A RECURSIVE MODEL FOR FORECASTING QUARTERLY AND MONTHLY U. S. HOG PRICES

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CHAPTER I

PURPOSE OF THE STUDY

Introduction

Institutions such as the U. S. Department of Agriculture, universities and private firms have published regularly current and outlook information to the participants of the livestock market.

Information about short-run future tendencies in the market place is a necessary tool used in the decision making process, by hog producers, wholesalers, retailers and others operating in the hog and pork markets. The forecasting techniques which have been used range from very sophisticated ones to simple "rules of thumb" or purely guesses. Many forecasters use their own procedures and techniques developed after long experience in operating in the market, and they only get their results after much "pencil and paper" work, and frequently the techniques used are known only to the forecasters.

The present work was developed under the supervision of Dr. John N. Ferris, professor of Agricultural Marketing and specialist in livestock outlook at Michigan State University. It is an attempt to formalize his techniques and procedures with some modifications, for predicting monthly hog prices two years in advance, using a model reasonably tailored to existing data published mainly by government sources. This research is a first step in the development of an improved model in the future.

Literature

Knowledge about the causes underlying short-run fluctuations on a monthly basis in the supply and prices of hogs and pork is vitally important as a tool for the decision making process for many participants in that sector of the economy. In recent years much effort has been devoted to the study of these fluctuations on a quarterly basis, but only a little research has been published concerning monthly fluctuations.

Crom (2) designed a recursive model for simulation and projections of the beef and pork sectors of the livestock industry using quarterly data. Commercial hog slaughter was explained as a function of pigs produced from sows farrowing two and three quarters previously; these farrowings from two quarters before would be responsible for the barrow and gilt slaughter. Hog and corn prices were not used as a ratio but in their separate components: hog price lagged one quarter and the corn price lagged one quarter. The variable pigs saved per litter enters in the model as an exogenous variable, but an equation was presented to estimate it. Imports and exports of pork were estimated as a function of lagged price of wholesale pork products, lagged per capita supply of pork, and a trend term; increases in domestic pork prices would stimulate imports, while high domestic prices would reduce the amount of pork supplied for export. Ending stocks and prices are jointly determined from the entire supply available. Over 120 operating rules are introduced in the model based on economically logical behavioral relationships. In the opinion of the author his model is of more value for long-run projections than in the short run.

Hayenga (9) presented a model to explain monthly fluctuations in the supply and prices of beef and pork. He used monthly average supply of pork per workday as a measure of the level of supply in the market which improved his estimates for some months. Least square methods were used in the estimation of the parameters. It is one of the few studies dealing with monthly prices and supply fluctuation.

Ferris (3) tested the hypotheses that the hog market would have cyclical tendencies and that it would be convergent. For this he used regression analysis and a method proposed by Nerlove (15). He used data from the period 1908-24, 1925-41 and 1947-58; his results confirmed the hypotheses above and a cycle of five to six years was indicated. Still, the results gave support to the idea that hog production is a function of past prices. Retail quarterly prices of pork were used as a dependent variable as a function of: (a) disposable income; (b) supply of pork; (c) supply of competing meats; (d) time; (e) population; and (f) dummy variables for the different seasons. He estimated the price flexibilities of the demand for hogs to be respectively for the four quarters: -2.09, -1.12, -1.33 and -1.56. He combined three equations to have a complete model: a quarterly demand equation for hogs, an equation to link "spring" farrowing to "fall" supply of pork, and a supply equation.

Hacklander (7) presented a study of the monthly fluctuations in the price of beef and pork at the wholesale level. He analyzed a model for the short-run forecast of monthly beef and pork prices at the wholesale level. Beginning pork storage level proved to be inversely related to pork cut prices. Simultaneous and close correlation was found between wholesale pork prices and live hog prices. The pork quantity level did not prove to be a significant variable to explain storage levels of pork.

Harlow (8) concluded that changes in the hog-corn ratio today have come about primarily because changes in its component price of hogs, since with Government price support programs the price of corn has become much more stable, thus price of hogs alone, independent of corn, has become more important. Harlow estimated the number of "spring" farrowings as a function of: (a) price received by farmers for hogs in the period of October-December, deflated by the Consumer Price Index; (b) price received by farmers for corn, October-December, deflated by the Consumer Price Index; (c) price received by farmers for beef cattle, October-December, deflated by the Consumer Price Index; (d) production of oats, barley, and sorghum grain. He found a supply elasticity of 0.82 using data for 1949-1960. "Fall" farrowing was explained in logarithmic form as a function of: (a) number of sows farrowing in the "spring"; (b) production of oats, barley and sorghum grain; (c) price of feeder cattle at Kansas City, April-June, deflated by the Consumer Price Index; (d) price received by farmers for corn, April-June, deflated by the Consumer Price Index. Price of hogs was explained, in logarithmic form, as determined by: (a) per capita consumption of pork; (b) per capita consumption of beef and veal; (c) per capita consumption of poultry meat; (d) deflated discretionary income per capita; (e) time. From this equation he computed the farm-level demand elasticity of -0.35.

Using data from the period 1949-1966, Myers et al. (14) estimated monthly price elasticities of demand at the retail level as being -0.73 for pork, -0.72 for beef and -1.55 for broilers. Average farm level price elasticities of demand for pork were -0.43 and -0.50 for beef. Average income elasticities were estimated to be 0.30 for pork, 1.10 for beef and 0.76 for broilers. He presented three forecast models for the hog-pork sector and evaluated the predictions on the basis of: (a) the direction of change in the endogenous variables; (b) other tests involving the magnitude and direction of the deviations among the observed and the predicted values generated by the model.

The Problem

Hog production, like agricultural production in general, is based upon a physiological production process which takes a certain period of time to be accomplished, i.e., there is necessarily a span of time between the farmer's decision about how much to be produced and the beginning of the process until the time when the output is ready for sale. The farmer's decision today about how many sows to be bred will have a future effect on the size of the supply of barrows and gilts in the market a year later. Excessive reliance upon present market conditions as an indicator of the situation for the next period may result in very poor decisions which would determine accentuated production and price fluctuations in the free hog market via the process of adjusting the supply and demand forces. These production and price oscillations bring increased risk and uncertainty to the market participants, resulting in lower efficiency and higher costs.

More adequate forecasts would result in a better performance in the market, since hog producers and other participants in the hog and pork market, such as meat packers, speculators, hedgers, chain stores, wholesalers and others are basically interested in predicting future prices in order to make their adjustments in time for future conditions in the market. Decisions about when is a good time for buying or selling, about the determination of adequate inventory policies and promotional schedules (9), and other decisions could be improved with the existence of reasonable forecasts. These would serve as an extension of the present hog market information available in the quarterly report "Hogs and Pigs" and other information published by the United States Department of Agriculture. The purpose of this work is, based on the information found in that source of publication, plus information about exogenous variables, to forecast monthly hog prices twenty-four months ahead.

CHAPTER II

METHODS, DATA AND PROCEDURES

Recursive Models

Regular fluctuations in a cyclical pattern in prices of hogs have been pointed out almost a century ago. A close association between corn prices in a period and the size of the supply of hogs was recognized too, and the hog-corn price ratio had been used as an indicator of hog production in the next period: a larger hog-corn price ratio would result in a higher level of supply of hogs in the next period, and vice versa. Today corn prices have become more stable, and added to this fact, the relative importance of the cost of corn in the total cost of hog production has been declining because of the increasing costs of other items such as protein supplements, buildings and installations; labor has also become relatively much more important than before. However these two tendencies which were thought to bring much more stabilization to hog prices may only have brought a partial alteration in the pattern, because a substantially regular cycle in the production and price of hogs can still be observed.

Many statistical models have been presented to explain cycles in agricultural products. A very simple one is of the type:

$$S_t = a_1 + b_1 P_{t-1} + U_t$$

$$P_t = a_2 + b_2 D_t + G_t$$

$$S_t = D_t$$

where:

S_t = supply size in a given period of time t.

a = estimated parameter.

b = other estimated parameter.

P_{t-1} = price in the previous period.

P_t = price in the current period.

D_t = quantity demanded during period t.

U_t = error term in the supply equation.

G_t = error term in the price equation.

In this model the current supply size is explained by a lagged variable which is the price level in the previous period. But the current price is explained by the demand forces in the same period t; for that is necessary to assume that the whole quantity supplied in the current period be totally consumed in the same period, i.e., $S_t = D_t$. This is a recursive model, i.e., "it shows how certain initial conditions will affect conditions in a coming period, say, t+1; then how conditions in period t+1 will affect conditions in t+2, and so on" (20).

Data Source and Periods

The recursive model to be presented will use eight exogenous variables and five lagged endogenous explanatory variables. It will explain and predict supply of pork and price of hogs. The forecast program was settled to start at the end of December_{t-1}, and generate 24 forecasts of hog prices in the period from January, year t, to December, year t+1. The computer program for this can be found in Appendix B.

The data period used was from 1958 to 1971, with the exception of the equation for sows farrowing in the "spring" when a slightly longer period was used, 1956-1971.

The use of all the forecast range of the program is necessary to have on hand the lagged data including that for December_{t-1}. Some of these data may not have been available at that time; thus some approximate estimates for this month may be necessary. Projected data for exogenous variables to be used are: Consumer Price Index, U. S. population, disposable income, consumption of turkeys and broilers, and consumption of non-pork red meats; some of these projections can be found in current publications while others must be obtained from specialists or experts in the area.

The following list presents a basic source of information used in the present work as well as other sources with collateral relevant outlook information. A relation of the data used can be found in Appendix A. We can see below relevant information sources for each variable used in the model; the variables are expressed in the same units as used in the equations.

1. (PC)--Price of No. 3 yellow corn at Chicago (average price from $October_{t-2}$ to $September_{t-1}$ in dollars/bushel.

   (a) Grain Market News--U. S. Department of Agriculture, published weekly.

   (b) Feed Situation--ERS, U. S. Department of Agriculture, published in February, April, May, August and November.

2. (PSM)--Average price of soybean meal, 44% protein Decatur, Illinois (average price from $October_{t-2}$ to $September_{t-1}$) in dollars/ton.

   (a) Agricultural Prices--SRS, U. S. Department of Agriculture, published monthly.

3. (PPDF)--Index of Prices Paid by Farmers (base 1967 = 100).

   (a) Agricultural Prices--same as above.

4. (PH)--Average price of barrows and gilts, in dollars per hundred pounds of live hogs, 7-8 major markets.

   (a) Livestock, Meat, Wool Market News--AMS, U. S. Department of Agriculture, published weekly.

   (b) Livestock and Meat Situation--ERS, U. S. Department of Agriculture, published in February, March, May, August, October and November.

5. (DSPK)--Domestic supply of pork (data from total production plus beginning stocks of pork) in millions of pounds.

   (a) Livestock and Meat Situation--from source cited previously.

   (b) Livestock Slaughter--SRS, U. S. Department of Agriculture report.

   (c) Cold Storage--SRS, U. S. Department of Agriculture, published monthly.

(d) Summary of Regional Cold Storage Holdings--SRS, U. S. Department of Agriculture, published annually.

6. (PGS) and (SF)--number of pigs saved and number of sows farrowing respectively, in thousands.

(a) Hogs and Pigs--ERS, U. S. Department of Agriculture, published trimonthly.

7. (POP), (CPI) and (DI)--respectively, U. S. population, Consumer Price Index (base 1967 = 100) and disposable income.

(a) Economic Indicators--Council of Economic Advisors, monthly.

8. (CNPK)--Consumption of non-pork red meat (beef, veal, lamb and mutton), in pounds.

(a) National Food Situation--ERS, U. S. Department of Agriculture.

9. (CTB)--Consumption of turkeys and broilers, in pounds.

(a) National Food Situation--cited above.

(b) Poultry and Egg Situation--ERS, U. S. Department of Agriculture, published in February, April, June, September, and November.

10. (PC), (PSM), (PPDF)--for projections of these variables, consult:

(a) outlook specialists.

(b) private sources of information.

(c) future prices on PC and PSM.

Some production and supply variables were used per workday; a table with the number of workdays in each of the months in the period 1958-71 can be found in Appendix A.

An index of seasonality in slaughter hog prices was computed for the period 1958-71 using the following procedure: by dividing each month's observation by a centered 12-month moving average, averaging these over the years, and multiplying by 100. See Tables 7 and 8 in Appendix A for the slaughter price of hogs data used and for the seasonal computations.

The hog price equations in the forecast model were used in their logarithmic form.

Least Square Estimates

The equations in our recursive model were estimated by the least squares procedure. In our demand equations instead of using prices of competitive commodities as independent variables, their quantities were used in order to reduce the possibility of high serial intercorrelation. "In a strict sense, demand theory requires that prices of substitutes be held constant. But as a practical matter in fitting a demand equation, quantities are often used to reduce the high intercorrelation found among many price series" (8). The quantities enter as predetermined independent variables, i.e., they are not simultaneously determined with price. The price equations were used in their logarithmic form since it shows a better statistical fit and because it makes possible almost direct obtainment of the price elasticity of demand value. Disturbances are assumed to be independently distributed.

Evaluation Criteria

The criteria used for evaluation of the estimates of the parameters of the equations were the value of the coefficient of correlation ($\bar{R}^2$) which expresses the proportion of the variation in the dependent variable which was explained by the independent variables used in the equation. The Student t-test was used to test the probability that the regression coefficient is not significantly different from zero; the levels of significance employed were 5% and 10%. The standard error of estimate (SEE) is shown for each equation.

A non-parametric measure of forecast efficiency to be used is the turning point criteria which considers the number of times the direction of changes in prices were correctly predicted by the model.

The magnitude of the error for each forecast value will be shown in the form of a list of the differences among the predicted and the actual value.

An annual measure of forecast error was computed using the formula

$$E = \frac{\frac{\Sigma\ (\text{Pred} - \text{Rep})}{n}}{\frac{\Sigma\ \text{Reported}}{n}} .100$$

where:

Pred = values predicted by the model.

Rep = reported values (taken as the actual values).

n = number of observations (it is cancelled out in this equation.

E = average forecast error during the year, in %.

CHAPTER III

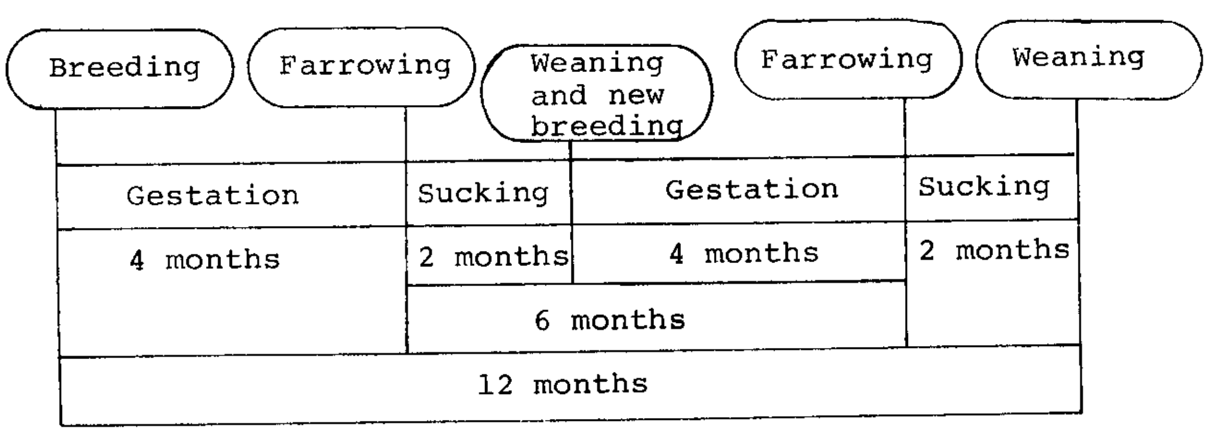
SUPPLY AND DEMAND

Production

The size of the pig crop for any given season is equal to the number of sows farrowing times the number of pigs saved per litter from these farrowings.

The production cycle is, on the average, accomplished in a period from 10 to 12 months. It is constituted by the gestation period, i.e., the time since the sow was bred until the farrowing occurs which takes around 4 months, plus 6 to 8 months more for the hog to reach an adequate slaughter weight.

Most specialized hog producers obtain two farrowings per year from the same sow, forming a 6-month farrowing cycle:



After farrowing sows are not bred immediately but only after a period of two months when the pigs will be weaned.

The year has therefore been arbitrarily divided into two production seasons: the "spring" farrowing season which takes place during a 6-month period from December to May, and the "fall" farrowing season from June to November. Such a dichotomy does not fit some hog producers. A declining number of farmers are following a "one litter system" with farrowings in the summer in pasture. An increasing number of farmers have sows farrowing throughout the year and not concentrated in the spring and fall. Even so, definite peaks in farrowings remain in these two seasons.

What would determine or influence the number of sows farrowing in a season? What factors do farmers take into consideration in their decision making process in determining the number of sows to be bred?

Certainly farmers consider the factors that influence the amount of profit likely to be obtained when their output will be ready for sale 10 to 12 months later. They have to form their future expectations based on past and present information. Some factors which are believed to enter into their considerations and which will enter formally in our equations are: past and current hog prices and the price of hog feed inputs such as corn and soybean meal, and costs of other inputs. Other factors which could be taken into consideration, although they are not formally included in our equations for simplification reasons, are the alternative possible returns which could likely be obtained from the production of other commodities such as beef cattle, considerations about prices of other minor hog feed inputs like oats, barley and sorghum grain.

Three variables will be considered as exogenous in our supply model: prices of corn and soybean meal, and the Index of Prices Paid by Farmers which represents the cost of non-feed inputs. These variables enter the supply relationship as components of a "gross margin" variable described on the next page. The expected "gross margin" is considered as a function of current and past "gross margins" in a distributed lag relationship.

The estimate of the number of sows farrowing during the "spring" season was derived from the following regression equation, fitted to data from 1956-1971. The "t" values on the coefficients are given in the parentheses.*

$$SFS_t = -926.36 + \underset{(6.28)}{0.9399}\, SFS_{t-1} + \underset{(4.67)}{71.46}\, \frac{GMH_{t-1}}{PPDF_{t-1}} \qquad (1)$$

$$\bar{R}^2 = 0.72$$
$$SEE = 286.0$$

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*Figures in parentheses below the equation express the calculated "t-values" for testing the hypothesis that coefficients = 0.

where:

SFS_t = number of sows farrowing during the "spring" season (from December to May), year t, in thousands.

SFS_{t-1} = number of sows farrowing during the "spring" season, year t-1, in thousands.

GMH_{t-1} = average gross margin on a hog weighing 230 pounds, after deducting costs of corn and soybean meal, year t-1, in dollars.

$PPDF_{t-1}$ = Index of Prices Paid by Farmers, year t-1, (base: 1967 = 100).

$\frac{GMH_{t-1}}{PPDF_{t-1}}$ = deflated gross margin on hogs.

Both coefficients show the expected signs; both coefficients for sows farrowing in the past "spring" and for the deflated gross margin on hogs are significantly different from zero at the 0.01 per cent level. The number of sows farrowing during the "spring," year t, is a function of the number of sows farrowing during the past "spring" season, and a function of the deflated gross margin on hogs in a past period; the greater the gross margin on hogs in one year, the larger will be the number of sows farrowing in the next "spring" season. The two independent variables in equation (1) explain 72% of the variability in the dependent variable.

The variable GMH_{t-1} expresses the aggregate effect of the variables: past prices of hogs, corn and of soybean meal. It is explained by the following identity:

$$GMH_{t-1} = 2.3\ PH_{t-1} - \frac{807}{56}\ PC_{t-1} - \frac{159}{100}\ PSM_{t-1}$$

where:

GMH_{t-1} = average gross margin obtained by a farmer on a hog weighing 230 pounds, after deducting the feeding costs of corn and soybean meal, year t-1, in dollars.

PH_t = average price of barrows and gilts, in dollars, per hundred pounds of live hog, 7-8 major markets, in year t.

PC_{t-1} = average price of No. 3 yellow corn at Chicago (average price from $October_{t-2}$ to $September_{t-1}$), in dollars per bushel.

PSM_{t-1} = average price of soybean meal, 44% protein Decatur, Illinois (average price from $October_{t-2}$ to $September_{t-1}$) in dollars per cwt.

The coefficients of the equation above were based on calculations for a typical average feeding cost to raise a hog to a live weight of 230 pounds. It was found that, on the average, for a hog to reach this weight it is necessary to feed around 807 pounds of corn and 159 pounds of soybean meal, including an allowance for the sow and boar. In order to simplify the introduction of data currently published by the USDA, expressed in units other than pounds, simple conversion factors were introduced into the equation to permit direct introduction of the prices of hogs/100 pounds, price of corn/bushel and price of soybean meal/cwt.

Thus:

2.3 to adjust quantity expressed in pounds to price in dollars/100 pounds

$\frac{807}{56}$ to adjust quantity expressed in pounds to price in dollars/bushel

$\frac{159}{100}$ to adjust quantity in pounds to price in dollars/cwt.

Thus, the gross margin on hogs represents an indication of the relative attractiveness of the hog producing activity. Other formulations of the supply equation were tested, including the addition of a variable for profits from cattle feeding, but they had less favorable statistical properties than equation (1).

The farmer usually makes his decisions in the last portion of a year concerning the production level of hogs for the entire following year, instead of planning just for the next season (8). This being true, what the farmer does during the "spring" season will be a good indication of what he will do in the "fall" season in the same year; changes in production in the "spring" in relation to the same season last year, would mean changes in the same direction during the "fall" season. The data in our period of study have been consistent at first moment with this idea as can be seen in Figure 1; here we can see a tendency of the difference between the number of sows farrowing during the two seasons becoming smaller over time. However, a more accurate examination of data shows that it does not hold true for the second half of the "fall," which is affected by the GMH during the "spring."

The estimate for the "fall" farrowing was derived from the following regression equation, fitted to data from the period 1958-1971.

$$SFF_t = 398.18 + \underset{(5.48)}{0.6997}\ SFS_t + \underset{(2.04)}{27.61}\ GMH3\text{-}5_t + \underset{(1.91)}{38.20}\ T \qquad (2)$$

$$\bar{R}^2 = 0.73$$
$$SEE = 225.57$$

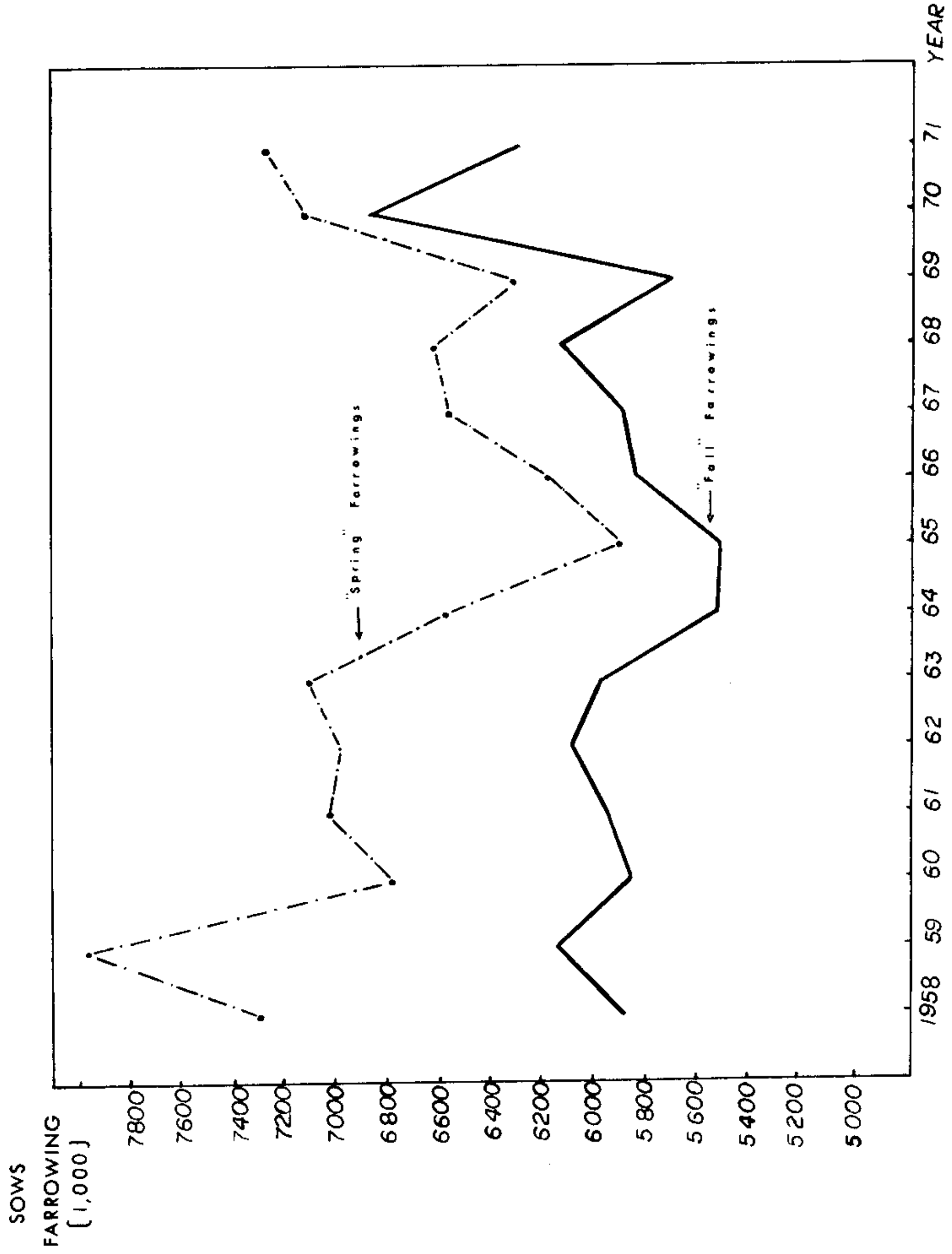

Figure 1. "Spring" and "Fall" Farrowings

where:

SFF_t = number of sows farrowing during the "fall" season (June to November), year t, in thousands.

SFS_t = number of sows farrowing during the "spring" season, year t, in thousands.

T = time variable which assumes the value $T_1 = 1$ when representing the year 1958; $T_2 = 2$ when representing 1959, and the same procedure was used for the following years.

$T_1 = 1$	for year 1958
$T_2 = 2$	for year 1959
$T_3 = 3$	for year 1960
. . .	for year . . .
$T_{14} = 14$	for year 1971

$GMH3\text{-}5_t$ = the same as explained before, now for the period March-May, year t.

In equation (2) all coefficients have the expected signs; the coefficients for sows farrowing during the "spring" year t is significantly different from zero at least at the 5 per cent level, and the coefficients for T and $GMH3\text{-}5_t$ variables are significant at the 10% level. This indicates fall farrowings are related to spring farrowings but that, in addition, it is related to the gross margin on hogs during the "spring" and to the time variable. Seventy-three per cent of the variability of the SFF_t variable is explained by the independent variables.

Estimates for different 3-month periods during the year were derived from the "spring" and "fall" farrowings and time in the following four regression equations fitted to data from the period 1958-1971.

$$SF12_{t-1}\text{-}2_t = \underset{}{-615.32} + \underset{(7.23)}{0.4469}\ SFS_t + \underset{(1.93)}{15.15}\ T \qquad (3)$$

$$\bar{R}^2 = 0.80$$
$$SEE = 110.2$$

$$SF3\text{-}5_t = 897.41 + \underset{(11.81)}{0.517}\ SFS_t - \underset{(-3.91)}{21.70}\ T \quad (4)$$

$$\bar{R}^2 = 0.94$$
$$SEE = 78.1$$

$$SF6\text{-}8_t = -124.99 + \underset{(2.63)}{0.0951}\ SFS_t + \underset{(9.88)}{0.4379}\ SFF_t - \underset{(-1.86)}{6.74}\ T \quad (5)$$

$$\bar{R}^2 = 0.97$$
$$SEE = 36.29$$

$$SF9\text{-}11_t = 124.83 - \underset{(-2.50)}{0.095}\ SFS_t + \underset{(12.04)}{0.5622}\ SFF_t + \underset{(1.55)}{6.63}\ T \quad (6)$$

$$\bar{R}^2 = 0.97$$
$$SEE = 38.24$$

where:

$SF12_{t-1}\text{-}2_t$ = number of sows farrowing in the three month period from December year t-1 to February year t, in thousands.

$SF3\text{-}5_t$ = number of sows farrowing during the period from March to May, year t, in thousands.

$SF6\text{-}8_t$ = number of sows farrowing during the period from June to August, year t, in thousands.

$SF9\text{-}11_t$ = number of sows farrowing during the period from September to November, year t, in thousands.

The coefficients for the independent variables, sows farrowing during the "spring," in the equations (3-4) are significantly different from zero at the 0.01 per cent level; and at the 5% level in equations (5) and (6); the coefficients for the time variables are significantly different from zero at the 0.01 per cent level in equation (4), but is not significant at this level in equation (3) and (5), where it is significant only at the 10 per cent level and in equation (6) in which it is not significant even at the 10%

level. The variability in the dependent variables was better explained in the three last quarters by the independent variables; 80% was explained in equation (3), 94% in equation (4), 97% in equation (5) and 97% in equation (6). The negative sign of the variable SFS_t in equation (6) acts as a device to reduce the value of the dependent variable $SF9\text{-}11_t$ when "spring" farrowings are large. The negative sign in the time variable in equation (5) expresses a tendency in reducing the number of sows farrowing in the period from June to August.

It is necessary, now, to have an estimate of the number of pigs saved per farrowing or litter; this was derived from the following two regression equations, fitted to data from 1958-1971.

$$(PGS/LS_t) = 7.01 + \underset{(4.65)}{0.0253}\, T \qquad \bar{R}^2 = 0.61 \quad SEE = 0.082 \tag{7}$$

$$(PGS/LF_t) = 7.08 + \underset{(3.47)}{0.0184}\, T \qquad \bar{R}^2 = 0.46 \quad SEE = 0.08 \tag{8}$$

where:

(PGS/LS_t) = average number of pigs saved per litter during the "spring," year t.

(PGS/LF_t) = average number of pigs saved per litter during the "fall," year t.

T = time variable as used previously.

The temporal coefficients in equations (7) and (8) both are significantly different from zero at least at the 5 per cent level.

The total number of pigs saved by quarters is given by the following identities, in thousands:

$$PGS12_{t-1}-2_t = SF12_{t-1}-2_t \cdot (PGS/L12_{t-1}-2_t)$$

$$PGS3\text{-}5_t = SF3\text{-}5_t \cdot (PGS/L3\text{-}5)_t$$

$$PGS6\text{-}8_t = SF6\text{-}8_t \cdot (PGS/L6\text{-}8)_t$$

$$PGS9\text{-}11_t = SF9\text{-}11_t \cdot (PGS/L9\text{-}11)_t$$

This simply means that the total number of pigs saved in a given period of time is equal to the number of sows farrowing during the same period multiplied by the average number of pigs saved per litter during the same period.

Where:

$PGS12_{t-1}-2_t$ = total number of pigs saved during the three month period from December, year t-1, to February, year t, in thousands.

$PGS3\text{-}5_t$ = total number of pigs saved during the period from March to May, year t, in thousands.

$PGS6\text{-}8_t$ = total number of pigs saved during the period of June-August, year t, in thousands.

$PGS9\text{-}11_t$ = total number of pigs saved during the period from September to November, year t, in thousands.

Since we do not have estimates of the number of pigs saved per litter for the different three month periods, these estimates will be made by use of the following simplifying assumptions:

$(PGS/L12_{t-1}-2_t) = (PGS/L3-5_t) = (PGS/LS_t)$

and

$(PGS/L6-8_t) = (PGS/L9-11_t) = (PGS/LF_t)$.

This means that we are taking the average number of pigs saved per litter during the whole "spring" season to represent either the first or the second half of the same season. A similar assumption was made for the "fall" season as being a good representative of either of the two half periods.

With these two simplifications, our total pigs saved identities will be:

$$PGS12_{t-1}-2_t = SF12_{t-1}-2_t \cdot (PGS/LS_t)$$

$$PGS3-5_t = SF3-5_t \cdot (PGS/LS_t)$$

$$PGS6-8_t = SF6-8_t \cdot (PGS/LF_t)$$

$$PGS9-11_t = SF9-11_t \cdot (PGS/LF_t)$$

Supply

The supply of pork in the market is formed by the total quantity of pork produced, plus cold storage stocks of pork, plus imports, and minus exports. Because imports and exports of pork are relatively minor in relationship to stocks and production, and because international trade in pork is difficult to forecast, these elements of supply were not analyzed in the model.

We are now interested in the domestic supply of pork expressed by the following identity:

$$DSPKm_t = STPKm_t + QPKm_t$$

where:

$DSPKm_t$ = domestic supply of pork in month m, year t.

$STPKm_t$ = cold storage of pork, month m, year t.

$QPKm_t$ = total quantity of pork produced in month m, year t.

The quantity of pork produced in month m affects the price of pork in the same period. This will be reflected in the price of hogs. The effect on the market is better understood when making measurements in terms of average quantity of pork produced during month m per workday in the month.*

$(QPKm/WKDm)_t$ = average quantity of pork produced per workday during month m, year t.

where:

$WKDm_t$ = number of workdays during month m, year t.

Quantity per workday in this case is a more adequate indicator of the average level of the flow of hogs being supplied to the meat packers than monthly totals which are affected by year to year variations in work or slaughter days. Also month to month comparisions are more valid on a per workday basis.

Now we are interested in estimating the change in the average pork production per workday occurring in a given

---

*The number of workdays in a given month, in a given year, was calculated for the period from 1958-1971 according to the rule: Monday to Friday = 1; Saturday = 1/3; Holiday = 1/2, except on Saturday when a holiday = 0 (9). See Table 4 in Appendix A for the number of workdays per month during the period 1958-1971.

month m, year t, relative to the production in the correspondent month m, in the year t-1.

$$\Delta(QPKm/WKDm)_t = \frac{(QPKm/WKDm)_t}{(QPKm/WKDm)_{t-1}}$$

where:

$\Delta(QPKm/WKDm)_t$ = change in pork production per workday.

The changes in the pork production variable are basically determined by the changes which occurred in the past in the total number of pigs saved. This can be expressed by the following identities:

$$\Delta(PGS12_{t-1}{-}2_t) = \frac{PGS12_{t-1}{-}2_t}{PGS12_{t-2}{-}2_{t-1}}$$ representing the changes in the number of pigs saved during the period from December to February, year t, relative to the same period a year before.

$$\Delta(PGS3{-}5)_t = \frac{PGS3{-}5_t}{PGS3{-}5_{t-1}}$$ change in the period from March to May, year t.

$$\Delta(PGS6{-}8)_t = \frac{PGS6{-}8_t}{PGS6{-}8_{t-1}}$$ change in the period from June to August, year t.

$$\Delta(PGS9{-}11)_t = \frac{PGS9{-}11_t}{PGS9{-}11_{t-1}}$$ change in the period from September to November, year t.

Estimates of the changes in pork production as a function of the changes in the number of pigs saved were derived from the following regression equations, fitted to data for 1959-1971.

For January:

$$\Delta(QPK1/WKD1)_t = -0.3826 + \underset{(3.41)}{0.7297}\Delta(PGS3{-}5)_{t-1} + \underset{(3.50)}{0.6684}\Delta(PGS6{-}8)_{t-1} \qquad (9)$$

$\bar{R}^2 = 0.85$
SEE = 0.05

For February:

$$\Delta(QPK2/WKD2)_t = -0.1265 + \underset{(11.29)}{1.13}\Delta(PGS6\text{-}8)_{t-1} \qquad (10)$$

$$\bar{R}^2 = 0.91$$
$$SEE = 0.035$$

For March:

$$\Delta(QPK3/WKD3)_t = 0.1657 + \underset{(2.17)}{0.4019}\Delta(PGS6\text{-}8)_{t-1}$$

$$+ \underset{(1.99)}{0.4405}\Delta(PGS9\text{-}11)_{t-1} \qquad (11)$$

$$\bar{R}^2 = 0.86$$
$$SEE = 0.031$$

For April:

$$\Delta(QPK4/WKD4)_t = 0.2716 + \underset{(2.66)}{0.5517}\Delta(PGS6\text{-}8)_{t-1}$$

$$+ \underset{(0.78)}{0.1942}\Delta(PGS9\text{-}11)_{t-1} \qquad (12)$$

$$\bar{R}^2 = 0.81$$
$$SEE = 0.034$$

For May:

$$\Delta(QPK5/WKD5)_t = 0.3488 + \underset{(2.90)}{0.6716}\Delta(PGS9\text{-}11)_{t-1} \qquad (13)$$

$$\bar{R}^2 = 0.38$$
$$SEE = 0.069$$

For June:

$$\Delta(QPK6/WKD6)_t = 0.2387 + \underset{(6.12)}{0.7755}\Delta(PGS9\text{-}11)_{t-1} \qquad (14)$$

$$\bar{R}^2 = 0.75$$
$$SEE = 0.038$$

For July:

$$\Delta(QPK7/WKD7)_t = 0.1882 + \underset{(2.79)}{0.3628}\Delta(PGS9\text{-}11)_{t-1}$$

$$+ \underset{(3.66)}{0.4629}\Delta(PGS12_{t-1}\text{-}2_t) \qquad (15)$$

$$\bar{R}^2 = 0.81$$
$$SEE = 0.031$$

For August:

$$\Delta(QPK8/WKD8)_t = 0.4430 + \underset{(1.98)}{0.3113}\Delta(PGS9\text{-}11)_{t-1}$$

$$+ \underset{(1.74)}{0.2669}\Delta(PGS12_{t-1}\text{-}2_t) \qquad (16)$$

$$\bar{R}^2 = 0.56$$
$$SEE = 0.037$$

For September:

$$\Delta(QPK9/WKD9)_t = 0.3093 + \underset{(1.84)}{0.4604}\Delta(PGS12_{t-1}\text{-}2_t)$$

$$+ \underset{(1.06)}{0.2557}\Delta(PGS3\text{-}5)_t \qquad (17)$$

$$\bar{R}^2 = 0.54$$
$$SEE = 0.052$$

For October:

$$\Delta(QPK10/WKD10)_t = 0.0165 + \underset{(1.87)}{0.3956}\Delta(PGS12_{t-1}\text{-}2_t)$$

$$+ \underset{(2.95)}{0.603}\Delta(PGS3\text{-}5)_t$$

$$\bar{R}^2 = 0.78$$
$$SEE = 0.044$$

For November:

$$\Delta(QPK11/WKD11)_t = -0.1894 + \underset{(8.53)}{1.213}\Delta(PGS3\text{-}5)_t \qquad (19)$$

$$\bar{R}^2 = 0.86$$
$$SEE = 0.045$$

For December:

$$\Delta(QPK12/WKD12)_t = -0.5587 + \underset{(2.83)}{0.8578}\Delta(PGS3\text{-}5)_t$$

$$+ \underset{(2.42)^*}{0.7215}\Delta(PGS6\text{-}8)_t \qquad (20)$$

$$\bar{R}^2 = 0.90$$
$$SEE = 0.047$$

From the 20 coefficients in equations (9) through (20), above, 12 are significantly different from zero at least at the five per cent level, 5 coefficients are not significant at this level but are at the 10 per cent level, and 3 coefficients are not significant even at the 10 per cent level. The variation in the dependent variables was better explained by the independent variables for the months of February and December, 91% and 90% respectively; the poorest explanation occurred for May, 38%. The other values were 85% for January, 86% for March, 81% for April, 75% for June, 81% for July, 56% for August, 54% for September, 78% for October and 86% for November.

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*The critical "t-value" at the 5 per cent level is 2.201, and the "t-value" at the 10 per cent level is 1.796 for 11 degrees of freedom.

With available information about past data on the variations on the number of pigs saved (PGS) on hand, it is possible to foresee future changes in pork production. Using now these forecasted change estimates, together with other past data, we can forecast monthly quantities of pork produced through the following identities:

$(QPK1/WKD1)_t = (QPK1/WKD1)_{t-1} \cdot \Delta(QPK1/WKD1)_t$ for January

$(QPK2/WKD2)_t = (QPK2/WKD2)_{t-1} \cdot \Delta(QPK2/WKD2)_t$ for February

$(QPK3/WKD3)_t = (QPK3/WKD3)_{t-1} \cdot \Delta(QPK3/WKD3)_t$ for March

$(QPK4/WKD4)_t = (QPK4/WKD4)_{t-1} \cdot \Delta(QPK4/WKD4)_t$ for April

$(QPK5/WKD5)_t = (QPK5/WKD5)_{t-1}) \cdot \Delta(QPK5/WKD5)_t$ for May

$(QPK6/WKD6)_t = (QPK6/WKD6)_{t-1} \cdot \Delta(QPK6/WKD6)_t$ for June

$(QPK7/WKD7)_t = (QPK7/WKD7)_{t-1} \cdot \Delta(QPK7/WKD7)_t$ for July

$(QPK8/WKD8)_t = (QPK8/WKD8)_{t-1} \cdot \Delta(QPK8/WKD8)_t$ for August

$(QPK9/WKD9)_t = (QPK9/WKD9)_{t-1} \cdot \Delta(QPK9/WKD9)_t$ for September

$(QPK10/WKD10)_t = (QPK10/WKD10)_{t-1} \cdot \Delta(QPK10/WKD10)_t$ for October

$(QPK11/WKD11)_t = (QPK11/WKD11)_{t-1} \cdot \Delta(QPK11/WKD11)_t$ for November

$(QPK12/WKD12)_t = (QPK12/WKD12)_{t-1} \cdot \Delta(QPK12/WKD12)_t$ for December

Now if we make the following simplifying assumption that: percent of change in the cold storage stocks of pork during a given quarter, year t, relative to the stocks in the correspondent period one year before, say t-1, is equal to the per cent of change in pork production in the correspondent quarters and years, i.e.,

$$\Delta STPKq_t = \Delta QPKq_t$$

then, this would imply that the variation or change in the quantity of pork produced would be equal to the changes in the domestic supply of hogs in the same period.*

Applying this reasoning for quarter periods, we have:

$$\frac{(QPK1\text{-}3/WKD1\text{-}3)_t}{(QPK1\text{-}3/WKD1\text{-}3)_{t-1}} = \frac{DSPK1\text{-}3_t}{DSPK1\text{-}3_{t-1}}$$

to express that changes in pork production are equal to changes in the pork supply, from which:

$$DSPK1\text{-}3_t = DSPK1\text{-}3_{t-1} \cdot \frac{(QPK1\text{-}3/WKD1\text{-}3)_t}{(QPK1\text{-}3/WKD1\text{-}3)_{t-1}}$$

or, finally:

$$DSPK1\text{-}3_t = DSPK1\text{-}3_{t-1} \cdot \Delta(QPK1\text{-}3/WKD1\text{-}3)_t$$

This means that we have the domestic supply of hogs in the period from January to March, year t, obtained from past domestic supply data for the correspondent quarter (January-March) and an estimated year to year change in total quantity of pork produced

---

*Based on the identity described previously: DSPK = (STPK + QPK).

obtained from equations presented before.

The same principle can be used for the other quarters:

$DSPK4\text{-}6_t = DSPK4\text{-}6_{t-1} \cdot \Delta(QPK4\text{-}6/WKD1\text{-}3)_t$ for the period from April to June,

$DSPK7\text{-}9_t = DSPK7\text{-}9_{t-1} \cdot \Delta(QPK7\text{-}9/WKD7\text{-}9)_t$ for the period from July to September,

$DSPK10\text{-}12_t = DSPK10\text{-}12_{t-1} \cdot \Delta(QPK10\text{-}12/WKD10\text{-}12)_t$ for the period from October to December.

The average quantity of pork produced per workday in a quarter can be obtained by averaging the monthly values for pork production identities previously expressed, or:

For the first quarter (January to March):

$$(QPK1\text{-}3/WKD1\text{-}3)_t = \frac{1}{3}[(QPK1/WKD1) + (QPK2/WKD2) + (QPK3/WKD3)]_t$$

For the second quarter (April to June):

$$(QPK4\text{-}6/WKD4\text{-}6)_t = \frac{1}{3}[(QPK4/WKD4) + (QPK5/WKD5) + (QPK6/WKD6)]_t$$

For the third quarter (July to September):

$$(QPK7\text{-}9/WKD7\text{-}9)_t = \frac{1}{3}[(QPK7/WKD7) + (QPK8/WKD8) + (QPK9/WKD9)]_t$$

For the fourth quarter (October to December):

$$(QPK10\text{-}12/WKD10\text{-}12)_t = \frac{1}{3}[(QPK10/WKD10) + (QPK11/WKD11) + (QPK12/WKD12)]_t$$

Demand

The consumption of pork is a function of such factors as the price of pork;consumption of substitute meats such as beef, broilers, turkeys, and veal; changes in disposable income; changes in population; temperature during the season; holidays and traditionally special dates; changes in tastes and preferences; and other factors.

We will overcome the population changes effect by expressing our data in per capita units. We will consider the following variables:

1. (CNPK/POP) = consumption per capita of non-pork red meats (beef, veal, lamb and mutton) in pounds, in a given quarter.
2. (CTB/POP) = consumption per capita of turkeys and broilers, in pounds, in a given quarter.
3. $(\frac{DI}{POP} \div CPI)$ = disposable income per capita, in dollars, in a given quarter, deflated by the Consumer Price Index (1967 = 100).
4. (PH/CPI) = deflated price of barrows and gilts, per 100 pounds of live hog.

Instead of using the variable,consumption of pork, we will use in its place the pork production plus stocks variable. This is reasonable because pork production and consumption are closely related but at the same time stocks of pork are relatively more significant than are other meat products. "The close relationship between pork production and consumption means that production can be used as an indicator of consumption in a statistical model" (8). And, instead of using quantity as the dependent variable we use price since quantity is largely predetermined in the time interval we are considering.

> Since the pioneering paper by Working on identification, price has commonly been used as the dependent variable when estimating demand functions for agricultural products by least squares. Justification as shown by Fox (5) is that consumption of agricultural products can be treated as predetermined; whereas price cannot be so treated (8).

Hog price estimates by quarters can be derived from one regression equation, fitted to data from the period 1958-1971. We will use one expression for each quarter, as this fits more clearly in the explanation for the forecasting model in Chapter IV. The regression equation was actually a single equation with dummy variables for quarters.

For the first quarter (January-March):

$$
\begin{aligned}
(PH1\text{-}3_t/CPI) = {} & 64.53 - \underset{(-9.13)}{2.55}(DSPK1\text{-}3_t/POP) \\
& - \underset{(-2.77)}{0.7777}(CNPK1\text{-}3_t/POP - \underset{(-0.27)}{0.1575}(CTB1\text{-}3_t/POP) \\
& + \underset{(2.56)}{0.0089}\left(\frac{DI}{POP} \div CPI\right) \qquad (21a)
\end{aligned}
$$

For the second quarter (April-June):

$$
\begin{aligned}
(PH4\text{-}6_t/CPI) = {} & 64.53 - \underset{(-1.14)}{8.33}D_1 - \underset{(-7.44)}{2.25}(DSPK4\text{-}6_t/POP) \\
& - 0.7777(CNPK4\text{-}6_t/POP) - 0.1575(CTB4\text{-}6_t/POP) \\
& + 0.0089\left(\frac{DI}{POP} \div CPI\right) \qquad (21b)
\end{aligned}
$$

For the third quarter (July-September):

$$(PH7\text{-}9_t/CPI) = 64.53 - \underset{(-1.23)}{8.97\,D_2} - \underset{(-6.94)}{2.19}(DSPK7\text{-}9_t/POP)$$

$$- 0.7777(CNPK7\text{-}9_t/POP) - 0.1575\ (CTB7\text{-}9_t/POP)$$

$$+ 0.0089(\frac{DI}{POP} \div CPI) \qquad (21c)$$

For the fourth quarter (October-December):

$$(PH10\text{-}12_t/CPI) = 64.53 - \underset{(-0.45)}{3.37\,D_3} - \underset{(-8.77)}{2.25}(DSPK10\text{-}12_t/POP)$$

$$-0.7777(CNPK10\text{-}12_t/POP)$$

$$-0.1575(CTB10\text{-}12_t/POP)$$

$$+0.0089(\frac{DI}{POP} \div CPI) \qquad (21d)$$

$$\bar{R}^2 = 0.83$$
$$SEE = 1.36$$

where:

$(PH1\text{-}3_t/CPI)$ = average price of barrows and gilts during the period January-March, in dollars per hundred pounds of live hog, deflated by the Consumer Price Index (1967 = 100), year t.

$(PH4\text{-}6_t/CPI)$ for period from April to June.

$(PH7\text{-}9_t/CPI)$ for period from July to September.

$(PH10\text{-}12_t/CPI)$ for period from October to December.

$D_1 = D_2 = D_3 = 1$ = dummy variables used for each of the last three quarters.

Since the expressions (21a), (21b), (21c), and (21d) are part of the same general equation for the four quarters, all present the same coefficient values for the variable consumption per capita of non-pork red meats, consumption of turkeys and broilers, and deflated disposable income per capita. Thus the "t-test" values are the same for these coefficients in any of the quarters. The $\bar{R}^2$ and SEE values are .83 and 1.36 respectively.

All coefficients have the expected signs; the negative signs of the coefficients for domestic supply of pork in the four equations show that increases in the amount of pork supplied would have a depressing effect on prices of hogs; the negative signs of the coefficients of the competing goods represented by the consumption of non-pork red meats and consumption of turkeys and broilers show that an increase in their consumption would bring a reduction in the price of hogs; the positive sign of the coefficient of the deflated disposable income per capita suggests that an increase in the real income per capita would bring higher prices for hogs. The coefficients for the domestic supply of hogs for the four quarters are significant at the 5 per cent level; the coefficients of the dummy variables used for the last three quarters are not significant at the 5 per cent level in any of the three quarters; the coefficient for consumption of non-pork red meat is significant at the 5 per cent level; the coefficient for consumption of turkeys and broilers proved to be not significant at the 5 per cent level; and the coefficient for real income proved to be significant at the 5 per cent level.

Similar estimates for hog prices were obtained in logarithmic form, since "with price dependent in a logarithmic relationship, the regression coefficient for consumption is the price flexibility which is the reciprocal of the price elasticity, providing other goods do not measurably affect consumption" (8).

The logarithmic estimates follow in their explicit forms, one for each quarter, as was done previously:

For the first quarter (January to March):

$$\log(PH1\text{-}3_t/CPI) = 1.85 - \underset{(-9.45)}{2.17}\log(DSPK1\text{-}3_t/POP) - \underset{(-3.01)}{1.06}\log(CNPK1\text{-}3_t/POP) - \underset{(-0.28)}{0.0623}\log(CTB1\text{-}3_t/POP) + \underset{(2.88)}{1.09}\log\left(\frac{DI}{POP} \div CPI\right) \quad (22a)$$

For the second quarter (April to June):

$$\log(PH4\text{-}6_t/CPI) = 1.85 - \underset{(-0.95)}{0.39}D_1 - \underset{(-8.02)}{1.91}\log(DSPK4\text{-}6_t/POP) - 1.06\log(CNPK4\text{-}6_t/POP) - 0.0623\log(CTB4\text{-}6_t/POP) + 1.09\log\left(\frac{DI}{POP} \div CPI\right) \quad (22b)$$

For the third quarter (July to September):

$$\log(PH7\text{-}9_t/CPI = 1.85 - \underset{(-1.39)}{0.58D_2} - \underset{(-7.22)}{1.75} \log (DSPK7\text{-}9_t/POP)$$

$$- 1.06 \log (CNPK7\text{-}9_t/POP)$$

$$- 0.0623 \log (CTB7\text{-}9_t/POP)$$

$$+ 1.09 \log (\frac{DI}{POP} \div CPI) \qquad (22c)$$

For the fourth quarter (October to December):

$$\log(PH10\text{-}12_t/CPI) = 1.85 + \underset{(0.04)}{0.014D_3} - \underset{(-9.60)}{2.15} \log (DSPK10\text{-}12_t/POP)$$

$$- 1.06 \log (CNPK10\text{-}12_t/POP)$$

$$- 0.0623 \log (CTB10\text{-}12_t/POP)$$

$$+ 1.09 \log (\frac{DI}{POP} \div CPI) \qquad \bar{R}^2 = .85 \quad SEE = .028 \qquad (22d)$$

The reciprocal of the pork consumption coefficient, here represented by the coefficient for the domestic supply of pork per capita, is an approximation of the price elasticity of demand. This coefficient points out an approximation of the farm-level demand elasticity (e) as being equal to $-\frac{1}{2.17}$ or -0.46 for the first quarter. This is just an approximation because the pork consumption is represented by the domestic pork supply per capita and because the consumption of pork is affected by the consumption of non-pork red meat and by the consumption of turkeys and broilers. The effect of these two competing goods acts to make our estimated elasticity lower than could be obtained from a more accurate estimation procedure (8).

Similar estimates of the demand price elasticity (e) with respect to the farm-price level for the other quarters show:

Second quarter: $e = -\frac{1}{1.91} = -0.52$

Third quarter: $e = -\frac{1}{1.75} = -0.57$

Fourth quarter: $e = -\frac{1}{2.15} = -0.46$

These approximations of the elasticity range from -0.46 to -0.57 depending on the quarter period considered. Myers and Havlicek (14), using data from the period 1949-1966, found an average farm level price elasticity of demand for hogs of -0.43, and using monthly average prices and quantities they found this elasticity ranging from -0.35 to -0.52.

Seasonality of Prices

Hog prices have exhibited regular seasonal fluctuations as a consequence of timing to fit work patterns on farms and to take advantage of pasture (not as important as formerly). Farrowings during the cold season require costly special installations and equipment; thus hog producers plan to have their sows farrowing during the spring and fall. The concentration of the farrowings in these two favorable periods brings a seasonal peak in the hog supply 6 to 9 months later. The rather large fluctuations in hog slaughter prices are illustrated in Figure 2, which was derived from data for 1958-1971. We can see two troughs, one in November when the spring pig crop is being marketed, and another in April when the fall pig crop is in the market. The peak occurs during the summer, in July, before the spring crop comes to market.*

The seasonal hog price oscillations are strong not only over the year, but also within the quarterly periods, which makes our quarterly hog price estimates less valuable for shorter time periods. Thus, 12 seasonal adjustment factors (K) were introduced, to permit us to estimate monthly hog prices.

$K_1 = 0.9741 + 0.00263\ T$ for January

$K_2 = 0.9816 + 0.0036\ T$ for February

$K_3 = 1.044 - 0.00622\ T$ for March

$K_4 = 0.9843 - 0.00458\ T$ for April

$K_5 = 0.9883 + 0.00084\ T$ for May

$K_6 = 1.0275 + 0.00374\ T$ for June

*The interrupted lines above and below the full line representing the index of seasonality bound the area of uncertainty about the index. The upper and lower bounds are one standard deviation above and one standard deviation below the mean respectively. This means, in other words, that in two years out of three the price will fall between the boundary lines. See Appendix A for original data and measures of seasonality in Tables 7 and 8.

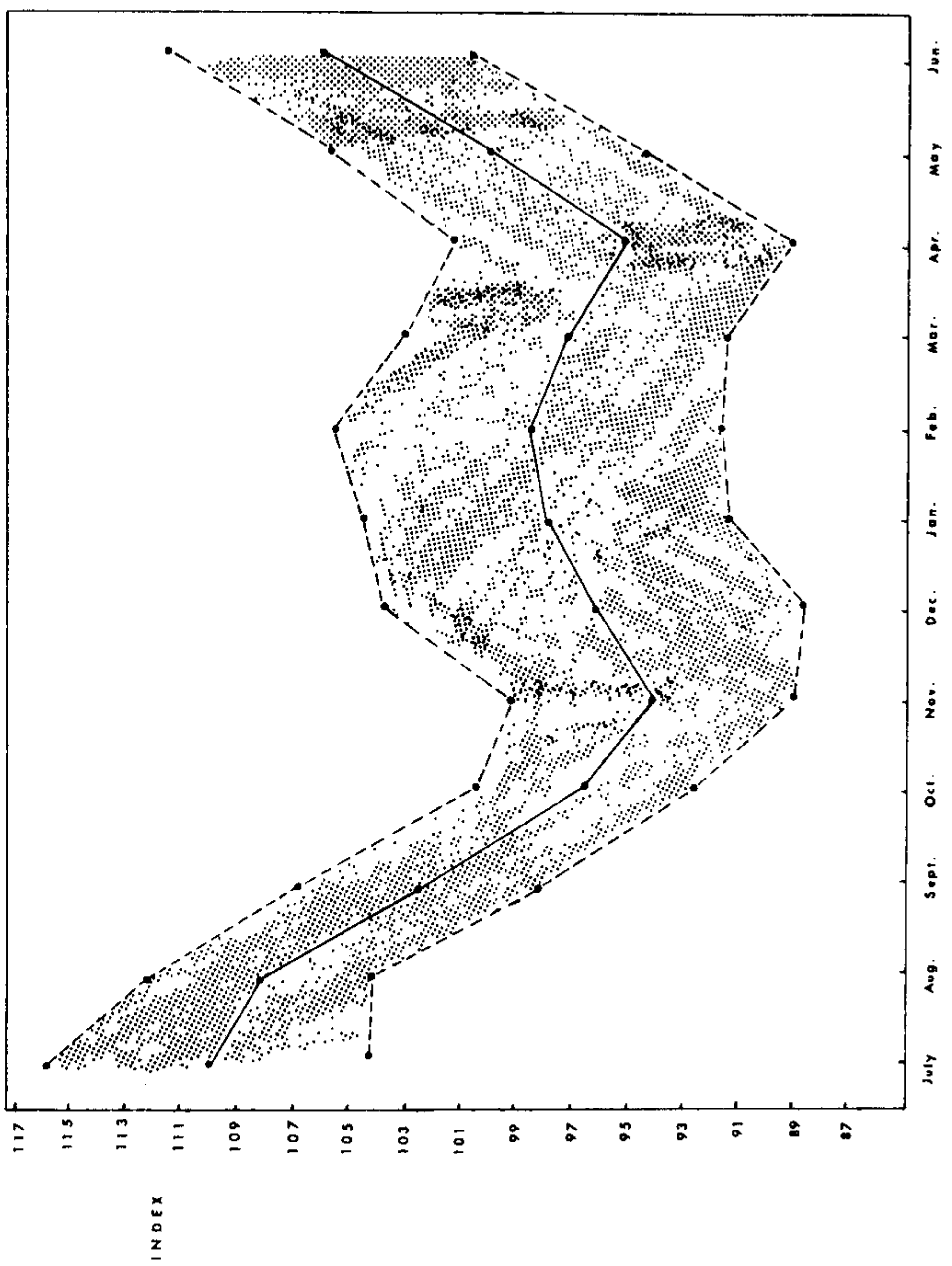

Figure 2. SEASONAL VARIATION ON SLAUGHTER HOG PRICES—1958-71

$K_7 = 1.0178 + 0.00122\ T$ for July

$K_8 = 1.013 - 0.0002\ T$ for August

$K_9 = 0.9692 - 0.00102\ T$ for September

$K_{10} = 1.017 - 0.00057\ T$ for October

$K_{11} = 0.9912 - 0.00107\ T$ for November

$K_{12} = 0.9919 + 0.00165\ T$ for December

where:

K = seasonal monthly adjustment factor.

T = time variable.

T_1= for year 1958; $T_2 = 2$ for year 1959; $T_3 = 3$ for year 1960, . . . , $T_{14} = 14$ for year 1971.

To obtain the K monthly adjustment factor for a given month m, we just substitute the value of T for the year wished.

The adjustment factors (K_i) came from a formula of the type:

$$K_i = 1957 \text{ values} + \Delta R \cdot T_i$$

where:

1957 value = the values from Table 11, in Appendix A, entitled "Smoothed Monthly Price Ratio Adjusted to Quarterly Data," for each month of the year 1957.

T = time variable, used in the same way as explained before.

ΔR = average year to year variation for each column-month on the previously mentioned Table 11 in Appendix A.

With the values of these adjustment factors for the month desired, together with our formulas for estimating quarterly hog prices, we could estimate the monthly hog prices through the following computations.

$Ph1_t = K_1 \cdot PH1\text{-}3_t$	for January	year t
$PH2_t = K_2 \cdot PH1\text{-}3_t$	for February	year t
$PH3_t = K_3 \cdot PH1\text{-}3_t$	for March	year t
$PH4_t = K_4 \cdot PH4\text{-}6_t$	for April	year t
$PH5_t = K_5 \cdot PH4\text{-}6_t$	for May	year t
$PH6_t = K_6 \cdot PH4\text{-}6_t$	for June	year t
$PH7_t = K_7 \cdot PH7\text{-}9_t$	for July	year t
$PH8_t = K_8 \cdot PH7\text{-}9_t$	for August	year t
$PH9_t = K_9 \cdot PH7\text{-}9_t$	for September	year t
$PH10_t = K_{10} \cdot PH10\text{-}12$	for October	year t
$PH11_t = K_{11} \cdot PH10\text{-}12$	for November	year t
$PH12_t = K_{12} \cdot PH10\text{-}12$	for December	year t

CHAPTER IV

THE FORECAST MODEL

Description

The representation of the forecast model presented in Figure 3 shows three different periods of time correspondent to three distinct areas bounded by the two broken lines: the upper area referred to as |T-1| represents a given year t-1; the middle |T| and the lower |T+1| represent the forecast period or the future, respectively the first and the second following year t and t+1, covering the period 24 months ahead.

The variables in the largest circles represent the exogenous variables, i.e., the ones outside this system or not explained by it. The endogenous variables, i.e., those explained by the model, are represented in the elliptical shaped boxes. The variables K_i inside the medium sized circles are pre-determined by trends in seasonal price patterns. The variable GMH is a mixture of endogenous and exogenous variables; it is presented arbitrarily in the boxes having the same shape as the ones used for the endogenous variables. The smallest circles contain mathematical symbols. The direction of the arrows represents the ordering of the

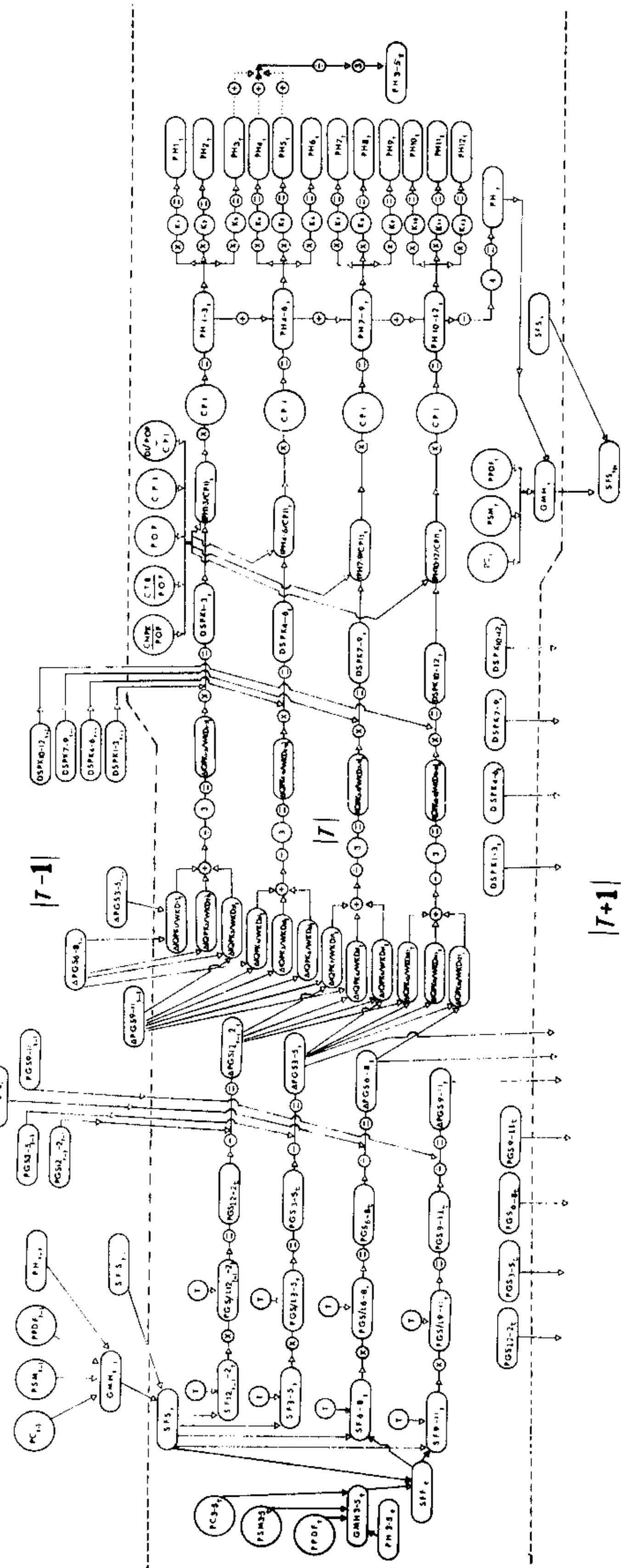

FIGURE 3 THE FORECAST MODEL

causal effects or influences from certain variables upon the others. The reason for the use of the whole figure is to make the functioning and the operation of the model more quick, direct and more easily understood.*

Five endogenous variables from the past year t-1, in area |T-1|, were used for the explanation of the variables in the following year t, area |T|:

1. the total number of pigs saved, by quarters, ($PGSq_{t-1}$);
2. the per cent change in the total number of pigs saved between year t-2 and year t-1, by quarters ($\Delta PGSq_{t-1}$);
3. the domestic supply of pork ($DSPKq_{t-1}$);
4. the price of hogs (PH_{t-1}).

Three exogenous variables from period year t-1, area T-1 were also used:

5. the price of corn (PC_{t-1});**
6. the price of soybean meal (PSM_{t-1});**
7. the index of prices paid by farmers ($PPDF_{t-1}$).

These three exogenous variables, together with the price of hogs, were aggregated into just one variable called gross margin on hogs, (GMH_{t-1}), to represent their associated effect.***

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*To circumvent the bordering problem which occurred when variables representing a three months average period when one of the months was in a given year and the two other months in the following year, the variable was indicated as belonging to the year in which most of the three month period falls.

**PC_{t-1} and PSM_{t-1} variables, respectively average price for corn and average price for soybean meal, were computed for the period from $October_{t-2}$ to $September_{t-1}$.

***A similar GMH is computed for the period March-May, year t.

We can begin our explanation of the model at the upper left portion of the figure where we see the lagged variables GMH_{t-1} together with SFS_{t-1} exerting their influence or determining the number of sows farrowing during the "spring" season in the following year t, SFS_t. This "spring" farrowing, which is of prime importance in the model, together with the trend variable T, establishes the number of farrowings in the first two quarters in the year t. The two quarter components of the "fall" season are determined by the variables SFF_t, SFS_t and by the time variable T.

The number of sows farrowing in a quarter multiplied by the average number of pigs saved per litter in the quarter, (PGS/Lq_t), will give us the total number of pigs saved in quarter q, $(PGSq_t)$.

The number of pigs saved per litter variables, (PGS/Lq), were explained as a function of time.

The total number of pigs saved in a quarter, (PGSq), divided by its correspondent value a year before will give us the change (increase or decrease) in the total number of pigs saved in quarter q, year t, relative to the correspondent period one year before, $(\Delta PGSq_t)$. These changes in a given quarter period will determine the future changes in the average quantity of pork produced per workday in a certain month, $[\Delta(QPKm/WKDm)_t]$.

Averaging three month values for the variable $\Delta(QPKm/WKDm)_t$, we can obtain the values for the quarterly changes, $[\Delta(QPKq/WKDq)_t]$.

Now, remembering the simplifying assumption made in Chapter III, that the changes in the quantity of pork produced would be equal to the changes in the domestic supply of pork, and, that it implied that

$$\Delta(QPKq/WKDq)_t \cdot DSPKq_{t-1} = DSPKq_t.$$

To this point we have described the supply side, relating hog prices to the domestic supply of pork. The next step is to generate hog prices from the equation incorporating the domestic pork supply.

The deflated price of hogs per quarter, (PHq/CPI), is the next variable to be explained. For that we introduced five new exogenous variables or demand factors:

8. consumption of turkeys and broilers in the quarter (CTB);
9. consumption of non-pork red meat in the quarter (CNPK);
10. disposable income per capita during the quarter (DI);
11. U. S..population for the quarter (POP);
12. Consumer Price Index in the quarter (CPI).

It can be observed that these values are projected values which must be obtained outside the model from external sources. Some of them may be found in some sources of information mentioned in Chapter II.

Some of these exogenous variables were aggregated and their overall effects together with the domestic supply of pork (DSPK) on the market will determine to a large extent the deflated price of hogs in the quarter, (PHq/CPI). To get the absolute values for the quarterly prices of hogs it is just enough to cancel the CPI value in the denominator. This is done by multiplying the deflated values by CPI.

Finally, the desired monthly hog prices are obtained by multiplying the quarterly hog prices by the adequate intra-quarter seasonal adjustment factor (K_i); there are 12 K_i values which permit us to determine the forecasted values for the hog prices during the 12 months of the year. The model was settled to forecast monthly prices for the two first quarters; after that, an average PH3-5_t is computed which turns around to the beginning of Figure 3 to enter the variable GMH3-5_t which will influence the two last quarters.

For the forecast of the values of PH for the 12 months of year t+1, area |T+1|, we just repeat the same process used here. In Figure 3 we can see that all variables which came from area |T-1| entering area |T|, will be generated in year t or will be predetermined for year t and will then generate values for variables in year t+1.

Forecasting

The following results were obtained using the model to forecast its total range, i.e., a 24 month period ahead.

Table 1. Results from forecasting quarterly domestic supply of pork per capita (DSPK/POP), in the first year ahead.

Year	Quarter	Reported (DSPK/POP) (lb)	Predicted (DSPK/POP) (lb)	Pred-Rep (lb)
1959	q_1	18.66	18.87	+0.21
	q_2	16.73	16.10	-0.63
	q_3	16.51	15.96	-1.05
	q_4	21.58	20.37	-1.21
			E = 4.2%	
1960	q_1	19.85	19.73	-0.12
	q_2	16.98	17.19	+0.21
	q_3	15.61	15.93	+0.32
	q_4	18.22	20.08	+1.86
			E = 3.6%	
1961	q_1	17.58	17.94	+0.36
	q_2	15.81	17.00	+1.19
	q_3	14.65	15.55	+0.90
	q_4	18.59	18.02	-0.57
			E = 4.5%	
1962	q_1	18.03	17.99	-0.04
	q_2	16.54	16.15	-0.39
	q_3	14.97	14.90	-0.07
	q_4	19.01	18.38	-0.63
			E = 1.6%	
1963	q_1	18.67	18.38	-0.29
	q_2	17.09	17.20	+0.11
	q_3	15.98	15.25	-0.73
	q_4	19.95	18.75	-1.93
			E = 4.3%	
1964	q_1	19.25	18.24	-1.01
	q_2	17.32	16.47	-0.85
	q_3	15.95	15.37	-0.58
	q_4	19.63	18.22	-1.41
			E = 5.3%	
1965	q_1	17.68	17.41	-0.27
	q_2	15.20	16.39	+1.19
	q_3	14.07	15.22	+1.15
	q_4	15.53	17.78	+2.25
			E = 7.8%	

Table 1 (Cont'd.).

Year	Quarter	Reported (DSPK/POP) (lb)	Predicted (DSPK/POP) (lb)	Pred-Rep (lb)
1966	q_1	14.82	15.40	+0.58
	q_2	14.61	14.37	-0.24
	q_3	14.44	14.55	+0.11
	q_4	17.66	17.61	-0.05
			E= 1.6%	
1967	q_1	18.03	16.51	-1.52
	q_2	16.20	15.79	-0.41
	q_3	16.08	15.91	-0.17
	q_4	18.53	19.28	+0.75
			E = 4.1%	
1968	q_1	17.89	17.67	-0.22
	q_2	17.12	16.39	-0.73
	q_3	15.95	16.09	+0.14
	q_4	19.07	17.85	-1.22
			E = 3.3%	
1969	q_1	18.30	18.58	+0.28
	q_2	16.87	17.62	+0.75
	q_3	15.97	16.75	+0.78
	q_4	17.47	18.83	+1.36
			E = 4.6%	
1970	q_1	16.45	16.83	+0.38
	q_2	16.66	16.22	-0.44
	q_3	16.90	16.34	-0.56
	q_4	20.43	19.87	-0.56
			E = 2.8%	
1971	q_1	19.91	19.84	-0.07
	q_2	19.70	19.32	-0.38
	q_3	18.88	18.71	-0.17
	q_4	20.28	20.51	+0.23
			E = 1.1%	
1972	q_1	--	18.32	--
	q_2	--	18.58	--
	q_3	--	17.76	--
	q_4	--	19.42	--
			E = ---%	

Table 2. Results from forecasting quarterly supply of pork (DSPK/POP), in the second year ahead.

Year	Quarter	Reported (DSPK/POP) (lb)	Predicted (DSPK/POP) (lb)	Pred-Rep (lb)
1960	q_1	19.85	20.51	+0.66
	q_2	16.98	16.10	-0.88
	q_3	15.61	15.46	-0.15
	q_4	18.22	20.37	+2.15
			E = 5.4%	
1961	q_1	17.58	19.28	+1.70
	q_2	15.81	17.69	+1.88
	q_3	14.65	15.80	+1.15
	q_4	18.59	18.91	+0.32
			E = 7.6%	
1962	q_1	18.03	17.38	-0.65
	q_2	16.54	16.61	+0.07
	q_3	14.97	15.57	+0.60
	q_4	19.01	18.10	-0.91
			E = 3.3%	
1963	q_1	18.67	18.19	-0.48
	q_2	17.09	16.45	-0.64
	q_3	15.98	15.26	-0.72
	q_4	19.95	18.78	-1.17
			E = 4.2%	
1964	q_1	19.25	17.62	-1.63
	q_2	17.32	16.65	-0.67
	q_3	15.95	14.86	-1.09
	q_4	19.63	18.01	-1.62
			E = 6.9%	
1965	q_1	17.68	16.88	-0.80
	q_2	15.20	15.94	+0.74
	q_3	14.07	15.20	+1.13
	q_4	15.53	17.93	+2.40
			E = 8.1%	
1966	q_1	14.82	16.52	+1.70
	q_2	14.61	16.53	+1.92
	q_3	14.44	15.67	+1.23
	q_4	17.66	18.35	+0.69
			E = 9.0%	

Table 2 (Cont'd.).

Year	Quarter	Reported (DSPK/POP) (lb)	Predicted (DSPK/POP) (lb)	Pred-Rep (lb)
1967	q_1	18.03	18.40	+0.37
	q_2	16.20	16.64	+0.44
	q_3	16.08	16.33	+0.25
	q_4	18.53	19.64	+1.11
			E = 3.2%	
1968	q_1	17.89	17.60	-0.29
	q_2	17.12	16.75	-0.37
	q_3	15.95	16.48	+0.53
	q_4	19.07	19.49	+0.42
			E = 2.3%	
1969	q_1	18.30	17.40	-0.90
	q_2	16.87	16.37	-0.50
	q_3	15.97	16.81	+0.84
	q_4	17.47	19.23	+1.76
			E = 5.8%	
1970	q_1	16.45	18.04	+1.59
	q_2	16.66	17.54	+0.88
	q_3	16.90	17.02	+0.12
	q_4	20.43	19.17	-1.26
			E = 5.5%	
1971	q_1	19.91	19.03	-0.88
	q_2	19.70	17.84	-1.86
	q_3	18.88	17.46	-1.42
	q_4	20.28	20.93	+0.65
			E = 6.1%	
1972	q_1	--	18.79	--
	q_2	--	18.44	--
	q_3	--	18.00	--
	q_4	--	19.20	--
			E = ---%	
1973	q_1	--	17.87	--
	q_2	--	18.59	--
	q_3		18.26	--
	q_4	--	20.19	--
			E = ---%	

Table 3. Results when forecasting monthly hog prices (PHm) in the first year ahead.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
						(dollars/cwt)							
1959	Reported (PH)	16.63	15.63	15.89	16.09	16.09	15.91	14.40	14.65	13.81	13.11	12.61	11.86
	Predicted ($\hat{PH}$)	15.04	15.18	15.84	16.83	17.09	17.87	18.20	18.06	17.25	13.37	13.02	13.10
	Pred-Rep ($\hat{PH}$-PH)	-1.59	-0.45	-0.05	+0.74	+1.00	+1.96	+3.80	+3.41	+3.44	+0.26	+0.41	+1.24
						E = 10.3%							
1960	Reported (PH)	12.65	13.56	16.55	15.96	16.03	16.88	17.74	16.91	16.59	17.30	17.36	17.27
	Predicted ($\hat{PH}$)	13.00	13.13	13.57	14.99	15.30	16.04	16.78	16.63	15.87	13.80	13.43	13.55
	Pred-Rep ($\hat{PH}$-PH)	+0.35	-0.43	-2.98	-0.97	-0.73	-0.84	-0.96	-0.28	-0.72	-3.50	-3.93	-3.72
						E = 10.0%							
1961	Reported (PH)	17.33	18.13	17.53	17.04	16.37	16.60	17.87	18.33	18.18	16.55	15.97	16.70
	Predicted ($\hat{PH}$)	16.08	16.27	16.64	14.13	14.50	15.25	17.82	17.64	16.82	17.37	16.90	17.10
	Pred-Rep ($\hat{PH}$-PH)	-1.25	-1.86	-0.89	-2.91	-1.87	-1.35	-0.05	-0.69	-1.36	+0.82	+0.93	+0.40
						E = 7.0%							
1962	Reported (PH)	16.98	16.69	16.31	15.81	15.51	16.87	18.30	18.50	18.82	16.87	16.50	16.16
	Predicted ($\hat{PH}$)	15.93	16.13	16.35	16.55	17.09	18.01	19.67	19.44	18.52	16.88	16.41	16.64
	Pred-Rep ($\hat{PH}$-PH)	-1.05	-0.56	+0.04	+0.74	+1.58	+1.14	+1.37	+0.94	-0.30	+0.01	-0.09	+0.48
						E = 4.1%							
1963	Reported (PH)	15.65	15.14	14.07	13.78	15.01	17.10	18.44	17.55	15.89	15.47	14.47	14.21
	Predicted ($\hat{PH}$)	15.49	15.70	15.75	14.35	14.89	15.74	18.49	18.25	17.37	15.66	15.21	15.47
	Pred-Rep ($\hat{PH}$-PH)	-0.16	+0.56	+1.68	+0.57	-0.12	-1.36	+0.05	+0.70	+1.48	+0.19	+0.74	+1.26
						E = 4.7%							
1964	Reported (PH)	14.70	14.70	14.48	14.16	14.84	15.83	17.11	17.05	16.76	15.39	14.43	15.55
	Predicted ($\hat{PH}$)	15.87	16.10	16.00	15.41	16.09	17.06	19.08	18.81	17.89	17.14	16.64	16.98
	Pred-Rep ($\hat{PH}$-PH)	+1.17	+1.40	+1.52	+1.25	+1.25	+1.23	+1.97	+1.76	+1.13	+1.75	+2.21	+1.43
						E = 9.8%							
1965	Reported (PH)	16.06	17.01	16.98	17.63	20.29	23.38	24.27	24.67	22.92	23.36	24.33	28.07
	Predicted ($\hat{PH}$)	18.31	18.59	18.30	17.33	18.20	19.34	20.73	20.41	19.39	18.57	18.02	18.43
	Pred-Rep ($\hat{PH}$-PH)	+2.25	+1.58	+1.32	-0.30	-2.09	-4.04	-3.54	-4.26	-3.53	-4.79	-6.31	-9.64
						E = 16.9%							

Table 3. (Cont'd.).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
						(dollars/cwt)							
1966	Reported (PH)	27.93	27.80	24.41	22.26	23.16	24.72	25.09	25.75	23.16	21.57	19.87	19.67
	Predicted ($\hat{PH}$)	25.20	25.61	24.95	22.33	23.58	25.13	22.60	22.21	21.08	20.44	19.83	20.34
	Pred-Rep ($\hat{PH}$-PH)	-2.73	-2.19	+0.54	+0.07	+0.49	+0.41	-2.49	-3.54	-2.08	-1.13	-0.04	+0.67
						E = 5.7%							
1967	Reported (PH)	19.46	19.38	18.43	17.62	21.83	22.29	22.58	21.04	19.46	18.16	17.36	17.29
	Predicted ($\hat{PH}$)	22.23	22.61	21.82	19.12	20.31	21.70	20.82	20.44	19.39	17.85	17.30	17.79
	Pred-Rep ($\hat{PH}$-PH)	+2.77	+3.23	+3.39	+1.50	-1.52	-0.59	+1.76	-0.60	-0.07	-0.31	-0.06	+0.50
						E = 6.9%							
1968	Reported (PH)	18.31	19.41	19.07	19.00	18.88	20.43	21.48	20.08	19.93	18.29	17.92	18.76
	Predicted ($\hat{PH}$)	20.14	20.51	19.59	19.19	20.50	21.96	20.96	20.55	19.47	21.81	21.14	21.80
	Pred-Rep ($\hat{PH}$-PH)	+1.83	+2.93	+0.52	+0.19	+1.62	+1.53	-0.52	+0.47	-0.46	+3.52	+3.22	+3.04
						E = 8.6%							
1969	Reported (PH)	19.77	20.41	20.69	20.38	23.14	25.16	26.05	26.91	25.94	25.53	25.77	26.93
	Predicted ($\hat{PH}$)	19.06	19.43	18.38	17.54	18.84	20.23	20.50	20.06	19.00	19.59	18.97	19.62
	Pred-Rep ($\hat{PH}$-PH)	-0.71	-0.98	-2.31	-2.84	-4.30	-4.93	-5.55	-6.85	-6.94	-5.94	-6.80	-7.31
						E = 19.3%							
1970	Reported (PH)	27.40	28.23	25.94	24.02	23.53	24.04	25.13	22.12	20.35	17.91	15.69	15.67
	Predicted ($\hat{PH}$)	24.64	25.13	23.54	21.34	23.06	24.83	23.10	22.58	21.36	19.21	18.60	19.28
	Pred-Rep ($\hat{PH}$-PH)	-2.76	-3.10	-2.40	-2.68	-0.47	+0.79	-2.03	+0.46	+1.01	+1.30	+2.91	+3.61
						E = 8.7%							
1971	Reported (PH)	16.30	19.43	17.13	16.19	17.43	18.38	19.84	19.07	18.91	19.80	19.38	19.65
	Predicted ($\hat{PH}$)	19.04	19.43	18.02	16.26	17.67	19.08	19.14	18.68	17.66	19.35	18.72	19.46
	Pred-Rep ($\hat{PH}$-PH)	+2.74	0.00	+0.89	+0.07	+0.24	+0.70	-0.70	-0.39	-1.25	-0.45	-0.66	-0.19
						E = 3.7%							
1972	Reported (PH)	--	--	--	--	--	--	--	--	--	--	--	--
	Predicted ($\hat{PH}$)	23.80	24.31	22.32	17.71	19.36	20.96	21.66	21.12	19.95	22.59	21.84	22.77
	Pred-Rep ($\hat{PH}$-PH)	--	--	--	--	--	--	--	--	--	--	--	--
						E = ---%							

Table 4. Results when forecasting monthly hog prices (PHm) in the second year ahead.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
						(dollars/cwt)							
1960	Reported (PH)	12.65	13.56	16.55	15.96	16.03	16.88	17.74	16.91	16.59	17.30	17.36	17.27
	Predicted ($\hat{PH}$)	12.60	12.73	13.15	14.72	15.03	15.75	17.77	17.62	16.81	14.47	14.08	14.21
	Pred-Rep ($\hat{PH}$-PH)	-0.05	-0.83	-3.40	-1.24	-1.00	-1.13	+1.10	+0.71	+0.22	-2.83	-3.28	-3.06
						E = 9.7%							
1961	Reported (PH)	17.33	18.13	17.53	17.04	16.37	16.60	17.87	18.33	18.18	16.55	15.97	16.70
	Predicted ($\hat{PH}$)	13.71	13.87	14.19	14.13	14.51	15.25	17.04	16.87	16.08	15.69	15.26	15.44
	Pred-Rep (PH-PH)	-3.62	-4.26	-3.34	-2.91	-1.86	-1.35	-0.83	-1.46	-2.10	-0.86	-0.71	-1.26
						E = 11.9%							
1962	Reported (PH)	16.98	16.69	16.31	15.81	15.51	16.87	18.30	18.50	18.82	16.87	16.50	16.16
	Predicted ($\hat{PH}$)	17.28	17.50	17.73	14.70	15.17	15.99	17.80	17.60	16.76	17.20	16.72	16.96
	Pred-Rep (PH-PH)	+0.30	+0.81	+1.42	-1.11	-0.34	-0.88	-0.50	-0.90	-2.06	+0.33	+0.22	+0.80
						E = 4.8%							
1963	Reported (PH)	15.65	15.14	14.07	13.78	15.01	17.10	18.44	17.55	15.89	15.47	14.47	14.21
	Predicted ($\hat{PH}$)	15.60	15.81	15.87	15.90	16.51	17.45	18.89	18.64	17.74	16.11	15.65	15.92
	Pred-Rep ($\hat{PH}$-PH)	-0.05	+0.67	+1.80	+2.12	+1.50	+0.35	+0.45	+1.09	+1.85	+0.64	+1.18	+1.71
						E = 7.2%							
1964	Reported (PH)	14.70	14.70	14.48	14.16	14.84	15.83	17.11	17.05	16.76	15.39	14.43	15.55
	Predicted ($\hat{PH}$)	17.03	17.27	17.16	15.31	15.99	16.94	19.37	19.09	18.15	17.05	16.56	16.89
	Pred-Rep ($\hat{PH}$-PH)	+2.33	+2.57	+2.68	+1.15	+1.15	+1.11	+2.26	+2.04	+1.39	+1.66	+2.13	+1.34
						E = 11.8%							
1965	Reported (PH)	16.06	17.01	16.98	17.63	20.29	23.38	24.27	24.67	22.92	23.36	24.33	28.07
	Predicted ($\hat{PH}$)	18.82	19.11	18.81	16.32	17.14	18.21	19.47	19.16	18.21	17.72	17.20	17.59
	Pred-Rep ($\hat{PH}$-PH)	+2.76	+2.10	+1.83	-1.31	-3.15	-5.17	-4.80	-5.51	-4.71	-5.64	-7.13	-10.48
						E = 21.1%							
1966	Reported (PH)	27.93	27.80	24.41	22.26	23.16	24.72	25.09	25.75	23.16	21.57	19.87	19.67
	Predicted ($\hat{PH}$)	20.56	20.90	20.36	16.97	17.92	19.10	19.72	19.39	18.41	17.33	16.81	17.24
	Pred-Rep ($\hat{PH}$-PH)	-7.37	-6.90	-4.05	-5.29	-5.24	-5.62	-5.37	-6.36	-4.75	-4.24	-3.06	-2.43
						E = 21.3%							

Table 4. (Cont'd.).

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
						(dollars/cwt)							
1967	Reported (PH)	19.46	19.38	18.43	17.62	21.83	22.29	22.58	21.04	19.46	18.16	17.36	17.29
	Predicted ($\hat{PH}$)	17.17	17.46	16.85	16.80	17.84	19.06	18.50	18.15	17.22	16.15	15.66	16.11
	Pred-Rep ($\hat{PH}$-PH)	-2.29	-1.92	-1.58	-0.82	-3.99	-3.23	-4.08	-2.89	-2.24	-2.01	-1.70	-1.18
						E = 11.9%							
1968	Reported (PH)	18.31	19.41	20.69	20.38	23.14	25.16	26.05	26.91	25.94	25.53	25.77	26.93
	Predicted ($\hat{PH}$)	19.42	19.78	18.89	17.01	18.17	19.47	19.60	19.22	18.21	17.42	16.88	17.41
	Pred-Rep ($\hat{PH}$-PH)	+1.11	+0.37	-1.80	-3.37	-4.97	-5.69	-6.45	-7.69	-7.73	-8.11	-8.89	-9.52
						E = 28.4%							
1969	Reported (PH)	19.77	20.41	20.69	20.38	23.14	25.16	26.05	26.91	25.94	25.53	25.77	26.93
	Predicted ($\hat{PH}$)	20.90	21.29	20.14	19.13	20.55	22.08	19.44	19.03	18.02	18.58	17.99	18.60
	Pred-Rep ($\hat{PH}$-PH)	+1.13	+0.88	-0.55	-1.25	-2.59	-3.08	-6.61	-7.88	-7.92	-6.95	-7.78	-8.33
						E = 19.2%							
1970	Reported (PH)	27.40	28.23	25.94	24.02	23.53	24.04	25.13	22.12	20.35	17.91	15.69	15.67
	Predicted ($\hat{PH}$)	19.37	20.77	19.45	17.61	19.03	20.49	19.96	19.51	18.46	18.84	18.24	18.91
	Pred-Rep ($\hat{PH}$-PH)	-8.03	-7.46	-6.49	-6.41	-4.50	-3.55	-5.17	-2.61	-1.89	+0.93	+2.55	+3.24
						E = 19.6%							
1971	Reported (PH)	16.30	19.43	17.13	16.19	17.43	18.38	19.84	19.07	18.91	19.80	19.38	19.65
	Predicted ($\hat{PH}$)	18.93	19.33	17.92	17.70	19.23	20.77	20.59	20.10	19.00	17.18	16.62	17.28
	Pred-Rep ($\hat{PH}$-PH)	+2.63	-0.10	+0.79	+1.51	+1.80	+2.39	+0.75	+1.03	+0.09	-2.62	-2.76	-2.37
						E = 8.5%							
1972	Reported (PH)	--	--	--	--	--	--	--	--	--	--	--	--
	Predicted ($\hat{PH}$)	21.50	21.96	20.16	17.68	19.33	20.93	20.50	19.99	18.88	22.28	21.55	22.46
	Pred-Rep ($\hat{PH}$-PH)	--	--	--	--	--	--	--	--	--	--	--	--
						E = ---%							
1973	Reported (PH)	--	--	--	--	--	--	--	--	--	--	--	--
	Predicted ($\hat{PH}$)	25.18	25.75	23.40	17.60	19.35	21.00	20.67	20.13	18.99	20.77	20.07	20.99
	Pred-Rep ($\hat{PH}$-PH)	--	--	--	--	--	--	--	--	--	--	--	--
						E = ---%							

In Table 1 are the results when using the model to forecast quarterly domestic supply of pork per capita one year in advance (year t).

A measure of the absolute magnitude of the error, i.e., the difference among predicted and reported (taken as actual) values is presented in the last column. An average measure of the error was computed by the formula

$$E = \frac{\frac{\Sigma\ (Pred-Rep)}{n}}{\frac{\Sigma\ Rep}{n}}$$

where:

Pred = values predicted by the model.

Rep = reported values.

n = number of observations, which is cancelled out in the expression above.

E = average forecast error during the year, in %.

E values for the forecast of (DSPK/POP), one year in advance, ranged from 7.8% in 1965, to 1.1% in 1971; see Table 1. The model predicted the right direction of changes in prices 46 times, of a total of 51, which is a good performance.

Table 2 shows correspondent results for (DSPK/POP) but when the model is forecasting two years in advance (year t+1), a larger error is expected.

Table 3 shows the results when the model is forecasting monthly hog prices one year in advance (year t).

E varies from 19.3% in 1969 to 3.7% in 1971. Correspondent forecasts can be found in Table 4, when the model is operating to make forecasts two years in advance.

The model proved to be much more accurate when forecasting the quarterly domestic supply of pork than forecasting monthly prices. It is expected because monthly variations are larger than quarterly variation; variation in a quarter is smoothed out since it is an averaged value. As expected, the model performed better when forecasting one year ahead than when performing the forecast two years in advance.

CHAPTER V

CONCLUSIONS

This research, as was previously mentioned, is a first step in the development of an improved model in the future. It is a basic general model in which the forecaster can introduce his own operating devices, as the ones used by Crom (2), in order to improve estimates involving particular situations. We can make a 24-month in advance forecast as a first development and later make continuous introduction of more recent information published by the USDA, which would be a dynamic way of improving our forecasts.

The December issue of the Hogs and Pigs report published by the USDA brings projections about the number of sows farrowing and other basic variables for the first half of the future year. An interesting check on our model would be to compare the results generated entirely by the model versus the results from introducing directly the variables $\Delta PGS12_{t-1}-2_t$ and $\Delta PGS\ 3\text{-}5_t$ in the model as estimated by the USDA which are based on the farmer's intentions.

The computer program for those who wish to use the model is available in Appendix B.

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APPENDIX A

Table 1. Sows Farrowing, U. S. (in thousands)--1958-1971.

Year	Dec.-Feb.	Mar.-May	Jun.-Aug.	Sept.-Nov.	Spring (Dec.-May)	Fall (Jun.-Nov.)
1958	2680	4601	3141	2746	7281	5887
1959	3053	4943	3346	2782	7996	6128
1960	2511	4279	3042	2813	6790	5855
1961	2531	4501	3099	2854	7029	5953
1962	2580	4416	3141	2957	6996	6098
1963	2593	4506	3125	2862	7099	5987
1964	2366	4230	2903	2622	6596	5525
1965	2178	3712	2548	2458	5890	5006
1966	2220	3981	3009	2802	6201	5811
1967	2450	4120	2974	2925	6570	5899
1968	2557	4112	3152	2977	6669	6129
1969	2570	3790	2924	2803	6360	5727
1970	2550	4421	3489	3409	7171	6898
1971	3009	4270	3201	3097	7279	6298

Table 2. Pigs Saved per Litter, U. S. (Units)--1958-1971.

Year	Spring (Dec. 1-May)	Fall (Jun.-Nov.)
1958	7.05	7.17
1959	7.07	6.98
1960	6.95	7.05
1961	7.18	7.16
1962	7.08	7.23
1963	7.15	7.23
1964	7.23	7.21
1965	7.22	7.27
1966	7.32	7.25
1967	7.34	7.38
1968	7.37	7.35
1969	7.36	7.34
1970	7.33	7.21
1971	7.19	7.25

Table 3. Estimated Total Pork Production (Mil. lb.) per Month.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1958	1011	802	878	824	750	726	730	735	841	1075	989	1094
1959	1064	1000	1013	937	838	840	860	809	946	1214	1178	1289
1960	1166	1036	1082	924	914	865	737	865	860	993	1074	1074
1961	1041	905	1078	835	936	866	734	855	851	1098	1143	1050
1962	1101	935	1093	944	976	864	809	880	798	1188	1144	1080
1963	1142	991	1135	1049	997	833	861	867	966	1196	1158	1218
1964	1234	1033	1117	1084	931	878	864	824	951	1216	1180	1192
1965	1070	970	1135	981	811	812	763	814	927	979	995	919
1966	859	838	1042	924	876	842	748	880	992	1058	1125	1138
1967	1140	1008	1168	1021	930	919	838	1010	1047	1185	1172	1124
1968	1184	1015	1091	1115	1112	897	945	998	1061	1281	1173	1192
1969	1200	1077	1160	1147	1030	991	972	945	1075	1218	1028	1131
1970	1081	956	1107	1139	1017	983	992	1010	1158	1306	1283	1402
1971	1305	1106	1374	1298	1191	1199	1000	1154	1224	1241	1325	1336

Table 4. Number of Workdays per Month--Period from 1958-1971.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1958	23.8	21.3	22.7	23.3	23.2	22.3	23.8	22.7	22.8	24.3	21.2	23.8
1959	23.2	21.3	23.3	23.3	22.3	23.3	24.0	22.7	22.8	23.7	21.2	23.8
1960	22.2	22.3	24.3	22.7	22.8	23.3	22.2	24.3	22.8	22.7	22.8	23.7
1961	23.3	21.3	24.3	21.7	23.8	23.3	22.2	24.3	22.2	23.3	22.8	22.2
1962	23.8	21.3	23.7	22.3	23.8	22.7	22.8	24.3	21.2	24.3	22.8	22.2
1963	23.8	21.3	22.7	23.3	23.8	21.7	23.8	23.7	21.8	24.3	22.2	22.8
1964	23.8	21.7	23.3	23.3	22.3	23.3	24.0	22.7	22.8	23.7	21.8	23.8
1965	22.2	21.3	24.3	23.3	22.2	23.3	23.2	23.3	22.8	22.7	22.8	24.0
1966	22.3	21.3	24.3	22.7	22.8	23.3	22.2	24.3	22.8	22.7	22.8	23.7
1967	23.3	21.3	24.3	21.7	23.8	23.3	22.2	24.3	22.2	23.3	22.8	22.2
1968	23.8	22.3	22.7	23.3	23.8	21.7	23.8	23.7	21.8	24.3	22.2	22.8
1969	23.8	21.3	22.7	23.3	22.7	22.3	23.8	22.7	22.8	24.3	21.2	23.8
1970	22.2	21.3	23.3	23.3	22.3	23.3	24.0	22.7	22.8	23.7	21.8	23.8
1971	22.2	21.3	24.3	23.3	22.7	23.3	23.7	23.3	22.8	22.7	22.8	24.0

TABLE 5

THE RATIO OF THE PORK PRODUCTION PER WORKDAYS , YEAR t RELATIVE TO YEAR t-1

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1959.	1.08[illegible]	1.247	1.124	1.137	1.162	1.107	1.168	1.101	1.125	1.158	1.191	1.178
1960.	1.145	.99[illegible]	1.024	1.012	1.067	1.030	.926	.999	.909	.854	.848	.837
1961.	.851	.915	.996	.945	.981	1.001	.996	.988	1.016	1.077	1.064	1.044
1962.	1.035	1.033	1.040	1.1[illegible]	1.043	1.024	1.073	1.029	.982	1.037	1.001	1.029
1963.	1.037	1.060	1.084	1.064	1.022	1.049	1.020	1.010	1.177	1.007	1.040	1.098
1964.	1.081	1.023	.959	1.033	.997	.982	.995	.992	.941	1.042	1.038	.938
1965.	.930	.957	.974	.9[illegible]5	.875	.925	.914	.962	.975	.841	.806	.765
1966.	.799	.864	.918	.967	1.052	1.037	1.025	1.037	1.070	1.091	1.131	1.254
1967.	1.27[illegible]	1.2[illegible]3	1.121	1.156	1.117	1.[illegible]91	1.120	1.148	1.084	1.091	1.042	1.054
1968.	1.017	.962	1.0[illegible]	1.[illegible]17	1.196	1.048	1.052	1.013	1.032	1.037	1.028	1.033
1969.	1.014	1.[illegible]11	1.063	1.029	.971	1.075	1.029	.989	.969	.951	.918	.969
1970.	.966	.988	.930	.993	1.0[illegible]5	.949	1.012	1.069	1.077	1.099	1.214	1.240
1971.	1.207	1.157	1.190	1.140	1.150	1.220	1.082	1.113	1.057	.992	.987	.945

Table 6a. Quarterly Data Used, 1958-1964.

Year	Quarter	Beginning Stocks of Pork (mil.lb.)	Production of Pork (mil.lb)	Domestic Supply of Pork (mil.lb)	U.S. Population (mil.)	Domestic Supply Pork/Capita (lb.)	Per Capita Cons. of Non-Pork (lb.)	Per Capita Cons. of Turkeys & Broilers (lb.)	Disp. Income Per Capita ÷ CPI (1967) ($)	CPI (1967=100)
1958	Q_1	194	2690	2884	173.1	16.66	22.30	5.5	2099	86.0
	Q_2	224	2299	2523	173.7	14.53	22.60	6.8	2090	86.6
	Q_3	210	2306	2516	174.5	14.42	23.70	8.1	2124	86.8
	Q_4	127	3159	3286	175.3	18.75	22.80	9.0	2147	86.8
1959	Q_1	206	3078	3284	176.0	18.66	21.80	6.1	2160	86.7
	Q_2	337	2617	2954	176.6	16.73	23.00	7.5	2188	87.0
	Q_3	313	2616	2929	177.4	16.51	23.80	8.0	2167	87.5
	Q_4	163	3682	3845	178.2	21.58	23.30	8.8	2172	88.0
1960	Q_1	264	3286	3550	178.8	19.85	23.60	5.7	2186	88.0
	Q_2	338	2710	3048	179.5	16.98	23.40	7.0	2210	88.5
	Q_3	351	2462	2813	180.2	15.61	25.30	7.9	2206	88.7
	Q_4	158	3141	3299	181.1	18.22	23.70	8.9	2185	89.3
1961	Q_1	170	3025	3195	181.7	17.58	23.60	6.0	2172	89.3
	Q_2	244	2640	2884	182.4	15.81	25.10	8.4	2211	89.3
	Q_3	240	2443	2683	183.1	14.65	25.20	9.0	2227	89.7
	Q_4	128	3292	3420	184.0	18.59	24.60	9.8	2260	89.9
1962	Q_1	200	3130	3330	184.7	18.03	24.90	6.3	2263	90.1
	Q_2	280	2785	3065	185.3	16.54	24.60	7.9	2265	90.5
	Q_3	295	2490	2785	186.1	14.97	25.50	8.3	2265	90.7
	Q_4	139	3413	3552	186.8	19.01	24.60	10.2	2266	91.1
1963	Q_1	230	3270	3500	187.5	18.67	25.10	6.6	2295	91.2
	Q_2	333	2882	3215	188.1	17.09	25.80	8.0	2318	91.3
	Q_3	323	2694	3017	188.8	15.98	26.90	8.9	2314	92.1
	Q_4	210	3572	3782	189.6	19.95	26.50	10.3	2337	92.3
1964	Q_1	277	3384	3661	190.2	19.25	26.30	7.1	2390	92.5
	Q_2	411	2894	3305	190.8	17.32	27.70	8.3	2439	92.7
	Q_3	413	2639	3052	191.3	15.95	27.70	9.2	2458	93.1
	Q_4	184	3588	3772	192.2	19.63	27.60	10.4	2472	93.5

Table 6b. Quarterly Data Used, 1965-1971.

Year	Quarter	Beginning Stocks of Pork (mil.lb)	Production of Pork (mil.lb)	Domestic Supply of Pork (mil.lb)	U.S. Population (mil.)	Domestic Supply Pork/Capita (lb.)	Per Capita Cons. of Non-Pork (lb)	Per Capita Cons. of Turkeys& Broilers (lb.)	Disp. Income Per Capita ÷ CPI (1967) ($)	CPI (1967=100)
1965	Q_1	284	3127	3409	192.8	17.68	26.80	7.3	2499	93.6
	Q_2	335	2604	2939	193.4	15.20	26.10	8.6	2519	94.2
	Q_3	224	2505	2729	194.0	14.07	27.70	9.9	2584	94.6
	Q_4	126	2896	3022	194.6	15.53	27.80	11.2	2614	95.1
1966	Q_1	152	2741	2893	195.2	14.82	27.60	7.9	2645	95.9
	Q_2	217	2643	2860	195.7	14.61	27.80	9.3	2642	96.9
	Q_3	214	2620	2834	196.2	14.44	29.10	10.8	2656	97.8
	Q_4	151	3324	3475	196.8	17.66	28.30	12.1	2682	98.4
1967	Q_1	239	3319	3558	197.3	18.03	28.50	8.4	2729	98.7
	Q_2	331	2873	3204	197.8	16.20	28.60	9.8	2740	99.4
	Q_3	293	2897	3190	198.4	16.08	28.80	10.9	2746	100.5
	Q_4	203	3483	3686	198.9	18.53	28.30	12.3	2763	101.3
1968	Q_1	286	3289	3575	199.8	17.89	29.00	8.6	2801	102.4
	Q_2	306	3124	3430	200.3	17.12	28.60	9.5	2829	103.5
	Q_3	326	3004	3330	200.8	15.95	30.10	10.8	2821	104.8
	Q_4	197	3646	3843	201.5	19.07	29.30	12.1	2827	106.1
1969	Q_1	256	3437	3693	201.8	18.30	29.00	9.0	2823	107.1
	Q_2	270	3142	3412	202.3	16.87	28.30	10.3	2817	109.0
	Q_3	246	2992	3238	202.8	15.97	30.30	11.3	2844	110.7
	Q_4	174	3382	3556	203.6	17.47	30.70	12.9	2841	112.2
1970	Q_1	211	3144	3355	203.9	16.45	30.00	9.7	2873	113.9
	Q_2	268	3138	3406	204.4	16.66	29.50	10.9	2898	115.7
	Q_3	304	3161	3465	205.0	16.90	30.50	11.9	2907	116.8
	Q_4	210	3991	4201	205.6	20.43	29.90	12.9	2878	118.5
1971	Q_1	336	3770	4106	206.2	19.91	29.20	9.9	2931	119.4
	Q_2	389	3683	4072	206.7	19.70	29.50	10.8	2961	120.8
	Q_3	476	3436	3912	207.2	18.88	30.90	12.1	2960	122.0
	Q_4	309	3907	4216	207.8	20.28	29.60	13.2	2961	122.7

Table 7. Monthly Average Prices on Barrows and Gilts at 7-8 Major Markets, 1957-1971.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1957	17.88	17.16	17.25	17.95	18.24	19.65	20.79	21.27	19.34	17.20	17.01	18.45
1958	19.26	20.16	21.20	20.64	22.03	22.97	23.12	21.33	20.42	18.88	18.13	17.86
1959	16.63	15.63	15.89	16.09	16.09	15.91	14.40	14.65	13.81	13.11	12.61	11.86
1960	12.65	13.56	16.55	15.96	16.03	16.88	17.74	16.91	16.59	17.30	17.36	17.27
1961	17.33	18.13	17.53	17.04	16.37	16.60	17.87	18.33	18.18	16.55	15.97	16.70
1962	16.98	16.69	16.31	15.81	15.51	16.87	18.30	18.50	18.82	16.87	16.50	16.16
1963	15.65	15.14	14.07	13.78	15.01	17.10	18.44	17.55	15.89	15.47	14.47	14.21
1964	14.70	14.70	14.48	14.16	14.84	15.83	17.11	17.05	16.76	15.39	14.43	15.55
1965	16.06	17.01	16.98	17.63	20.29	23.38	24.27	24.67	22.92	23.36	24.33	28.07
1966	27.93	27.80	24.41	22.26	23.16	24.72	25.09	25.75	23.16	21.57	19.87	19.67
1967	19.46	19.38	18.43	17.62	21.83	22.29	22.58	21.04	19.46	18.16	17.36	17.29
1968	18.31	19.41	19.07	19.00	18.88	20.43	21.48	20.08	19.93	18.29	17.92	18.76
1969	19.77	20.41	20.69	20.38	23.14	25.16	26.05	26.91	25.94	25.53	25.77	26.93
1970	27.40	28.23	25.94	24.02	23.53	24.04	25.13	22.12	20.35	17.91	15.69	15.67
1971	16.30	19.43	17.13	16.19	17.43	18.38	19.84	19.07	18.91	19.80	19.38	19.65

Table 8. Index of the Seasonal Pattern.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Index	97.3	98.8	97.1	95.0	99.7	105.9	109.8	108.1	102.7	96.7	93.9	96.1
Std Dev	6.4	6.7	5.7	6.0	5.7	5.4	5.3	4.0	4.2	3.8	5.0	7.5
Trend	0.5	0.6	-0.3	-0.7	-0.2	0.1	0.3	0.1	0.0	0.2	0.1	0.4

Table 9. Smoothed Monthly Price Ratio for Barrows and Gilts, 1958-1971.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1958	0.9358	0.9437	0.9941	0.9993	1.0089	1.0518	1.0788	1.0722	1.0250	0.9563	0.9316	0.9348
1959	0.9411	0.9500	0.9908	0.9922	1.0072	1.0528	1.0815	1.0734	1.0253	0.9579	0.9327	0.9385
1960	0.9465	0.9564	0.9876	0.9851	1.0054	1.0538	1.0843	1.0746	1.0256	0.9595	0.9338	0.9422
1961	0.9518	0.9628	0.9843	0.9781	1.0037	1.0548	1.0871	1.0759	1.0258	0.9611	0.9348	0.9459
1962	0.9572	0.9691	0.9810	0.9710	1.0019	1.0558	1.0899	1.0771	1.0261	0.9627	0.9359	0.9496
1963	0.9626	0.9754	0.9778	0.9640	1.0002	1.0568	1.0927	1.0784	1.0264	0.9643	0.9369	0.9533
1964	0.9679	0.9818	0.9745	0.9569	0.9984	1.0578	1.0954	1.0796	1.0267	0.9659	0.9380	0.9570
1965	0.9733	0.9881	0.9712	0.9498	0.9967	1.0588	1.0982	1.0808	1.0270	0.9675	0.9391	0.9607
1966	0.9786	0.9945	0.9679	0.9427	0.9949	1.0599	1.1010	1.0821	1.0273	0.9691	0.9401	0.9643
1967	0.9840	1.0008	0.9647	0.9356	0.9932	1.0609	1.1038	1.0833	1.0276	0.9707	0.9412	0.9680
1968	0.9894	1.0072	0.9614	0.9286	0.9914	1.0619	1.1066	1.0846	1.0279	0.9723	0.9422	0.9717
1969	0.9947	1.0135	0.9581	0.9215	0.9897	1.0629	1.1093	1.0858	1.0282	0.9739	0.9433	0.9754
1970	1.0001	1.0199	0.9549	0.9144	0.9879	1.0639	1.1121	1.0870	1.0285	0.9755	0.9444	0.9791
1971	1.0054	1.0262	0.9516	0.9074	0.9862	1.0649	1.1149	1.0883	1.0287	0.9771	0.9454	0.9828

Table 10. Quarterly Average Smoothed Price Ratio for Barrows and Gilts, 1958-1971.

Year	Q_1 (Jan.,Feb.,Mar.)	Q_2 (Apr.,May,Jun.)	Q_3 (Jul.,Aug.,Sept.)	Q_4 (Oct.,Nov.,Dec.)
1958	0.9579	1.0200	1.0587	0.9409
1959	0.9606	1.0174	1.0601	0.9430
1960	0.9635	1.0148	1.0615	0.9452
1961	0.9663	1.0122	1.0629	0.9473
1962	0.9691	1.0096	1.0644	0.9494
1963	0.9719	1.0070	1.0658	0.9515
1964	0.9747	1.0044	1.0672	0.9536
1965	0.9775	1.0018	1.0687	0.9558
1966	0.9803	0.9992	1.0701	0.9578
1967	0.9832	0.9966	1.0716	0.9600
1968	0.9860	0.9940	1.0730	0.9621
1969	0.9888	0.9914	1.0744	0.9642
1970	0.9916	0.9887	1.0759	0.9663
1971	0.9944	0.9862	1.0773	0.9684

Table 11. Smoothed Monthly Price Ratio Adjusted to Quarterly Averages.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1957	0.9741	0.9816	1.0440	0.9843	0.9883	1.0275	1.0178	1.0130	0.9692	1.0170	0.9912	0.9919
1958	0.9769	0.9852	1.0378	0.9797	0.9891	1.0312	1.0190	1.0128	0.9682	1.0164	0.9901	0.9935
1959	0.9797	0.9890	1.0314	0.9752	0.9900	1.0348	1.0202	1.0125	0.9672	1.0158	0.9891	0.9952
1960	0.9824	0.9926	1.0250	0.9707	0.9907	1.0384	1.0215	1.0123	0.9662	1.0151	0.9879	0.9968
1961	0.9850	0.9964	1.0186	0.9663	0.9916	1.0421	1.0228	1.0122	0.9651	1.0146	0.9868	0.9985
1962	0.9877	1.0000	1.0123	0.9618	0.9924	1.0458	1.0240	1.0119	0.9640	1.0140	0.9858	1.0002
1963	0.9904	1.0036	1.0061	0.9573	0.9932	1.0495	1.0252	1.0118	0.9630	1.0135	0.9847	1.0019
1964	0.9930	1.0073	0.9998	0.9527	0.9940	1.0532	1.0264	1.0116	0.9621	1.0129	0.9836	1.0036
1965	0.9957	1.0108	0.9936	0.9481	0.9949	1.0569	1.0276	1.0113	0.9610	1.0122	0.9825	1.0051
1966	0.9983	1.0145	0.9874	0.9435	0.9957	1.0607	1.0289	1.0112	0.9600	1.0118	0.9815	1.0068
1967	1.0008	1.0179	0.9812	0.9388	0.9966	1.0645	1.0300	1.0109	0.9589	1.0111	0.9804	1.0083
1968	1.0034	1.0215	0.9751	0.9342	0.9974	1.0683	1.0313	1.0108	0.9580	1.0106	0.9793	1.0100
1969	1.0060	1.0250	0.9690	0.9295	0.9983	1.0721	1.0325	1.0106	0.9570	1.0101	0.9783	1.0116
1970	1.0086	1.0285	0.9630	0.9249	0.9992	1.0761	1.0336	1.0103	0.9559	1.0095	0.9773	1.0132
1971	1.0111	1.0320	0.9570	0.9201	1.0000	1.0798	1.0349	1.0102	0.9549	1.0090	0.9762	1.0149

Note: The data above was obtained by dividing the smoothed monthly price ratio into the quarterly average smoothed price ratio.

APPENDIX B

COMPUTER PROGRAM

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PROGRAM     HOG       TRACE                          CDC 6400 FTN V3.0-L292 OPT=0  06/13/72 .12.02.15.     PAGE    1

          PROGRAM  HOG( INPUT, OUTPUT)
          COMMON/JAN1/ IDATE,IYEAR,KONT
          COMMON/S/ PSF1(10,14), PSF2(10,14), PSF3(10,14), PSF4(10,14)
          COMMON/JPRINT/ PDKPOP1(10,14), PDKPOP2(10,14), PDKPOP3(10,14),
         1 PDKPOP4(10,14), PH13(10,14), PH46(10,14), PH79(10,14),
         2 PH102(10,14), PPHMONT(12,10,14), PSFS(10,14),
         3 PGMHC(10,14), PRINTPH(10,14), PQPKWD(12,10,14),
         4SFFP(10,14),PGMHT(10,14), PHNEW(10,14),
         5 PPGS1(10,14), PPGS2(10,14), PPGS3(10,14), PPGS4(10,14)
          DATA( KONT=0)
          READ 10, IDATE,IYEAR
       10 FORMAT(I4,I1)
          DO 1 KK=1,14
          DO 1 LL=1,10
          PGMHT(LL,KK)= PHNEW(LL,KK)=0
        1 PSF1(LL,KK)= PSF2(LL,KK)= PSF3(LL,KK)= PSF4(LL,KK)=0
          DO 30 M=1,14
          DO 30 N=1,10
          PDKPOP1(N,M)= PDKPOP2(N,M)= PDKPOP3(N,M)= PDKPOP4(N,M)=0
          PH13(N,M)= PH46(N,M)= PH79(N,M)= PH102(N,M)= SFFP(N,M)=0
          PSFS(N,M)= PGMHC(N,M)= PRINTPH(N,M)=0
          PPGS1(N,M)= PPGS2(N,M)= PPGS3(N,M)= PPGS4(N,M)=0
       30 CONTINUE
          DO 35 LL=1,14
          DO 35 MM=1,10
          DO 35 NN=1,12
       35 PQPKWD(NN,MM,LL)= PPHMONT(NN,MM,LL)=0
        5 KONT=KONT+1
          IF(KONT.GT.IYEAR)  GO TO 100
          IF(KONT.NE.1) CALL JANLEG
          CALL JANUARY
          GO TO 5
      100 CALL PRINTJ
          CONTINUE
          END
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      SUBROUTINE JANUARY
      COMMON/JAN1/ IDATE, DUMMY, IYEAR
      COMMON/S/ PSF1(10,14), PSF2(10,14), FSF3(10,14), PSF4(10,14)
      COMMON/JPRINT/ PDKPOP1(10,14), PDKPOP2(10,14), PDKPOP3(10,14),
     1 PDKPOP4(10,14), PH13(10,14), PH46(10,14), PH79(10,14),
     2 PH1012(10,14), PPHMONT(12,10,14), PSFS(10,14),
     3 PGMHC(10,14), PRINTPH(10,14), PUPKWD(12,10,14),
     4SFFP(10,14),FGMHT(10,14), FHNEW(10,14),
     5 PPGS1(10,14), PPGS2(10,14), PPGS3(10,14), PPGS4(10,14)
      DIMENSION C(121), PPDF(15), PC(15), PSM(15), PH(14), POP(4,15),    DATA
     1 CPI(4,15), CNP(4,15), CTB(4,15), DI(4,15), SFS(14), PG2(14),       DATA
     2 PG3(14), PG4(14), PIG3(14), PIG4(14),                              DATA
     3 PIG1(14), PIG2(14), PCC(15), PSMC(15),                             DATA
     4 DSPK1(14), DSPK2(14), DSPK3(14), DSPK4(14)                         DATA
      DIMENSION SFSL(14), SFSC(14), FHC(14), FHL(14), DSPKC(4,14),
     1 DSPKL(4,14), GMHC(14), GMHL(14), SF1(14), SF2(14), SF3(14),
     2 SF4(14), PGSLS(14), PGSLF(14), APGS1(14), APGS2(14), APGS3(14),
     3 APGS4(14), PIG1C(14), PIG2C(14), PIG3C(14), PIG4C(14), SFF(14),
     4 PIG1L(14), PIG2L(14), PIG3L(14), PIG4L(14), DPGSL1(14),
     5 DPGSL2(14), DPGSL3(14), DPGSL4(14), DPGSC1(14), DPGSC2(14),
     6 DPGSC3(14), DPGSC4(14), SK(12,14), GPKWD(12,14), GMHT(14),
     7 FHMM(14),     DQPK(4,14), FHQT1(14), FHQT2(14), FHQT3(14),
     8 PHQT4(14), PHMONT(12,14), DKPOP1(14), DKPOP2(14), DKPOP3(14),
     9 DKPOP4(14)
      DATA( C(I),I=1,121)/ -926.36,  0.3399,  71.46,  2.3,  -14.41,
     1  -1.59,     -615.32, 0.4469,  15.15,  897.41,  0.517,  -21.7,      C1-5
     2  272.26,  0.3895,  18.27,  634.95,  0.2829,  38.84,  907.21,       C6-12
     3  0.6724,  57.11,  7.01,  0.0253,  7.08,  0.0164,  64.53,  -2.55,  C13-19
     4  -0.7777,  -0.1575,  0.0089,  56.20,  -2.25,  -0.7777,  -0.1575,  C20-27
     5  0.0089,  55.56,  -2.19,  -0.7777,  -0.1575,  0.0089,  61.16,     C28-34
     6  -2.25,  -0.7777,  -0.1575,  0.0089,  1.85,  -2.17,  -1.06,       C35-41
     7  -0.0623,  1.09,  1.46,  -1.91,  -1.66,  -0.0623,  1.09,  1.27,   C42-48
     8  -1.75,  -1.00,  -0.0623,  1.09,  1.86,  -2.15,  -1.06,  -0.0623,C49-56
     9  1.09,  0.9741,  0.00263,  0.9816,  0.0036,  1.044,  -0.00622,    C57-64
     1  0.9843,  -0.00458,  0.9883,  0.00084,  1.0275,  0.00374, 1.0178,C65-71
     2  0.00122,  1.013,  -0.0002,  0.9692,  -0.00102,  1.017, -0.00057,C72-78
     3  0.9912,  -0.00107,  0.9919,  0.00165,  -0.3826,  0.7297, 0.0684,C79-85
     4  -0.1265,  1.13,  0.1657,  0.4019,  0.4405,  0.2716,  0.5517,     C86-92
     5  0.1942,  0.3488,  0.6716,  0.2387,  0.7755,  0.1882,  0.3628,    C93-99
     6  0.4629,  0.4430,  0.3113,  0.2669,  0.3093,  0.4604,  0.2557,    C100-106
     7  0.0165,  0.3956,  0.603,  -0.1094,  1.213,  -0.5587,  0.8578,     C107-113
     8  0.7215/                                                           C114-120
      DATA( PPDF(I), I=1,15)/ .86,  .87,  .88,  .88,  .90,  .91,  .92,
     1  .94,  .98,  1.00,  1.04,  1.09,  1.14,  1.20,  1.25/             PDF 1- 7
      DATA( PC(J), J=1,15)/ 1.21, 1.21, 1.17, 1.10, 1.11, 1.19,          PDF 8-15
     1 1.20, 1.26, 1.27, 1.36, 1.12, 1.17, 1.25, 1.44, 1.13/             PC  1- 6
      DATA(PSM(K), K=1,15)/  4.07, 4.25, 4.11, 4.36, 4.44, 4.87, 4.94,   PC  7-15
     1  4.87, 5.37, 5.46, 5.30, 5.31, 5.52, 5.69, 5.75/                  PSM 1- 7
      DATA( PH(L), L=1,14)/ 20.25, 14.64, 15.96, 17.16, 16.82, 15.38,   PSM 8-15
     1 15.31, 21.30, 23.49, 19.37, 19.19, 23.71, 21.95, 18.46/          PH  1- 6
      DATA( PCC(I), I=1,15)/          1.26,  1.19,  1.11,  1.13,  1.21,  PH  7-14
     1  1.24,  1.33,  1.27,  1.37,  1.15,  1.18,  1.26,  1.52,  1.26,    PCC T
     2  1.21/                                                             PCC T
      DATA(PSMC(I), I=1,15)/          4.25,  4.13,  4.63,  4.38,  4.83,  PCC T
     1  4.98,  4.81,  5.11,  5.35,  5.22,  5.22,  5.51,  5.64,  5.50,    PSMC T
                                                                          PSMC T
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     2  5.50/                                                            PSMC T
      DATA((POP(I,J), I=1,4), J=1,15)/ 176.0, 176.6, 177.4, 178.2,       POP   59
     1  178.8, 179.5, 180.2, 181.1, 181.7, 182.4, 183.1, 184.0,          POP60-61
     2  184.7, 185.3, 186.1, 186.8, 187.5, 188.1, 188.8, 189.6,          POP62-63
     3  190.2, 190.8, 191.3, 192.2, 192.8, 193.4, 194.0, 194.6,          POP64-65
     4  195.2, 195.7, 196.2, 196.8, 197.3, 197.8, 198.4, 198.9,          POP66-67
     5  199.8, 200.3, 200.8, 201.5, 201.8, 202.3, 202.8, 203.6,          POP68-69
     6  203.9, 204.4, 205.0, 205.6, 206.2, 206.7, 207.2, 207.8,          POP70-71
     7  208.4, 209.0, 209.6, 210.2, 210.8, 211.4, 212.0, 212.6/          POP72-73
      DATA((CPI(I,J), I=1,4), J=1,15)/  .867,  .870,  .875,  .880,       CPI   59
     1  .880,  .885,  .887,  .893,  .893,  .893,  .897,  .899,           CPI60-61
     2  .901,  .905,  .907,  .911,  .912,  .913,  .921,  .923,           CPI62-63
     3  .925,  .927,  .931,  .935,  .936,  .942,  .946,  .951,           CPI64-65
     4  .959,  .969,  .978,  .984,  .987,  .994, 1.005, 1.013,           CPI66-67
     5 1.024, 1.035, 1.048, 1.061, 1.071, 1.090, 1.107, 1.122,           CPI68-69
     6 1.139, 1.157, 1.168, 1.185, 1.194, 1.208, 1.220, 1.227,           CPI70-71
     7 1.237, 1.249, 1.261, 1.268, 1.276, 1.283, 1.290, 1.297/           CPI72-73
      DATA((CNP(I,J), I=1,4), J=1,15)/  21.8,  23.0,  23.9,  23.3,       CNP   59
     1  23.6,  23.4,  25.3,  23.7,  23.6,  25.1,  25.2,  24.6,           CNP60-61
     2  24.9,  24.6,  25.5,  24.6,  25.1,  25.8,  26.9,  26.5,           CNP62-63
     3  26.3,  27.7,  27.7,  27.6,  26.3,  26.1,  27.7,  28.8,           CNP64-65
     4  27.0,  27.8,  29.1,  28.3,  28.5,  28.6,  28.8,  28.3,           CNP66-67
     5  29.0,  28.6,  30.1,  29.3,  29.0,  28.3,  30.5,  30.7,           CNP68-69
     6  30.0,  29.5,  30.5,  29.9,  29.2,  29.5,  30.9,  29.6,           CNP70-71
     7  29.2,  30.4,  31.8,  30.8,  29.8,  31.0,  32.4,  31.4/           CNP72-73
      DATA((CTB(I,J), I=1,4), J=1,15)/ 6.1,  7.5,  8.0,  8.5,            CTB  -59
     1 5.7, 7.0, 7.9, 6.9, 6.1, 8.4, 9.0, 9.8, 6.3, 7.9, 8.3, 10.2,      CTB60-62
     2 6.7, 8.0, 8.9, 10.2, 7.1, 8.3, 9.1, 10.4, 7.3, 8.5, 9.9, 11.2,    CTB63-65
     3 7.9, 9.3, 10.7, 12.1, 8.5, 10.1, 10.9, 12.5, 8.6, 9.5, 10.8,12.1,CTB66-68
     4 9.0, 10.3, 11.3, 12.9, 9.7, 10.9, 11.9, 12.9,                     CTB69-70
     5 9.9, 10.8, 12.1, 13.2, 10.5, 11.7, 12.6, 13.5,                    CTB71-72
     6 10.7, 12.1, 12.7, 13.6/                                           CTB  -73
      DATA(( DI(I,J), I=1,4), J=1,15)/ 2160., 2188., 2167., 2172.,       DI   -59
     1 2186., 2210., 2206., 2185., 2172., 2211., 2227., 2260.,           DI 60-61
     2 2263., 2265., 2265., 2266., 2295., 2318., 2314., 2337.,           DI 62-63
     3 2390., 2439., 2456., 2472., 2499., 2519., 2584., 2614.,           DI 64-65
     4 2645., 2642., 2656., 2682., 2729., 2740., 2746., 2763.,           DI 66-67
     5 2841., 2829., 2821., 2827., 2823., 2817., 2844., 2841.,           DI 68-69
     6 2873., 2898., 2907., 2878., 2931., 2961., 2960., 2961.,           DI 70-71
     7 2973., 3013., 3047., 3097., 3147., 3177., 3197., 3207./           DI 72-73
      DATA( PIG1(I), I=1,14)/
     1  18894.,  21584.,  17451.,  18172.,  18266.,  18539.,  17106.,    PGS12-2L
     2  15725.,  16259.,  17983.,  18845.,  18915.,  18691.,  21634./    PGS12-2L
      DATA( PIG2(I), I=1,14)/
     1  32437.,  34947.,  29739.,  32317.,  31265.,  32217.,  30582.,    PGS 3-5L
     2  26800.,  29140.,  30240.,  30365.,  27894.,  32405.,  30701./    PGS 3-5L
      DATA(  PIG3(K), K=1,14)/ 22521., 23355., 21446., 22153., 22709.,   PGS6-8 L
     1 22594., 20931., 18524., 21815., 21948., 23167., 21462., 25156.,   PGS6-8 L
     2 23207./                                                           PGS6-8 L
      DATA(  PIG4(I), I=1,14)/ 19089.,  19418.,  19832.,  20435.,        PGS9-11L
     1  21379.,  20692.,  18905.,  17870.,  20315.,  21587.,  21880.,    PGS9-11L
     2  20574.,  24579.,  22452./                                        PGS9-11L
      DATA( DSPK1(J), J=1,14)/  2884.,  3284.,  3598.,  3195.,  3330.,   DSPK1-3L
     1  3503.,  3661.,  3409.,  2893.,  3558.,  3575.,  3693.,           DSPK1-3L
     2  3355.,  4106./                                                   DSPK1-3L
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      DATA( DSPK2(K), K=1,14)/  2523.,  2954.,  3048.,  2884.,
     1  3065.,  3215.,  3305.,  2939.,  2860.,  3204.,  3430.,        DSPK4-6L
     2  3412.,  3406.,  4072./                                        DSPK4-6L
      DATA( DSPK3(L), L=1,14)/  2516.,  2929.,  2813.,  2683.,        DSPK4-6L
     1  2785.,  3017.,  3052.,  2729.,  2834.,  3190.,  3330.,        DSPK7-9L
     2  3238.,  3465.,  3912./                                        DSPK7-9L
      DATA( DSPK4(N), N=1,14)/  3280.,  3845.,  3299.,  3420.,        DSPK7-9L
     1  3552.,  3782.,  3772.,  3022.,  3475.,  3686.,  3843.,        DSPK0-2L
     2  3556.,  4201.,  4215./                                        DSPK0-2L
      DATA( SFS(K), K=1,14)/  7281.,  7996.,  6782.,  7018.,  6996.,  DSPK0-2L
     1  7099.,  6596.,  589..,  6231.,  6570.,  6669.,  6360.,  7171.,SFS59-63
     2  7279./                                                        SFS64-71
      DATA(  PG2 (I),  I=1,14)/  .96,  1.07,  .88,  1.05,  .98,  1.00,SFS72
     1  .91,  .86,  1.09,  .98,  .97,  .92,  1.16,  .97/              =PGS3-5L
      DATA(  PG3 (J),  J=1,14)/ 1.13, 1.06, .91, 1.02, 1.03, .99,     =PGS3-5L
     1 .92, .98, 1.11, .98, 1.06, .93, 1.19, .92/                     =PGS6-8L
      DATA(  PG4 (K),  K=1,14)/ 1.14, 1.03, 1.03, 1.03, 1.06, .93,    =PGS6-8L
     1 .92, .93, 1.1?,1.02, 1.02, .94, 1.22, .91/                     =PGS9-11
      IF(IYEAR.NE.1) GO TO 1000                                       =PGS9-11
      DO 10 II=1,14
      SFSL(II)=SFS(II)
      PHL(II)= PH(II)
      DPGSL2(II)= PG2(II)
      DPGSL3(II)= PG3(II)
      DPGSL4(II)= PG4(II)
      PIG1L(II)= PIG1(II)
      PIG2L(II)= PIG2(II)
      PIG3L(II)= PIG3(II)
      PIG4L(II)= PIG4(II)
      DSPKL(1,II)=DSPK1(II)
      DSPKL(2,II)=DSPK2(II)
      DSPKL(3,II)=DSPK3(II)
      DSPKL(4,II)=DSPK4(II)
   10 CONTINUE
      DO 20 I=1,14
   20 GMHL(I)= C(4)* PHL(I) + C(5)* PC(I) +  C(6)* PSM(I)
      PRINT 5, IYEAR, (GMHL(IG), IG=1,14)
    5 FORMAT(1H0, *GMHT-1*, I3, 7(2X,F14.2)/10X, 7(2X,F14.2))
 1000 DO 30 J=1,14
      IT= J + IYEAR
      SFSC(J)= C(1)+ C(2)* SFSL(J) + C(3)* GMHL(J)/ PPDF(J)
      SF1(J)= C(7) + C(8) *SFSC(J) + C(9)*IT
      SF2(J)= C(10)+ C(11)* SFSC(J) + C(12)*IT
      PGSLS(J)= C(22) + C(23)*IT
      PGSLF(J)= C(24) + C(25)*IT
      APGS1(J)=PGSLS(J)
      APGS2(J)=PGSLS(J)
      APGS3(J)=PGSLF(J)
      APGS4(J)=PGSLF(J)
      PIG1C(J)= SF1(J) *  APGS1(J)
      PIG2C(J)= SF2(J) *  APGS2(J)
   50 DPGSC1(J)=PIG1C(J)/ PIG1L(J)
      DPGSC2(J)=PIG2C(J)/ PIG2L(J)
   60 DO 70 K=1,12
      KK=K*2
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```
   70 SK(K,J)=  C(KK+64) + C(KK+65)* IT
      QPKWD(1,J)=C(90)  + C(91)* DPGSL2(J)  + C(92)* DPGSL3(J)
      QPKWD(2,J)=C(93)  + C(94)* DPGSL3(J)
      QPKWD(3,J)=C(95)  + C(96)* DPGSL3(J)  + C(97)* DPGSL4(J)
      QPKWD(4,J)=C(98)  + C(99)* DPGSL3(J)  + C(100)* DPGSL4(J)
      QPKWD(5,J)=C(101)+ C(102)* DPGSL4(J)
      QPKWD(6,J)=C(103)+ C(104)* DPGSL4(J)
      QPKWD(7,J)=C(105)+ C(106)* DPGSL4(J)  + C(107)* DPGSC1(J)
      QPKWD(8,J)=C(108)+ C(109)* DPGSL4(J)  + C(110)* DPGSC1(J)
      QPKWD(9,J)= C(111)  + C(112)* DPGSC1(J)  +C(113)* DPGSC2(J)
      DO 85 L=1,3
      LL=L*3-2
      DQPK(L,J)=  .33333* ( QPKWD(LL,J)+  QPKWD(LL+1,J)+ QPKWD(LL+2,J))
   85 CONTINUE
      DO 86 N=1,3
   86 DSPKC(N,J)=  DQPK(N,J) * DSPKL(N,J)
      A1=  C(46) +C(47)* ALOG10(DSPKC(1,J)/ POP(1,J)) + C(48)*
     1     ALOG10( CNP (1,J)) + C(49)* ALOG10( CTB(1,J)) +
     2     C(50)* ALOG10( DI(1,J))
      A2=  C(51) + C(52)* ALOG10(DSPKC(2,J)/ POP(2,J)) + C(53)*
     1     ALOG10( CNP (2,J)) + C(54)* ALOG10( CTB(2,J)) +
     2     C(55)* ALOG10( DI(2,J))
      A3=  C(56)+ C(57)* ALOG10( DSPKC(3,J)/ POP(3,J)) + C(58)*
     1     ALOG10( CNP (3,J)) + C(59)* ALOG10( CTB(3,J))  +
     2     C(60) * ALOG10(DI(3,J))
      PHQT1(J)=(10**A1) * CPI(1,J)
      PHQT2(J)=(10**A2) * CPI(2,J)
      PHQT3(J)=(10**A3) * CPI(3,J)
      DO 87 M=1,3
   87 PHMONT(M,J)= SK(M,J) * PHQT1(J)
      DO 88 M=4,6
   88 PHMONT(M,J)= SK(M,J) * PHQT2(J)
      DO 89 M=7,9
   89 PHMONT(M,J)= SK(M,J) * PHQT3(J)
      DKPOP1(J) = DSPKC(1,J)/ POP(1,J)
      DKPOP2(J) = DSPKC(2,J)/ POP(2,J)
      DKPOP3(J) = DSPKC(3,J)/ POP(3,J)
      PHMM(J)=(PHMONT(3,J) + PHMONT(4,J) + PHMONT(5,J))/3.
      GMHT(J)= C(4)* PHMM(J) + C(5) * PCC(J) + C(6)* PSMC(J)
      SFF(J)=  398.18 + .6997 * SFSC(J) + 38.20 *IT + 27.61*
     1 GMHT(J)/ PPOF(J+1)
      SF3(J)= -124.99 +  0.0951 * SFSC(J) + 0.4379* SFF(J) -
     1 6.74 * IT
      SF4(J)= 124.83 - .095 * SFSC(J) +.5622 * SFF(J) + 6.6325 * IT
      PIG3C(J)= SF3(J) *  APGS3(J)
      PIG4C(J)= SF4(J) *  APGS4(J)
      DPGSC3(J)=PIG3C(J)/ PIG3L(J)
      DPGSC4(J)=PIG4C(J)/ PIG4L(J)
      QPKWD(10,J)=C(114) + C(115)* DPGSC1(J) +C(116)* DPGSC2(J)
      QPKWD(11,J)=C(117) + C(118)* DPGSC2(J)
      QPKWD(12,J)=C(119) + C(120)* DPGSC2(J) + C(121)* DPGSC3(J)
      DQPK(4,J)=  .33333* ( QPKWD(10,J)+  QPKWD(11,J) +  QPKWD(12,J))
      DSPKC(4,J)=  DQPK(4,J) * DSPKL(4,J)
      A4=  C(61) + C(62)* ALOG10( DSPKC(4,J)/ POP(4,J)) + C(63)*
     1     ALOG10(CNP (4,J)) + C(64)* ALOG10( CTB(4,J)) + C(65)*
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     2      ALOG10( OI(4,J))
      JIYEAR=1957+ J + IYEAR
      PRINT 31,JIYEAR, A1,A2,A3,A4
   31 FORMAT(1H0,*LOGPH*, I5, 4(F15.2))
      PHQT4(J)=(10**A4) * CPI(4,J)
      PRINT 32,JIYEAR, PHQT1(J), PHQT2(J), PHQT3(J), PHQT4(J)
   32 FORMAT(1H0,20HANTILOG OF PH X CIF , I5,4(2X,F18.2))
      DO 90 M=10,12
   90 PHMONT(M,J)= SK(M,J) * PHQT4(J)
      PHC(J)=  .25 *( PHQT1(J) + PHQT2(J) + PHQT3(J)+ PHQT4(J))
      GMHC(J)= C(4)* PHC(J) + C(5)* PC(J+1) + C(6)* PSM(J+1)
      DKPOP4(J) = OSPKC(4,J)/ POF(4,J)
   30 CONTINUE
      PRINT 6, IYEAR, (SFSC(IS), IS=1,14)
    6 FORMAT(1H0,*SFS*, 3X,I3, 7(2X,F14.2)/10X, 7(2X,F14.2))
      PRINT 7, IYEAR, (SFF(JS),  JS=1,14)
    7 FORMAT(1H0,*SFF*, 3X,I3, 7(2X,F14.2)/10X, 7(2X,F14.2))
      PRINT 8, IYEAR, (SF1(KSF1), KSF1=1,14)
    8 FORMAT(1H0,*SF1*, 3X,I3, 7(2X,F14.2)/10X, 7(2X,F14.2))
      PRINT 9, IYEAR, (SF2(KSF2), KSF2=1,14)
    9 FORMAT(1H0,*SF2*, 3X,I3, 7(2X,F14.2)/10X, 7(2X,F14.2))
      PRINT 304, IYEAR,(SF3(KSF3), KSF3=1,14)
  304 FORMAT(1H0, *SF3*, 3X,I3, 7(2X,F14.2)/ 10X, 7(2X,F14.2))
      PRINT 305, IYEAR,(SF4(KSF4), KSF4=1,14)
  305 FORMAT(1H0, *SF4*, 3X,I3, 7(2X,F14.2)/ 10X, 7(2X,F14.2))
      PRINT 11, IYEAR, (APGS1(JA), JA=1,14)
   11 FORMAT(1H0, 9HPGS/L12-2, I3, 7(F15.2)/13X,7(F15.2))
      PRINT 12, IYEAR, (APGS2(JB), JB=1,14)
   12 FORMAT(1H0, 9HPGS/L3-5 , I3, 7(F15.2)/13X,7(F15.2))
      PRINT 61,IYEAR, (APGS3(JF), JF=1,14)
   61 FORMAT(1H0, 9HPGS/L6-8 , I3, 7(F15.2)/13X, 7(F15.2))
      PRINT 62, IYEAR, (APGS4(JO), JO=1,14)
   62 FORMAT(1H0, 9HPGS/L9-11, I3, 7(F15.2)/13X,7(F15.2))
      PRINT 13, IYEAR, (PIG1C(JC), JC=1,14)
   13 FORMAT(1H0, 8HPGS12-2 , I3,  7(F15.2)/ 12X,7(F15.2))
      PRINT 14, IYEAR, (FIG2C(JD), JD=1,14)
   14 FORMAT(1H0, 7HPGS3-5 , I4, 7(F15.2)/12X,7(F15.2))
      PRINT 63, IYEAR, (PIG3C(JG),JG=1,14)
   63 FORMAT(1H0, 7HPGS6-8 , I4, 7(F15.2)/12X, 7(F15.2))
      PRINT 64, IYEAR, (PIG4C(JH), JH=1,14)
   64 FORMAT(1H0, 7HPGS9-11, I4, 7(F15.2)/ 12X, 7(F15.2))
      PRINT 16, IYEAR,(DPGSC1(KC), KC=1,14)
   16 FORMAT(1H0, 8HAPGS12-2, I3, 7(F15.2)/12X, 7(F15.2))
      PRINT 17, IYEAR,(DPGSC2(KD), KD=1,14)
   17 FORMAT(1H0, 8HAPGS3-5 , I3, 7(F15.2)/12X, 7(F15.2))
      PRINT 71,IYEAR, (DPGSC3(KE), KE=1,14)
   71 FORMAT(1H0,8HAPGS6-8 , I3, 7(F15.2)/ 13X, 7(F15.2))
      PRINT 72, IYEAR, (DPGSC4(KF), KF=1,14)
   72 FORMAT(1H0,8HAPGS9-11, I3, 7(F15.2)/ 12X, 7(F15.2))
      PRINT 18, IYEAR
   18 FORMAT(1H0,*K*, I3/)
      DO 21 K1=1,14
      PRINT 22,(SK(L1,K1), L1=1,12)
   22 FORMAT(1H ,12(F10.2))
   21 CONTINUE
```

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      PRINT 23, IYEAR
   23 FORMAT(1H0,10HA(QPK/WKD), I3,/)
      DO 24  KQ=1,14
      NYEAR= 1957 + KQ + IYEAR
      PRINT 26,NYEAR, (QPKWD(KP,KQ), KP=1,12)
   26 FORMAT(1H ,I4,2X, 12(F10.3))
   24 CONTINUE
      PRINT 27, IYEAR
   27 FORMAT(1H0,4HAQPK, *UNNUAL CHANGE IN QUARTERLY PORK PRODUCTINO*,
     1I3,/)
      DO 29 MQ=1,14
      MYEAR=1957+MQ + IYEAR
   29 PRINT 28, MYEAR, (DQPK(MP,MQ), MP=1,4)
   28 FORMAT(1H , I5, 4(F16.3))
      PRINT 41,IYEAR
   41 FORMAT(1H0,I3, 5X,*MONTHLY HOG PRICE*,/)
      DO 42 NP=1,14
      PRINT 43,(PHMONT(NQ,NP), NQ=1,12)
   43 FORMAT(1H , 12(F10.2))
   42 CONTINUE
      PRINT 44, IYEAR,(PHC(IN),IN=1,14)
   44 FORMAT(1H0, *PHT*,I3, 7(2X,F14.2)/ 7X,7(2X,F14.2))
      PRINT 45, IYEAR, (PHMM(I), I=1,14)
   45 FORMAT(1H0,*PHNEW*, I3, 7(2X,F13.2)/ 9X, 7(2X,F13.2))
      PRINT 46, IYEAR,(GMHC(IM),IM=1,14)
   46 FORMAT(1H0,*GMHT*,I3, 7(2X,F14.2)/ 8X,7(2X,F14.2))
      PRINT 55, IYEAR, (GMHT(M), M=1,14)
   55 FORMAT(1H0, *GMHNEW*,I3, 7(2X,F13.2)/ 10X, 7(2X,F13.2))
      PRINT 47, IYEAR
   47 FORMAT(1H0, 8HDSPK/POP, I3/30X, *(1)*, 15X,*(2)*,15X,*(3)*,15X,
     1 *(4)*/)
      DO 48 M1=1,14
      MM=1957+M1 + IYEAR
      PRINT 49, MM, DKPOP1(M1), DKPOP2(M1), DKPOP3(M1), DKPOP4(M1)
   49 FORMAT(1H , 5X,I5, 4X, 4(3X,F15.2))
   48 CONTINUE
      DO 110 I=1,14
      PDKPOP1(IYEAR,I)= DKPOP1(I)
      PDKPOP2(IYEAR,I)= DKPOP2(I)
      PDKPOP3(IYEAR,I)= DKPOP3(I)
  110 PDKPOP4(IYEAR,I)= DKPOP4(I)
      DO 250 I=1,14
      PGMHT(IYEAR,I)= GMHT(I)
  250 PHNEW(IYEAR,I)= PHMM(I)
      DO 111 J=1,14
      PH13(IYEAR,J)= PHQT1(J)
      PH46(IYEAR,J)= PHQT2(J)
      PH79(IYEAR,J)= PHQT3(J)
      PH102(IYEAR,J)=PHQT4(J)
  111 CONTINUE
      DO 113 I=1,14
      DO 113 J=1,12
      PPHMONT(J,IYEAR,I)= PHMONT(J,I)
  113 CONTINUE
      DO 114 K=1,14
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      PSFS(IYEAR,K)= SFSC(K)
      FGMHC(IYEAR,K)= GMHC(K)
      PRINTPH(IYEAR,K)= PHC(K)
  114 CONTINUE
      DO 115 L=1,14
      PSF1(IYEAR,L)= SF1(L)
      PSF2(IYEAR,L)= SF2(L)
      PSF3(IYEAR,L)= SF3(L)
      PSF4(IYEAR,L)= SF4(L)
      PPGS1(IYEAR,L)= PIG1C(L)
      PPGS2(IYEAR,L)= PIG2C(L)
      PPGS3(IYEAR,L)= PIG3C(L)
      PPGS4(IYEAR,L)= PIG4C(L)
      SFFP(IYEAR,L)= SFF(L)
  115 CONTINUE
      PRINT 300,IYEAR, (PSF1(IYEAR,NX), NX=1,14)
      PRINT 301,IYEAR, (PSF2(IYEAR,NX), NX=1,14)
      PRINT 302,IYEAR, (PSF3(IYEAR,NX), NX=1,14)
      PRINT 303,IYEAR, (PSF4(IYEAR,NX), NX=1,14)
  300 FORMAT(1H0, *SF1*, I4, 7(2X,F14.2)/ 8X, 7(2X,F14.2))
  301 FORMAT(1H0, *SF2*, I4, 7(2X,F14.2)/ 8X, 7(2X,F14.2))
  302 FORMAT(1H0, *SF3*, I4, 7(2X,F14.2)/ 8X, 7(2X,F14.2))
  303 FORMAT(1H0, *SF4*, I4, 7(2X,F14.2)/ 8X, 7(2X,F14.2))
      PRINT 13, IYEAR, (PPGS1(IYEAR,NY), NY=1,14)
      PRINT 14, IYEAR, (PPGS2(IYEAR,NY), NY=1,14)
      PRINT 63, IYEAR, (PPGS3(IYEAR,NY), NY=1,14)
      PRINT 64, IYEAR, (PPGS4(IYEAR,NY), NY=1,14)
      PRINT 7, IYEAR, (SFFP(IYEAR,NZ), NZ=1,14)
      PRINT 23, IYEAR
      DO 117 K=1,14
      DO 116 L=1,12
      PQPKWD(L,IYEAR,K)= QPKWD(L,K)
  116 CONTINUE
      NYEAR= 1957 + K  + IYEAR
      PRINT 26, NYEAR, (PQPKWD(LP,IYEAR,K), LP=1,12)
  117 CONTINUE
      RETURN
      ENTRY JANLEG
      DO 200 M=1,14
      SFSL(M)= SFSC(M)
      GMHL(M)= GMHC(M)
  200 CONTINUE
      DO 201 M=1,14
      PIG1L(M)= PIG1C(M)
      PIG2L(M)= PIG2C(M)
      PIG3L(M)= PIG3C(M)
  201 PIG4L(M)= PIG4C(M)
      DO 202 M=1,14
      DPGSL1(M)= DPGSC1(M)
      DPGSL2(M)= DPGSC2(M)
      DPGSL3(M)= DPGSC3(M)
      DPGSL4(M)= DPGSC4(M)
  202 CONTINUE
      DO 203 M=1,14
      DO 203 N=1,4
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      DSFKL(N,M)= DSFKC(N,M)
  203 CONTINUE
      RETURN
      END
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10


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      SUBROUTINE PRINTJ
      COMMON/JAN1/ IDATE,IYEAR,KONT
      COMMON/S/ PSF1(10,14), PSF2(10,14), PSF3(10,14), PSF4(10,14)
      COMMON/JPRINT/ PDKPOP1(10,14), PDKPOP2(10,14), PDKPOP3(10,14),
     1 PDKPOP4(10,14), PH13(10,14), PH46(10,14), PH79(10,14),
     2 PH102(10,14), PPHMONT(12,10,14), PSFS(10,14),
     3 PGMHC(10,14), PRINTPH(10,14), PGPKMC(12,10,14),
     4SFFP(10,14),PGMHT(10,14), PHNEW(10,14),
     5 PPGS1(10,14), PPGS2(10,14), PPGS3(10,14), PPGS4(10,14)
      PRINT 10
   10 FORMAT(1H1,36X,*MODEL FOR GENERATING MONTHLY HOG PRICE FORECASTS F
     1ROM*,    /37X, *DECEMBER PIG CROP REPORT AND SUPPLY-DEMAND EQUATIO
     2NS*,     /44X, *( 24 MONTHS BEGINNING IN JANUARY )*,//
     316X, *YEAR*,12X, 11HDSPK1-3/POP, 9X, 11HDSPK4-6/POP, 9X,
     411HDSPK7-9/POP, 9X,13HDSPK10-12/POP,//)
      K=0
      DO 15 I=1,14
      DO 16 J=1,IYEAR
      KK=1958+J+K
      PRINT 20, KK, PDKPOP1(J,I), PDKPOP2(J,I), PDKPOP3(J,I),
     1 PDKPOP4(J,I)
   20 FORMAT(1H ,15X, I4,5X, 4(F17.2,3X))
   16 CONTINUE
      K=K+1
      PRINT 17
   17 FORMAT(1H0)
   15 CONTINUE
      IN=0
      PRINT 25
   25 FORMAT(1H1,/,16X,*YEAR*,15X,5HPH1-3, 15X, 5HPH4-6,15X,5HPH7-9,
     1 15X,7HPH10-12,//)
      DO 30 I=1,14
      DO 31 J=1,IYEAR
      INN=1958+J+IN
      PRINT 35, INN, PH13(J,I), PH46(J,I), PH79(J,I), PH102(J,I)
   35 FORMAT(1H ,15X,I4, 5X, 4(F15.2,5X))
   31 CONTINUE
      IN=IN+1
      PRINT 17
   30 CONTINUE
      J1=0
      PRINT 35
   36 FORMAT(1H1,/,15X, *YEAR*, 13X, 6HSF12-2,15X,5HSF3-5,15X,5HSF6-8,
     1 15X,6HSF9-11,//)
      DO 40 I=1,14
      DO 41 J=1,IYEAR
      JJ=1958+J+J1
      PRINT 35, JJ, PSF1(J,I), PSF2(J,I), PSF3(J,I), PSF4(J,I)
   41 CONTINUE
      J1=J1+1
      PRINT 17
   40 CONTINUE
      PRINT 45
      L1=0
   45 FORMAT(1H1,/,15X,*YEAR*, 13X,7HPGS12-2, 12X, 6HPGS3-5, 13X,
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      1 6HPGS6-8,13X, 7HPGS9-11,//)
        DO 50 I=1,14
        DO 51 J=1,IYEAR
        LL=1958+J+L1
        PRINT 35, LL, PPGS1(J,I), PPGS2(J,I), PPGS3(J,I), PPGS4(J,I)
     51 CONTINUE
        L1=L1+1
        PRINT 17
     50 CONTINUE
        INDEX=0
        PRINT 55
     55 FORMAT(1H1,/,5X, *YEAR*,16X,*PH1*,15X,*PH2*,15X,*PH3*,15X,*PH4*,
      1 15X, *PH5*,15X,*PH6*,//)
        DO 56 I=1,14
        DO 57 J=1,IYEAR
        IM=1958+J+INDEX
        PRINT 60, IM, ( PPHMONT(K,J,I), K=1,6)
     60 FORMAT(1H ,5X,I4, 7X, 6(F15.2, 3X))
     57 CONTINUE
        INDEX=INDEX+1
        PRINT 17
     56 CONTINUE
        PRINT 65
     65 FORMAT(1H1,/,5X, *YEAR*, 16X,*PH7*,15X,*PH8*,15X,*PH9*,15X,
      1 *PH10*,14X, *PH11*, 14X, *PH12*,//)
        INDEX=0
        DO 70 I=1,14
        DO 71 J=1,IYEAR
        JM= 1958+J+INDEX
        PRINT 60, JM, ( PPHMONT(K,J,I), K=7,12)
     71 CONTINUE
        INDEX=INDEX+1
        PRINT 17
     70 CONTINUE
        PRINT 75
     75 FORMAT(1H1,/,5X, *YEAR*,15X,12H^(QPK1/WKD1), 6X, 12H^(QPK2/WKD2),
      1 6X, 12H^(QPK3/WKD3), 6X, 12H^(QPK4/WKD4), 6X, 12H^(QPK5/WKD5),
      2 6X, 12H^(QPK6/WKD6),//)
        MM=0
        DO 80 I=1,14
        DO 81 J=1,IYEAR
        M1= 1958+J+MM
        PRINT 85, M1, ( PQPKWD(L,J,I), L=1,6)
     85 FORMAT(1H ,5X,I4,10X, 6(F15.3,3X))
     81 CONTINUE
        MM=MM+1
        PRINT 17
     80 CONTINUE
        PRINT 90
     90 FORMAT(1H1,/,5X, *YEAR*, 13X,12H^(QPK7/WKD7), 6X, 12H^(QPK8/WKD8),
      1  6X, 12H^(QPK9/WKD9),  6X, 14H^(QPK10/WKD10), 5X,
      2 14H^(QPK11/WKD11), 5X, 14H^(QPK12/WKD12),//)
        J2=0
        DO 91 I=1,14
        DO 92 J=1,IYEAR
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```
      JYR= 1958+J+J2
      PRINT 85, JYR, ( PJPKND(L,J,I), L=7,12)
   92 CONTINUE
      J2=J2+1
      PRINT 17
   91 CONTINUE
      PRINT 95
   95 FORMAT(1H1,/, 5X,*YEAR*, 13X,*SFST*, 13X,*GMHT*, 14X,*PHT*,14X,
     1 *SFF*,12X, *GMHNEW*,12X,*PHNEW*,//)
      LL=0
      DO 96 I=1,14
      DO 97 J=1,IYEAR
      LYR= 1958+J+LL
      PRINT 98, LYR,  FSFS(J,I) , PGMHC(J,I), PRINTPH(J,I),SFFP(J,I),
     2 PGMHT(J,I), PHNEW(J,I)
   98 FORMAT(1H , 5X, I4, 6(F17.2))
   97 CONTINUE
      LL=LL+1
      PRINT 17
   96 CONTINUE
      RETURN
      END
```