872 + 6.511\text{NR(I-2)} + .012\text{PS(I-1)} - 42.552\text{D4} \\
 &\quad [8.37] \quad [5.01] \quad [6.26] \quad [-4.25] \\
 &- 27.860\text{D3} + 86.058\text{D2} + 23.764\text{TV(1977)} \\
 &\quad [-2.78] \quad [7.79] \quad [10.98]
 \end{aligned}$$

Table C-1. (Continued)

$$\text{BRQ}(I) = -187.374 + 4.548\text{NR}(I-4) + 2.494\text{EBH}(I-1) - 138.008\text{D3}$$

[-1.20] [1.63] [10.99] [5.18]

$$\text{BRP}(I) = .218 - .000047\text{EBRQ}(I) + .004\text{EPP}(I) + .037\text{CRP}(I)$$

[3.33] [-1.11] [3.65] [2.36]

$$+ .018\text{D3} + .015\text{D2}$$

(1.18) [.95]

Source: Calculated from data in Appendix B.

APPENDIX D

Table D-1. Summary of Analysis of the Models

Type Analysis	One Quarter Model	Two Quarter Model	Three Quarter Model
Mean Square Error	108.3074	76.6623	76.3883
Root-mean- square Error	10.4071	8.7557	8.7400
Inequality Coefficient	0.9954	0.8374	0.8359
Average Error (¢/lb.)	2.6300	2.2400	2.5500

Source: Calculated from data in Appendix B.

VITA

Stephen Haynes was born July 16, 1948 in Knoxville, Tennessee and raised in Simpsonville, South Carolina. He graduated from Hillcrest High School in Simpsonville in 1966. From there he entered the University of South Carolina graduating in 1970 with a B.A. in Political Science. Immediately upon graduating he entered the Peace Corps and served 3½ years in Ecuador. While there he met and married Claudia Martinez.

After returning to the U.S. he worked for 8 months as a recruiter for Peace Corps in Washington, D.C. In June 1975 he was admitted as a graduate student to the Department of Agricultural Economics at Virginia Polytechnic Institute and State University. In August 1977 he completed the requirements for the degree of Master of Science in Agricultural Economics. In September 1977 he will begin work as a Research Associate at Louisiana State University.

Stephen S. Haynes

ONE, TWO AND THREE QUARTER FORECASTING MODELS
FOR BROILER PRICE

by

Stephen Leland Haynes

(ABSTRACT)

The purpose of this study was to develop easy to use price forecasting models to predict broiler price one, two and three quarters in advance.

A system of five equations was developed for the two and three quarter lag models and a system of four equations was developed for the one quarter lag model. All coefficients in the equations were estimated using data published by the U.S. Department of Agriculture.

The models presented are true forecasting models which predict outside the data base. The models are user oriented. Examples were presented and the data base supplied so that anyone interested in using the models can easily duplicate the results.

The models were analyzed for predictive ability and were compared with the ability of the futures market to forecast broiler price. Results showed all three models predicted better than no-change extrapolation. The models predicting broiler price two and three quarters in advance predicted better than the futures market.