Swine - Prices

Econometric Models of Quarterly and Monthly Live Hog Prices

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ECONOMETRIC MODELS OF

QUARTERLY AND MONTHLY LIVE HOG PRICES

by

Sujit K. Roy, Richard J. Foote and George Sadler*

INTRODUCTION

Short-run variations in production, marketings and prices have typically characterized the U.S. hog-pork sector. Such variations, especially the price fluctuations, create problems of uncertainty in the decision making process of producers, traders and other participants in the industry. Prices of hogs and feed grains are the two major variables which influence the producer's net return situation and the decision making process for future levels of production. Since the short-run price elasticity of demand is low, an increased market supply of hogs may lead to a more than proportionate fall in hog price, and an absolute decline in producer's return. On the other hand, the declining price fails to reduce supply to any major extent in the short-run, since the short-run supply is essentially price inelastic. Thus, these two forces--inelastic demand and supply--combine to cause substantial short-run variations in price and producer's income.

Market prices of hogs tend to exhibit a pattern of short-run variations which is related to the marketings of hogs. The latter, in its turn, is related to the time of farrowing and to feeding and breeding programs. The highest concentrations of farrowings are usually in the spring during March

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and April and during September for the fall pig-crop. Subsequently, short-run variations in the production and prices of hogs tend to show some degree of regularity. Hog prices usually maintain a high level in the summer (June, July) when supplies are small, and decline to low levels in the fall (November) when supplies are relatively large.

Objectives of the Study

The broad objective of the study was to develop econometric prediction models for short-run live hog prices based on structural relations underlying the price determining forces in the sector.

The specific objectives were:

1. To identify the structural relations and factors which affect short-run prices of live hogs;
2. To formulate and estimate econometric models for quarterly and monthly live hog prices based on specified demand and price determining structural relations within the sector;
3. To evaluate the performance of selected models in terms of the accuracy of estimation or prediction of live hog prices and other endogenous variables both within and beyond the period of fit.

THE HOG-PORK INDUSTRY

Production, Prices and Consumption

The importance of the U.S. hog-pork sector within the livestock-meat industry is evidenced by the fact that the annual cash income for the hog-pork sector ranks second only to beef. Production of red meat animals has been traditionally concentrated in the Corn Belt states within the West North Central Division which accounted for 40 percent of all livestock production in the U.S. in 1970. Six states -- Iowa, Missouri Nebraska, Minnesota, Kansas and South Dakota -- in this Division together accounted for about 50 percent of total U.S. hog production. Illinois, Indiana, Ohio and Wisconsin in the East North Central Division produced 27 percent and the six states in the South -- North Carolina, Georgia, Kentucky, Texas, Tennessee and Alabama -- accounted for about 12.5 percent of total U.S. hog production in 1970. Thus, these 16 states together produced about 90 percent of the total U.S. hog production of 21.9 billion pounds [15, 16]. The hog-pork sector's contribution ($4.6 billion) in cash receipts was 24.87 percent of the total cash receipts from all livestock. The leading 10 hog-producing states in the West North Central, and East North Central Divisions accounted for 79.6 percent and the six states in the South contributed 11.49 percent of the total U.S. cash receipts from the hog-pork sector in 1970 [15, 16].

Production of hogs in the past decades has exhibited longer run cyclical variations. Data for the number of hogs on farms from 1940 through 1970 indicate the presence of several "hog cycles". The length of these cycles has averaged slightly more than 4 years -- of which two years may be accounted for by expansion and two years by liquidation. There appears to be alternating major and minor peaks in the production cycles. The high peaks are usually followed by low peaks in the hog cycles [10, p. 74]. The phenomenon of the cycles is generally explained on the basis of the cobweb theorem using the hog-corn ratio [5]. A high hog-corn ratio would imply a relatively high price of hogs and a relatively small market supply, and would typically stimulate an increased production in the following period. The longer run adjustments would, however, lead to a relatively abundant supply resulting in a low hog-corn ratio. Subsequently, an unfavorable hog-corn ratio would induce a decrease in farrowings, which in the succeeding period would lead to reduced market supplies of hogs and a relatively high hog price and hog-corn ratio, thus completing the cycle.

Seasonal or shorter run variations in hog production and prices are superimposed on the longer run cycles. The seasonal variations in hog production and marketings are primarily influenced by the seasonal patterns of farrowings. Although farrowings are distributed throughout the year, there appears to be some concentration of farrowings in certain months and subsequent bunching of marketings. The relatively high concentration of farrowings is during March and April for the spring crop, and in September for the fall pig crop. The spring pig crop has represented the larger of the two farrowings, although in recent years the difference has lessened. For instance, the spring pig crop during the 1940's accounted for about 61 percent of annual production, and in the 1970's the proportion declined to 52 percent. It has been observed that the seasonal index of marketings tends to correspond directly with the index of farrowings lagged seven months, although the amplitude of variations in the marketings index seemed to be less than that of the farrowings index [10, pp. 77-78.]

The slaughter of hogs under federal inspection is usually the highest in December; it declines subsequently for a couple of months, and rises again reflecting the sale of hogs from the fall pig crop. Hog slaughter would then fall steadily and reach the lowest ebb in mid-summer (July and August). Seasonal swings in the slaughter of barrows and gilts appear to be greater relative to the variations in total hog slaughter.

The total quantity of pork produced during a given period depends on the number of hogs slaughtered, the average slaughter weight and the dressing yield. The dressing yield seems to remain fairly stable and, hence, does not cause significant changes in pork production. However, the average slaughter weight appears to vary seasonally thus contributing to seasonal variations in pork production.

The total available market supply of pork consists of production during the period and the quantity of pork in storage at the beginning of the period. Hence, variations in storage stocks may affect pork supply and price. The pattern of seasonality of stocks of meat in cold storage is characterized by relatively high levels of carry-over from the winter months to the spring and summer months. The lowest inventory of cold storage stocks of pork in the recent decade occurred mostly in September or October. Seasonal accumulation of inventories provides some cushioning effect to short-run variations in the market supply of pork.

Data on hog prices reveal that variations in short-run (monthly or quarterly) prices occur with some degree of regularity and in inverse relation with production. Highest average prices prevail usually during the summer months -- June, July, and August. Hog prices tend to reach the lowest level in the winter months and more frequently in November, when the marketings are high. There appears to be a small rise in prices in February, and a fall thereafter which bottoms out in April and May. Subsequently, hog prices begin to rise back to the seasonal highs in the summer months. It has been observed that the amplitude of seasonal variations in hog prices in recent periods has diminished considerably relative to that in the fifties and earlier years [10, p. 79].

The total meat consumption in the United States has more than doubled since the beginning of the century. The rise is due to increased per capita consumption and population growth. The increase in beef consumption primarily accounts for the increased consumption of red meat. Pork consumption on the other hand has become a smaller and smaller proportion of the total meat supply. Beef accounted for 61 percent of total red meat consumption in 1970, pork for 35.6 percent, and veal, and lamb and mutton for 1.6 and 1.8 percent respectively. In terms of per capita consumption in 1970, beef consumption was 113.7 pounds, while pork consumption amounted to 66.4 pounds. The average annual per capita consumption of pork in the late sixties and early seventies did not show any appreciable change from the average in the early fifties [15, 16].

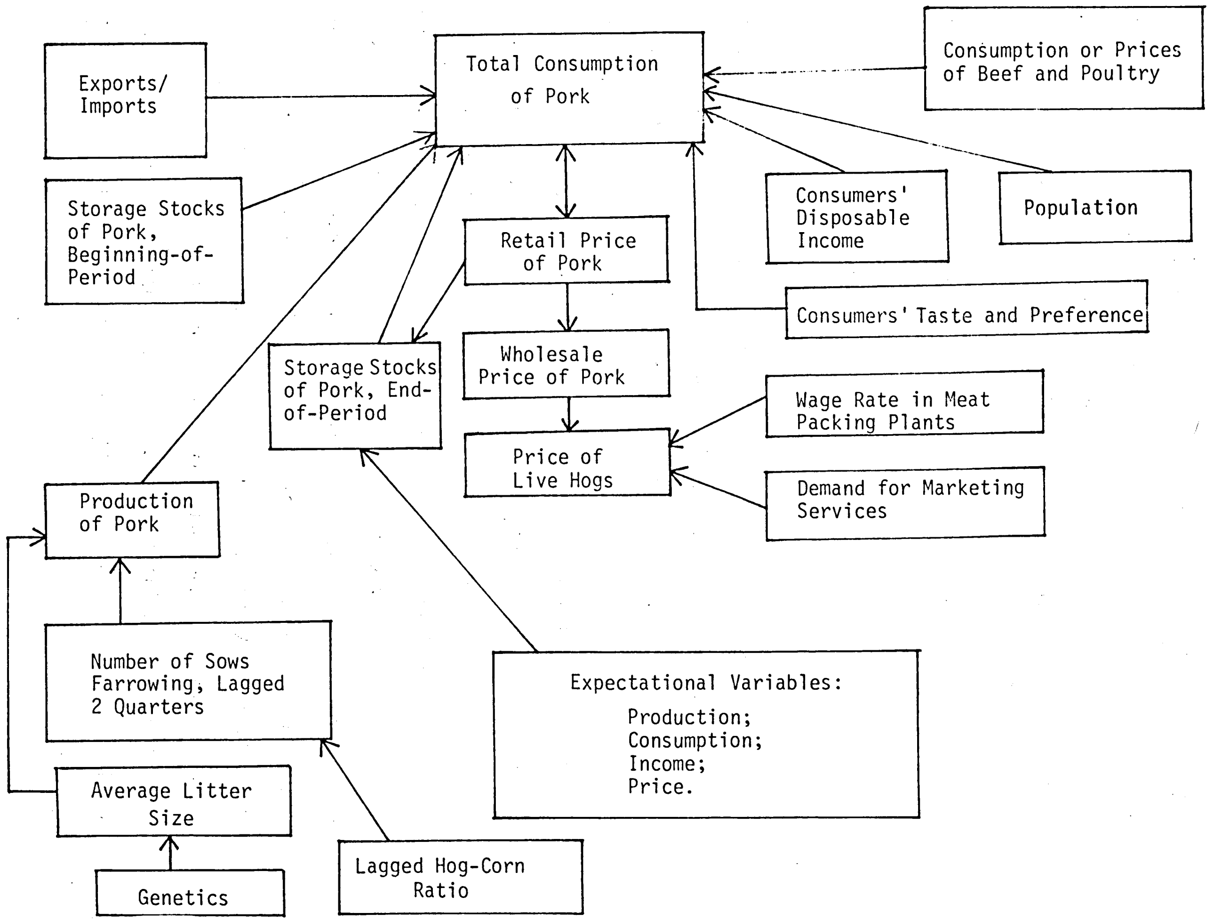
The per capita consumption of pork is presumed to depend on pork price, the relative supply or prices of beef and poultry, consumer income and market supply of pork. The price elasticity of demand for pork is reported to be relatively low. Brandow [1, p. 24] and Hassler [6, p. 14], estimated the elasticity between -.7 and -.8. Although the consumer's per capita disposable income has increased steadily during the past decades, the expenditure on all food comprised a decreasing portion of income. The percentage of disposable income spent on pork has also generally declined. Past studies based on earlier data revealed no significant effect of increased income on pork consumption. It has also been observed that as income rose, consumers tended to direct their increased demand for meat toward beef [2, pp. 18-32]. Furthermore, Luby reported that there appeared to be an increase in the consumption of poultry as a substitute for pork [7, p. 1835]. However, Roy and Young, in a recent study, found a positive significant effect of income on pork consumption, and a relatively low substitution of pork by beef and poultry [12, pp. 51-53].

Structural Specification of the Hog-Pork Sector

The demand and price structure of the hog-pork industry may be represented generally by the interrelations among numerous variables of which some are determined within the system during the current period, while the others are determined either externally or during the preceeding periods. The market forces which are hypothesized to influence prices and consumption of pork are presented in Figure 1. The direction of influence among variables is indicated by the lines with arrows in the figure.

Pork consumption in the short-run, such as during a quarter or month, equals the pork production plus the carry over of pork products in storage stocks from the preceding period and net imports minus the storage stocks of pork at the end of the period. Net exports or imports are negligible for the U.S. pork industry. Production of pork is dependent on the number of sows farrowing lagged approximately two quarters and the litter size. The average size of litter is predetermined since it is dependent on production practices and genetics which do not vary significantly in the short-run.

Figure 1. Structural Specifications of the Hog-Pork Sector



Lagged prices of hogs and feed, or the hog-corn ratios, representing the cost-return situation in the hog sector, are considered to be the major determinants of the number of sows farrowing. Thus, the production of pork during the period is essentially a predetermined variable.

Consumption of pork may be affected by some or all of the following factors: retail price of pork, consumption or prices of beef and poultry, consumers' disposable income, population and consumers' tastes and preference. Pork consumption and retail pork price are two mutually dependent variables within the system.

The end-of-period storage stock of pork, a determinant of available market supply of pork for consumption, is assumed to be influenced by expectations regarding future levels of pork production, consumption, pork price and disposable income of the consumer. A more detailed discussion of these expectational specifications is presented in the following section (see pp. 13-16).

The demand for live hogs is derived from retail demand for pork. Prices of live hogs is determined primarily by the retail pork price via the wholesale price of pork. The differential between the retail pork price and the live hog price is also influenced by the demand for marketing services and processing costs which may be represented by the prevailing wage rate in the meat packing industry.

Four major variables--consumption and retail price of pork, live hog prices and end-of-period storage stocks of pork--are determined within the described structural system, and the remaining ones are exogenous or predetermined variables. The generalized econometric model presented in the following section is based on the foregoing specifications of variables and relations underlying the price-determining process in the hog-pork sector.

QUARTERLY MODELS FOR LIVE HOG PRICES

Specification of the Basic Model

The basic structural relations of the retail pork and live hog price models are as follows:

Consumption-Retail price relation for pork:

(1) $C_t = f\ (R_t, I_t, B_t, P_t)$

Function relating live hog price and retail pork price:

(2) $H_t = f\ (R_t, W_t, T, Q_t)$

Cold storage stocks of pork products relation:

(3) $S_{t+1} = f\ (C^*_{t+1} - Q^*_{t+1}, C^*_{t+2} - Q^*_{t+2})$

or

(3a) $S_{t+1} = f\ [R_t, \Delta I_t, I^*_{t+1}, S_t, (F_{t-2} \times L_{t-2}), (F_{t-1} \times L_{t-1}), (F_t \times L^*_t)]$

The model included Eq. (3a), instead of Eq. (3), for the purpose of estimation. The specification of Eq. (3) and the derivation of Eq. (3a) were based on Nerlove's expectational models, and will be discussed in a latter part of the section (see pp. 13-16).

Market clearing identity for pork products:

(4) $C_t = Q_t + S_t - S_{t+1}$

The variables included in the preceding relations are defined as follows:

C = consumption of pork (civilian consumption) in the U.S. during the quarter, million pounds, derived from the identity, Eq. (4).

R = adjusted weighted average retail price of pork products for the quarter, cents per live hog equivalent pound; source: Livestock and Meat Situation [15], and Livestock and Meat Statistics [16].

(The adjusted price series, used for statistical estimation, was developed by using net yield conversion factors to express the series on a comparable basis with the live hog price series.[1/]

I = disposable personal income for the quarter at seasonally adjusted annual rates, billion dollars; source; Survey of Current Business [20].

B = consumption of beef during the quarter, million pounds; source; Livestock and Meat Statistics [16].

P = consumption of poultry, estimated by using data on civilian consumption of turkeys and broilers, during the quarter, million pounds; source; Poultry and Egg Situation [17] and Selected Statistical Series for Poultry and Eggs, [19].

H = price of live hogs at Omaha, Nebraska, 200-220 pounds, barrows and gilts, U.S. No. 1-2, cents per pound; source; Livestock and Meat Situation [15] and Livestock and Meat Statistics [16].

W = average weekly earnings of production or non-supervisory workers in meat packing plants during the quarter; source; Employment and Earning Statistics of the United States [21]

T = time, where T = 57 for 1957, T = 58 for 1958, etc.

1/ The live hog equivalent in pounds to one pound of retail pork products changed from 2.06 in 1957 to 1.97 in 1969 [18, p. 24], and was estimated to have declined during the period at an annual average rate of .004. The same rate of change was assumed to apply for years beyond 1969 in the present study. The reciprocals of the live hog equivalent in pounds to one pound of retail pork were used as net yield conversion factors. Retail pork prices were multiplied by the corresponding annual yield factors to obtain the adjusted retail price series.

Q = production of pork, million pounds, during the quarter, commercial pork production, 48 states of the U.S., excluding lard and rendered pork fat; source; Livestock and Meat Statistics [16].

S = inventory stocks of cold storage pork, first of quarter, million pounds, frozen and cured pork, cold storage holdings, 48 states of the U.S.; source; Livestock and Meat Situation [15], and Livestock and Meat Statistics [16].

F = number of sows farrowed during the quarter, million head; source; Hogs and Pigs [14] and Livestock and Meat Statistics [16].

L = estimated average number of pigs saved per litter during the quarter; source; Hogs and Pigs [14] and Livestock and Meat Statistics [16]; published projections for the average litter size, L^*, were compiled from Hogs and Pigs [14].

The variables with the asterisk refer to the expected value or level of the corresponding variables, and the subscripts t, t-i, and t+i, (where i=1,2) refer to the current, lagged and succeeding quarters respectively.

Consumption of pork in Eq. (1) is specified to depend on retail prices of pork and disposable personal income. Consumption of beef and poultry, two substitute products for pork, may be inversely related to pork consumption.

The demand for live hogs is a derived demand originating from the primary consumer demand for pork products at the retail level. Hence, live hog price is expressed as a function of the retail pork price in the second relation, Eq. (2). The equation in essence depicts the role of the marketing system which transmits consumers' demand for pork to the live hog marketing level. The difference between retail pork price and live hog price can be to some extent explained by the processing cost which is represented partly by the wage of labor (W) in meat packing plants. The differential between prices of pork and live hogs would increase when wages rise. The additional labor cost may be passed on to the consumer in the form of higher retail prices of pork and/or passed back in part to the producer in the form of lower prices for live hogs. Thus, given the retail price of pork, rising labor costs would tend to depress live hog prices. Production of pork during the period (Q_t) was included in Eq. (2) as an approximate indicator of the current demand for marketing services in the hog-pork sector. A rise in Q_t would imply an increased pressure on existing limited marketing services leading to an increased distribution cost per unit of the product. This would subsequently lower the price of live hog, assuming a constant retail pork price. It may be assumed that the available per unit marketing services would not increase significantly in the short run. Finally, the time variable T was introduced into the equation, Eq. (2), to reflect the possible time trend in the series in recent years.

The first equation representing the cold storage stocks relation, Eq. (3), can not be estimated directly since it includes expectation variables such as the expected levels of consumption and production of pork one and two quarters ahead. However, the alternative version of the storage stock relation, Eq. (3a), which is derived from Eq. (3) under specified assumptions, includes variables for which actual data are available from published sources. The derivation of Eq. (3a) from Eq. (3) may be presented as follows:[2/] Expected levels of production, Q^*_{t+1} and Q^*_{t+2} in Eq. (3), are assumed to depend primarily on expected pig crops which would be marketable one and two quarters ahead. Since it takes approximately 6 months for the pigs from

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2/ The derivation is based on the approach used in Foote et. al. [3]

birth to attain a 200-240 pound marketable weight, expected pig crops and hence expected production (Q^*) may be assumed to be a function of lagged values of the number of sows farrowed (F) and the average litter size (L), i.e.,

$$\text{(i)} \quad Q^*_t = f(F_{t-2} \times L_{t-2})$$

$$\text{(ii)} \quad Q^*_{t+1} = f(F_{t-1} \times L_{t-1}) \text{ and}$$

$$\text{(iii)} \quad Q^*_{t+2} = f(F_t \times L^*_t)$$

Data on each of the independent variables including L^*_t, are published in <u>Hogs and Pigs</u> [14] report. The report contains a projected number of pigs per litter for the current quarter and the projected litter size is used in this model as L^*_t.

Expected consumption levels, C^*_{t+1} and C^*_{t+2} in Eq. (3), is assumed to be influenced by expected consumer incomes and expected prices of pork. Thus,

$$\text{(iv)} \quad C^*_{t+1} = f(R^*_{t+1}, I^*_{t+1}) \text{ and}$$

$$\text{(v)} \quad C^*_{t+2} = f(R^*_{t+2}, I^*_{t+2})$$

Substituting C^* and Q^* by appropriate variables, Eq. (3) may be presented as follows:

$$\text{(vi)} \quad S_{t+1} = f(R^*_{t+1}, I^*_{t+1}, F_{t-1} \times L_{t-1}, R^*_{t+2}, I^*_{t+2}, F_t \times L^*_t)$$

With respect to income expectations, it is assumed that projections regarding future income levels may be made on the basis of the most recent quarter-to-quarter change in income. Thus,

$$I^*_{t+1} = I_t + \Delta I_t, \text{ where } \Delta I_t = I_t - I_{t-1}$$

Furthermore, it was expected that I^*_{t+1} and I^*_{t+2} in Eq. (vi) would be highly correlated. Consequently, for the purposes of estimation, I^*_{t+2} was omitted and ΔI_t was introduced into the equation.

Expectations regarding prices (R^*) were assumed to be based on Nerlove's specifications which imply that price expectations are adjusted in proportion to the error made in the most recent past [11]. That is,

$$\text{(vii)} \quad R^*_t - R^*_{t-1} = \beta\,(R_{t-1} - R^*_{t-1}) \text{ or}$$

$$\text{(viii)} \quad R^*_t = \beta R_{t-1} + (1-\beta)\,R^*_{t-1}$$

Since R^*_{t+1} and R^*_{t+2} would be highly correlated under these specifications, R^*_{t+2} may also be excluded from Eq. (vi) which can be rewritten in the linear form as follows:

$$\text{(ix)} \quad S_{t+1} = a + b_1\,R^*_{t+1} + b_2 I^*_{t+1} + b_3 \Delta I_t + b_4\,(F_{t-1} \times L_{t-1}) + b_5\,(F_t \times L^*_t) = b_1\,R^*_{t+1} + Z_{t+1}$$

where, Z_{t+1} represents all additive terms except $b_1 R^*_{t+1}$ in Eq. (ix). Lagging Eq. (ix) by one time period, the following equation is obtained:

$$\text{(x)} \quad S_t = b_1 R^*_t + Z_t \text{ or}$$

$$\text{(xi)} \quad R^*_t = \frac{1}{b_1}\,(S_t - Z_t)$$

Lagging Eq. (xi) by one time period,

$$\text{(xii)} \quad R^*_{t-1} = \frac{1}{b_1}\,(S_{t-1} - Z_{t-1})$$

Recalling Eq. (viii), that is, $R^*_t = \beta R_{t-1} + (1-\beta)\,R^*_{t-1}$, and substituting R^*_{t-1} in the equation by Eq. (xii), the following equation is obtained:

$$\text{(xiii)} \quad R^*_t = \beta R_{t-1} + (1-\beta)\frac{1}{b_1}(S_{t-1} - Z_{t-1})$$

The equation may now be rewritten by using simplified coefficients as follows;

$$\text{(xiv)} \quad R^*_t = B_1 R_{t-1} + B_2 S_{t-1} + B_3 Z_{t-1}$$

Rewriting Eq. (xiv) for the succeeding time period,

$$\text{(xv)} \quad R^*_{t+1} = B_1 R_t + B_2 S_t + B_3 Z_t$$

Substituting Eq. (xv) into Eq. (ix) the following relation is developed:

$$\text{(xvi)} \quad S_{t+1} = b_1\,(B_1 R_t + B_2 S_t + B_3 Z_t) + Z_{t+1}$$

The equation may be presented more explicitly but in a general functional form as follows:

$$\text{(xvii)} \quad S_{t+1} = f\,(R_t,\ S_t,\ I^*_t,\ \Delta I_{t-1},\ F_{t-2} \times L_{t-2},\ F_{t-1} \times L^*_{t-1},$$
$$I^*_{t+1},\ \Delta I_t,\ F_{t-1} \times L_{t-1},\ F_t \times L^*_t)$$

The preceding equation was modified to obtain Eq. (3a) by excluding some variables (such as I^*_t, I_{t-1} and $F_{t-1} \times L^*_{t-1}$) which were believed to be highly correlated or being adequately represented by other variables in the equation. Thus,

$$\text{(xviii)} \quad S_{t+1} = f\,(R_t,\ S_t,\ I^*_{t+1},\ \Delta I_t,\ F_{t-2} \times L_{t-2},\ F_{t-1} \times L_{t-1},\ F_t \times L^*_t)$$

The present treatment of the storage stocks relation is significantly different from those in earlier studies [4,9] in terms of expectational specifications.

Data for all variables appearing in Eq. (xviii) or Eq. (3a) are available from published sources and, hence, the relation lends itself to statistical estimation procedures. While the projected litter size for the current period, L^*_t, is available from <u>Hogs and Pigs</u> [14], projected income level, I^*_{t+1}, may be obtained from outside sources. However, as indicated earlier, for the present study such projections were based on the most recent quarter-to-quarter change in the income level.

The last equation of the model, Eq. (4), is the closing identity in the system. It equates consumption of pork products with production of pork and net storage movement during the period.

Statistical Procedures

The stochastic relations, Eqs. (1), (2), and (3a), and the identity Eq. (4), are the four structural relations underlying the process of determination of live hog prices. The endogenous variables which are simultaneously determined within the system are R_t, H_t, S_{t+1} and C_t. Each of the three stochastic relations is over-identified, and subsequently Eq. (1), (2) and (3a) were estimated by using the three-stage least squares method. The general procedure of the three-stage least squares method involves several steps. First, the endogenous variables appearing on the right hand side of the stochastic structural relations are expressed individually as a function of all exogenous or predetermined variables within the simultaneous equation system. Ordinary least squares estimates are obtained for these equations which may be termed as the first-round equations. The values of the endogenous variables are then estimated from the first round equations. In the second stage of estimation (two-stage least squares), the estimated values of the endogenous variables are used in the structural equations, and ordinary least squares method is applied to obtain the estimates of the structural relations. The final stage of the three-stage least squares procedure involves the simultaneous estimation of the coefficients of the stochastic structural equations by the application of generalized least squares method incorporating the error variance-covariance matrix from the two-stage least squares estimates [22]. The three-stage least squares procedure yields consistent estimators which are generally more efficient than the corresponding two-stage least squares estimators [8, 22].

The only endogenous variable which appears on the right hand side of each of the three stochastic relations, Eqs (1), (2) and (3a), is R_t. Consequently, the estimation process involved only one first-round equation with R_t as the dependent variable. The calculated or estimated values of the variable, i.e., R_t, obtained from the ordinary least squares first-round equation were then utilized to develop the three-stage least squares estimates of the three structural relations. As the statistical results would later indicate, some relatively minor variables were omitted from the selected equations in the model. A variable was excluded when it entered the equation with a sign contrary to logical expectation or a priori knowledge.

A separate model was developed for each of the calendar quarters using data for the period 1957 through 1971. It may also be observed that the estimated model presented here for each quarter is only one of several alternative estimates which were developed for each quarter. For instance, alternative equations were fitted by using certain quantity and income variables either in total or per capita terms. The estimated models presented in the following section were selected on the basis of relative accuracy in predicting or estimating the endogenous variables, especially the live hog price, H_t.

The performance of each model in predicting or estimating the endogenous variables was examined by means of Theil's U_2-coefficient for each relevant variable. The inequality or U_2-coefficient is defined as follows [13]:

$$U_2 = \sum(\Delta P_{it} - \Delta A_{it})^2 \div \sum \Delta A^2_{it} = \sum(P_{it} - A_{it})^2 \div \sum (A_{it} - A_{it-1})^2$$

where, $\Delta P_{it} = P_{it} - A_{it-1}$, $\Delta A_{it} = A_{it} - A_{it-1}$, and P_{it} and A_{it} are the predicted (or estimated) and actual levels of the variable during the current period, and A_{it-1} is the actual level of the variable in the preceding period. The U_2-coefficient becomes zero, when all forecasts or estimates for the specified periods are identical to the actual levels of the variable. On the other hand, a "naive no-change" extrapolative model, which for all periods yields estimates for the current period equal to the actual level in the preceding period, (that is, $P_{it} = A_{it-1}$ for all t periods), would generate a U_2-coefficient of unity. The coefficient may become greater than unity when prediction errors are substantially large.

Statistical Results

Alternative models for each quarter were compared in terms of relative accuracy of predictions with the aid of U_2-coefficients. The set of equations presented in this section for each quarter was judged to be superior to others. The reduced form equations for the endogenous variables were derived algebraically from the three estimated stochastic structural relations and the identity, Eq. (4). The first-round equation for R_t, the three-stage least squares (3-SLS) estimates of the three structural equations, Eqs. (1), (2), and (3a), and the reduced form equation for live hog price (H_t) are presented here in that order.

First quarter:

First-round equation for R_t:

$$R_t = \underset{(5.498)}{68.17} - \underset{(-2.781)}{.6631B_t'} + \underset{(2.365)}{41.93\Delta I_t'} - \underset{(-10.93)}{2.558S_t'} - \underset{(-5.759)}{107.1}\,(F_{t-2} \times L_{t-2})'$$

$$- \underset{(-7.292)}{179.6}\,(F_{t-1} \times L_{t-1})' - \underset{(-1.587)}{52.06}\,(F_t \times L_t^*)' + \underset{(5.982)}{.2643W_t} \qquad [R^2 = .9885]$$

3-SLS structural equations:

$$(1)\quad C_t' = \underset{(17.36)}{17.70} - \underset{(-1.501)}{0.1117B_t'} + \underset{(8.143)}{3.537I_t'} - \underset{(-9.665)}{0.2837R_t}$$

$$(2)\quad H_t = \underset{(0.7651)}{4.506} - \underset{(-2.392)}{0.7341Q_t'} - \underset{(-2.073)}{0.0551W_t} + \underset{(0.6651)}{0.0758T} + \underset{(10.78)}{0.9120R_t}$$

$$(3)\quad S_{t+1}' = \underset{(1.458)}{4.954} + \underset{(0.9287)}{7.170\Delta I_t'} + \underset{(0.9055)}{0.5377I_{t+1}^*} + \underset{(1.996)}{0.5626S_t'} - \underset{(-0.1053)}{1.620}(F_{t-2} \times L_{t-2})'$$

$$- \underset{(-1.229)}{0.1088R_t}$$

Reduced form equation for H_t:

$$H_t = 57.14 - 3.058Q_t' - 0.2595B_t' + 8.218I_t' + 16.64\Delta I_t' + 1.249I_{t+1}^{*\prime} - 1.016S_t'$$

$$- .0551W_t - 3.764\,(F_{t-2} \times L_{t-2})' + 0.0758T$$

Second quarter:

First-round equation for R_t:

$$R_t = \underset{(11.35)}{45.83} - \underset{(-1.738)}{.001793B_t} + \underset{(4.177)}{.05436I_t} - \underset{(-2.225)}{.00416S_t} - \underset{(-4.464)}{1.127(F_{t-2} \times L_{t-2})}$$

$$- \underset{(-.5700)}{.03992W_t} \qquad [R^2 = 0.9624]$$

3-SLS structural equations:

$$(1)\ C_t = \underset{(7.681)}{3506.0} - \underset{(-3.407)}{0.3564B_t} - \underset{(-.2000)}{0.6662P_t} + \underset{(3.927)}{4.160I_t} - \underset{(-4.543)}{68.47R_t}$$

$$(2)\ H_t = \underset{(-2.613)}{-14.86} - \underset{(-.3176)}{.00074Q_t} - \underset{(-2.840)}{.1461W_t} + \underset{(3.071)}{.3767T} + \underset{(8.900)}{.9953R_t}$$

$$(3a)\ S_{t+1} = \underset{(-1.967)}{-711.3} + \underset{(.2736)}{.07953I^*_{t+1}} + \underset{(.3937)}{.7124S_t} + \underset{(1.416)}{35.89(F_{t-2} \times L_{t-2})}$$

Reduced form equation for H_t:

$$H_t = 25.75 - .0153Q_t - .00052B_t - .00097P_t + .06044I_t + .00116I^*_{t+1}$$

$$-.00418S_t + .5215(F_{t-2} \times L_{t-2}) - .1461W_t + .3767T$$

Third quarter:

First-round equation for R_t:

$$R_t = \underset{(6.416)}{45.12} - \underset{(-2.680)}{.008325B_t} + \underset{(3.923)}{.07190I_t} + \underset{(1.895)}{.3380\Delta I_t} - \underset{(-3.683)}{.01231S_t} \qquad [R^2 = 0.8148]$$

3-SLS structural equations:

$$(1)\ C_t = \underset{(10.81)}{4426.0} - \underset{(-3.248)}{.4506B_t} - \underset{(-2.531)}{.7525P_t} + \underset{(7.465)}{7.902I_t} - \underset{(-5.376)}{55.08R_t}$$

$$(2)\ H_t = \underset{(-2.844)}{-38.94} - \underset{(-3.587)}{.2258W_t} + \underset{(3.022)}{.9873T} + \underset{(5.251)}{.7798R_t}$$

$$(3a)\ S_{t+1} = \underset{(.7698)}{211.5} + \underset{(3.240)}{1.033I^*_{t+1}} + \underset{(1.085)}{.1522S_t} + \underset{(1.510)}{14.99\ (F_{t-2} \times L_{t-2})} - \underset{(-1.584)}{15.28R_t}$$

Reduced form equation for H_t:

$$H_t = 12.44 - .01108Q_t - .00499B_t - .00834P_t + .08756I_t + .0145I^*_{t+1}$$
$$- .00939S_t + .1661(F_{t-2} \times L_{t-2}) - .2258W_t + .9873T$$

Fourth quarter:

First-round equation for R_t:

$$\underset{(11.27)}{R_t = 29.91} + \underset{(7.308)}{.05309I_t} - \underset{(-7.942)}{.01788S_t} - \underset{(-1.029)}{.2255(F_t \times L^*_t)} - \underset{(-1.254)}{.06352W_t}$$

3-SLS structural equations:

$$(1)\quad C_t = \underset{(16.58)}{3191.0} - \underset{(-.1392)}{.0173B_t} - \underset{(-.1720)}{.03416P_t} + \underset{(8.502)}{4.522I_t} - \underset{(-10.17)}{70.64R_t}$$

$$(2)\quad H_t = \underset{(-1.405)}{-7.658} - \underset{(-7.064)}{.010037Q_t} + \underset{(3.134)}{.6796T} + \underset{(3.505)}{.5239R_t}$$

$$(3a)\quad S_{t+1} = \underset{(1.108)}{3725.0} + \underset{(0.5382)}{5.638\Delta I_t} + \underset{(1.182)}{5.594I^*_{t+1}} - \underset{(.7952)}{1.582S_t} + \underset{(.7911)}{16.62(F_{t-2} \times L_{t-2})}$$

$$- \underset{(-.5329)}{26.46\,(F_{t-1} \times L_{t-1})} - \underset{(1.313)}{148.2R_t}$$

Reduced form equation for H_t:

$$H_t = 8.8712 - .01276Q_t - .00003B_t - .00008P_t + .01081I_t + .01347\Delta I_t$$
$$+ .01337I^*_{t+1} - .00617S_t + .03972(F_{t-2} \times L_{t-2}) - .06324(F_{t-1} \times L_{t-1})$$
$$+ .6796T$$

The variables with prime (') signs in the equations for the first quarter were expressed in per capita terms. The quantity and income variables for all other quarters were used in terms of total data. The number within parentheses immediately below a coefficient is the ratio of the coefficient to its standard error.

Evaluation of Models

The signs of the coefficients of major variables in the structural equations were found to be consistent with logical expectations. As stated earlier, some relatively minor variables yielding incorrect signs in initial estimates were excluded from the final equations. The results of the consumption-price relation, Eq. (1), for the first quarter, indicates that consumption of poultry, P_t, as a substitute product was excluded from the equation. However, for all other quarters, both beef and poultry consumption entered the consumption-price relation with the expected negative signs. The ratios of coefficients to respective standard errors for retail price of pork and income were relatively high. With regard to Eq. (2), coefficients of most of the variables in the quarterly equation had relatively small standard errors. Two variables, W_t or Q_t, were excluded from the equations for the last two quarters. The estimated equations for storage stocks, Eq. (3a), indicate as expected that the current retail pork price influences end-of-period storage stocks (S_{t+1}) in the negative direction, while income (I^*_{t+1}) or the change in income (ΔI_t) affects S_{t+1} directly. Other variables, such as ($F_{t-2} \times L_{t-2}$) and S_t, were allowed to enter the equations regardless of signs since there were no firm a-priori knowledge or expectations regarding the direction of effects. The estimated coefficients of Eq. (3a) were in most cases small relative to respective standard errors.

Values of the four endogenous variables of the model for each quarter were estimated from the reduced form equations which were algebraically derived from the three 3-SLS structural equations and the identity, Eq. (4). The estimated values of the endogenous variables along with the actual values are included in Appendix, Table A, by quarters for the period fit, 1957-1971. The inequality (U_2) coefficients computed from the actual and calculated values of the four variables for the period are presented in Table 1. The coefficients were based on quarter-to-quarter changes in the variables. The U_2 coefficients

Table 1. Inequality (U_2) Coefficients for Endogenous Variables of the Quarterly Live Hog Price Models, 1957-1971

Quarter	Endogenous Variables			
	Price of live hogs (H_t)	Retail price of Pork (R_t)	Consumption of Pork (C_t)	End-of-quarter stocks (S_{t+1})
1st [a/]	0.2242	0.8337	0.2475	0.3173
2nd	0.4400	0.8479	0.3237	0.3920
3rd	0.2487	0.8419	0.1588	0.2253
4th	0.3914	0.2026	0.2476	0.2797

[a/] Consumption and storage stocks, C_t and S_{t+1}, were in per capita terms for the first quarter model.

for all endogenous variables were less than 1.0 for the selected models. The estimates of live hog prices generally involved smaller errors than those for R_t for the first three quarters. The errors for retail pork prices in the fourth quarter were considerably smaller than the errors for the other quarters. The models produced more accurate estimates of live hog prices for the first and third quarters than those for the other two quarters. The estimates of pork consumption, C_t, and end-of-quarter storage stocks appeared to be reasonably accurate. The largest U_2-coefficient for these two quantity variables was less than 0.4.

Price predictions were generated from the structural models for three years (1972-73-74) beyond the period of fit to further evaluate the models' performance during a period of unusual market situations. Predictions and actual levels of live hog prices for the period are presented in Table 2. Predicted prices for four out of twelve quarters involved errors of 5 cents or more. In some cases, however, although the error magnitude was large,

Table 2. Predicted and Actual Quarterly Live Hog Prices, Cents/Pound, for Years Beyond the Period of Fit, 1972-1974

Quarter	1972		1973		1974	
	$\hat{H}_t$	H_t	$\hat{H}_t$	H_t	$\hat{H}_t$	H_t
1st	24.31	25.64	34.48	35.96	34.09	39.62
2nd	27.98	22.74	35.57	37.68	31.56	30.12
3rd	32.36	29.42	48.70	48.93	41.77	37.71
4th	29.38	29.82	34.36	42.97	34.49	39.87

the direction of change was predicted correctly. The three years under consideration represented a period of unusual market conditions as reflected by record high feed prices, the imposition and subsequent withdrawal of the price freeze policy, and drastic changes in meat prices. Despite the abnormal market situation, the quarterly models seemed to be sensitive enough to capture the price variations for most quarters during this period.

MONTHLY MODELS FOR LIVE HOG PRICES

Models for monthly live hog prices were essentially identical to the preceding quarterly models in terms of structural relations. It may be recalled that the quarterly models included four structural relations: (1) the consumption-retail pork price relation, (2) an equation relating live hog price and retail pork price, (3) the end-of-period storage stocks relation and (4) the market clearing identity.

The notations for variables used in the monthly models are the same as those in the quarterly models. All price and quantity variables were converted to monthly average or volume, with the exception of two variables. The values of income and the pig crop variable ($F_t \times L_t$) for a given quarter were assigned to each of the three months within that quarter. Incorporating the mentioned adjustments in the variables, the structural stochastic relations in the live hog price model were estimated separately for each of the twelve calendar months. The three-stage least squares procedure was utilized to estimate the coefficients of the three stochastic relations using data for the period 1957-1971. The choice of variables in the final estimates of the monthly equations depended, as in the quarterly analysis, on the consistency of the derived signs of the coefficients in terms of a priori knowledge or logical expectations regarding the postulated relations. Since, for some relatively minor variables, no firm prior knowledge or expectations existed, these variables were allowed to enter the equations regardless of the signs. The first-round equation, used to develop the three-stage least squares structural relations, contained retail pork price, R_t, as the dependent variable and selected exogenous variables from the four-equation structural system. Several alternative estimates for the set of equations were obtained for each month under different specifications.

The final results of the estimates, as presented here, were selected on the basis of lowest inequality (U_2) coefficients for the calculated live hog prices, H_t. The results of the structural models for some of the months are excluded from this report since the estimated or calculated live hog prices from the models for these months involved large errors which subsequently resulted in U_2-coefficients substantially greater than unity. Price estimates from the structural models for May, June, August, October and November, however, appeared to be reasonable for the period 1957-1971. The first-round equation, and the 3-SLS estimates of the three stochastic relations for each of the five months are presented in this section, along with the reduced form equations for live hog prices, H_t.

Statistical Results and Evaluation of Monthly Structural Models for May, June, August October and November

The ordinary least squares estimates of the first-round equation for R_t for each of the five months were as follows:

First-round equations by months for R_t:

May

$$R_t = \underset{(3.315)}{56.62} - \underset{(-2.228)}{1.759B'_t} + \underset{(3.766)}{11.64I'} - \underset{(-3.297)}{3.679S'_t} - \underset{(-2.177)}{43.14}\,(F_{t-2} \times L_{t-2})'$$

$$- \underset{(-.3797)}{.02986W_t} - \underset{(-.5993)}{.2207T} \qquad [R^2 = 0.9389]$$

June

$$R_t = \underset{(8.786)}{49.32} - \underset{(-3.148)}{1.674B'_t} + \underset{(8.828)}{9.673I'_t} - \underset{(-3.926)}{2.444S'_t} - 73.52\,(F_{t-2} \times L_{t-2})' \qquad [R^2 = 0.9487]$$

August

$$R_t = 106.4 + .07537I_t + .07021\Delta I_t - 0.2694S_t - 1.666\,(F_{t-2} \times L_{t-2})$$
$$\quad (6.605) \quad (5.935) \quad (.9475) \quad (-5.868) \quad (-1.473)$$

$$-.2162\,(F_{t-1} \times L_{t-1}) - .02723W_t - 1.407T$$
$$(.4452) \quad (.3617) \quad (-5.040) \qquad [R^2 = 0.9696]$$

October

$$R_t = 32.86 - .001801B_t - .002011P_t + .05894I_t - .05078S_t - .0927W_t$$
$$\quad (7.462) \quad (-.6556) \quad (-.2227) \quad (6.722) \quad (-6.453) \quad (-2.3300)$$

$$- .04437T$$
$$(-.3890) \qquad [R^2 = 0.9578)$$

November

$$R_t = 53.96 - .008193B_t + .06171I_t + .1267\Delta I_t - .03184S_t - 1.113\,(F_{t-2} \times L_{t-2})$$
$$\quad (1.786) \quad (-1.568) \quad (7.490) \quad (1.486) \quad (-3.693) \quad (-2.098)$$

$$- .05881W_t - .2352T$$
$$(-1.026) \quad (-.3737) \qquad [R^2 = 0.9718]$$

The variables with prime (') signs were used in per capita terms. The numbers in parentheses are the ratios of the coefficients to respective standard errors. The calculated values for retail price of pork, R_t, obtained from the preceding first-round equations were subsequently used to develop the three-stage least squares estimates of the three stochastic structural relations. The results of the three-stage least squares equations are presented in Tables 3, 4, and 5.

The results of the three-stage least squares equations for the consumption-price relation, Table 3, indicate that both retail pork price (R_t) and income (I_t) entered the equation with signs consistent with economic expectations. The coefficients for both variables were high relative to the standard errors. It may be observed that inconsistent signs were obtained for income when the variable was used in total term for May and June.

Table 3. Three-Stage Least Squares Estimates of Consumption-Price Equations, Eq. (1) by Months; Dependent Variable: C_t, Consumption of Pork, Million Pounds [a]

Months	Retail Pork Price Cents Per Pound (R_t)	Disposable Income, Billion Dollars (I_t)	Per Capita Disposable Income Dollars (I'_t)	Constant Term
May	-.1087 (-3.678)[b]	-	1.017 (4.866)	5.904 (10.28)
June	-.09190 (-3.019)	-	1.026 (4.838)	5.288 (8.976)
August	-22.56 (-5.185)	1.268 (10.17)	-	1081.0 (10.46)
October	-24.01 (-2.906)	1.231 (5.459)	-	1249.9 (6.999)
November	-34.95 (-7.286)	1.572 (11.91)	-	1374.0 (13.72)

[a] Consumption of pork was expressed in pounds per capita for May and June.

[b] The numbers in parentheses below the coefficient is the ratio of the coefficient to its standard error.

Table 4. Three-Stage Least Squares Estimates of Equations Relating Live Hog Price with Retail Price of Pork: Eq. (2), Dependent Variable: H_t, Live Hog Price, Cents Per Pound

Months	Retail Pork Price Per Pound (R_t)	Wage, Dollars (W_t)	Production of Pork, Million Pounds (Q_t)	Time, (T)	Constant Term
May	1.026 (3.333)	-.1173 (-1.675)	-.6765[a] (-.3092)	-	7.087 (.6418)
June	1.125 (10.07)	-.1427 (-4.272)	-	.2463 (1.351)	12.30 (1.722)
August	.9887 (9.062)	-1.984 (-4.354)	-.007955 (-1.373)	.9272 (4.585)	-39.02 (-4.695)
October	.6338 (2.768)	-	-.02977 (-4.327)	-.3278 (1.854)	10.52 (1.641)
November	.6633 (4.459)	-.09675 (-4.087)	-.02538 (-6.420)	.9314 (4.845)	-21.82 (-4.032)

[a] The variable was expressed in per capita term.

Table 5. Three-Stage Least Squares Estimates of Storage Stocks Equations, Eq. (3a), by Months; Dependent Variable: S_{t+1}, Storage Stocks of Pork Products, End of Period, Million Pounds [a]

Months	Retail Pork Price Cents Per Pound (R_t)	Storage Stocks First of Month Million Pounds (S_t)	Expected Disposable Income Billion Dollars, (I^*_{t+1})	Change in Income, Billion Dollars (ΔI_t)	Sows Farrowed, Million, Times Litter Size ($F_{t-1} \times L_{t-1}$)	Sows Farrowed, Million, Times Litter Size ($F_{t-2} \times L_{t-2}$)	Constant Term
May	-.01158 (-.7118)	.9587[a] (6.384)	-	5.447[b] (2.218)	-	-1.519[b] (-.08613)	.2335 (.2502)
June	-	.9696[a] (20.49)	-	-	-	8.072[b] (.9646)	-.4334 (-2.036)
August	-	.7128 (20.41)	.2496 (.9497)	.6767 (1.173)	-4.912 (-1.400)	19.57 (2.656)	-31.27 (-1.102)
October	-1.324 (-.3053)	.8374 (3.638)	.1117 (.7093)	1.180 (.8258)	-	7.473 (1.041)	-44.17 (-.3129)
November	-4.161 (-.8329)	.8227 (3.391)	.1257 (.6828)	1.325 (.9963)	-	10.97 (1.491)	13.14 (.08104)

[a] The storage stock variables, S_{t+1} and S_t, were expressed in pounds per capita for May and June

[b] The variables were expressed in per capita terms.

However, when income was expressed in per capita terms, the coefficients became positive and were associated with low standard errors. The other two variables, B_t and P_t, were omitted from all five monthly equations because of the resulting inappropriate signs of the two coefficients. With regard to the three-stage least squares estimates of Eq. (2), Table 4, the coefficients of W_t and/or Q_t in the monthly equations were negative and, in most cases, had small standard errors. The ratio of the coefficient of R_t to its standard error for all five months, as expected, was high. The estimated storage stocks relations, Table 5, in contrast with the results of the first two stochastic relations, indicate that most of the coefficients, excepting those for S_t, were small relative to respective standard errors. Some variables, such as $I^{*\prime}_{t+1}$ or ΔI_t and $(F_{t-1} \times L_{t-1})$, were excluded from some of the monthly equations for S_{t+1} because of the inconsistency of signs.

The following reduced form equations for H_t by months were derived algebraically from the three estimated stochastic equations and the identity, $C_t = Q_t + S_t - S_{t+1}$, of the structural system for each month:

Reduced form equations for H_t:

<u>May</u>

$$H_t = 57.8207 - 9.1156Q'_t + 9.5621I'_t + 45.2674\Delta I'_t - .4868S'_t + 52.4869(F_{t-2} \times L_{t-2})' - .1414W_t$$

<u>June</u>

$$H_t = 47.1647 - 12.2492Q'_t + 12.5676I'_t - .4826S'_t + 98.8752\ (F_{t-2} \times L_{t-2})' - .1427W_t + .2463T$$

<u>August</u>

$$H_t = 6.9788 - .01233Q_t + .0559I_t + .02966\Delta I_t + .00109I^*_{t+1} - .01259S_t + .8577\ (F_{t-2} \times L_{t-2}) - .2153\ (F_t \times L^*_t) - .1984W_t + .9272T$$

October

$$H_t = 40.6601 - .05479Q_t + .03079I_t + .02952\Delta I_t + .00279I^*_{t+1} - .00407S_t$$
$$- .18695\ (F_{t-2} \times L_{t-2}) + .3278T$$

November

$$H_t = 1.7067 - .04234Q_t + .02666I_t + .02247\Delta I_t + .00213I^*_{t+1} - .00301S_t$$
$$+ .1861\ (F_{t-2} \times L_{t-2}) \quad -.09675W_t + .9314T$$

The values of the endogenous variables were calculated from the reduced form equations for each of the five months. The calculated values, along with the actual values of the four endogenous variables, are included in Appendix, Table B. The inequality (U_2) coefficients, based on month-to-month changes, for the four endogenous variables are presented in Table 6.

Table 6. Inequality (U_2) Coefficients for Endogenous Variables of the Monthly Live Hog Price Models, 1957-1971

Months	Price of live hogs (H_t)	Retail Price of Pork (R_t)	Consumption of pork (C_t)	End-of-Period stocks (S_{t+1})
May[a/]	0.8651	5.0822	0.2522	0.7071
June [a/]	0.8094	2.4301	0.2545	0.2282
August	0.0265	3.4938	0.0968	0.1134
October	0.0191	3.1921	0.0826	0.0814
November	0.0053	0.9807	0.0743	0.0708

a/ Consumption and storage stocks, C_t and S_{t+1}, were in per capita terms for May and June.

While the U_2-coefficients for live hog price (H_t) were smaller than unity for all five months, the corresponding coefficients for retail pork price (R_t) for all months except November were substantially larger than unity indicating large errors in estimating R_t. The estimates of H_t were more accurate for August, October and November relative to those for May and June. The estimates of the quantity variables, C_t and S_{t+1}, appeared to be of reasonable accuracy since the U_2-coefficients by months for both variables, with the exception of the coefficient for S_{t+1} for May, were lower than .25. The models yielded more accurate estimates for C_t and S_{t+1} for the months of August, October and November than those for the same variables for May and June.

Price predictions were developed from the reduced form equations of the structural models to examine the performance of the models beyond the period of fit, 1972-1974. The predicted and actual monthly live hog prices are presented in Table 7.

Table 7. Predicted and Actual Monthly Live Hog Prices, Cent/Pound, for Years Beyond the Period of Fit, 1972-74, 5 Months [a/]

Months	1972 $\hat{H}_t$	1972 H_t	1973 $\hat{H}_t$	1973 H_t	1974 $\hat{H}_t$	1974 H_t
May	20.28	26.46	27.50	37.14	20.63	28.24
June	25.45	28.05	35.95	39.41	32.84	29.89
August	27.24	29.11	39.81	56.95	31.35	38.86
October	24.81	28.66	31.46	42.52	30.15	39.42
November	24.22	28.72	28.90	42.00	31.50	38.90

a/ Predicted prices were obtained from the reduced form equations of the structural systems for the specified five months.

The performance of the selected five monthly models in predicting live hog prices beyond the period of fit did not appear to be satisfactory. Actual prices in all months excepting June 1974 were higher than the predicted prices. This is perhaps indicative of the failure of the monthly models to respond to the unusual market situation of the period. Prediction errors were particularly large for most of 1973. As discussed earlier, the quarterly models, however, performed reasonably well during the same period. Furthermore, the same monthly models did produce live hog price estimates for the period of fit with reasonable accuracy for August, October, and November.

Results and Evaluation of Ordinary Least Squares Price (H_t) Equations for January, February, March, April, July, September and December

As mentioned earlier, the structural models for the remaining seven months yielded price estimates with substantially large errors for the sample period. Subsequently, attempts were made to develop alternative live hog price equations for these months. In essence, the exogenous variables in the first-round equation for R_t were used as the independent variables in the equation for live hog price (H_t). The equations may be presented in the following general form:

$$H_t = f[(F_{t-1} \times L_{t-1}) \text{ or } (F_{t-2} \times L_{t-2}),\ I_t \text{ and/or } \Delta I_t,\ S_t,\ B_t,\ P_t,\ W_t,\ T, H_{t-1}]$$

The notations in the price equation are the same as those defined earlier (see pp.10-12, 25). The ordinary least squares estimates of the selected monthly equations are presented here. The numbers in parentheses below the coefficients are the t-statistics.

<u>January</u>

$$H_t = 64.9206 + \underset{(2.9107)}{.0434I_t} + \underset{(.8568)}{.1640\Delta I_t} - \underset{(-4.9127)}{.0523S_t} - \underset{(-4.6482)}{1.6343} (F_{t-1} \times L_{t-1}) - \underset{(-.7928)}{.3316T}$$

$$[R^2 = .9274]$$

<u>February</u>

$$H_t = 49.7542 - \underset{(-.7426)}{.0018B_t} + \underset{(5.2480)}{.0324I_t} + \underset{(.2921)}{.0289\Delta I_t} - \underset{(-8.7228)}{.04091S_t} - \underset{(-9.6251)}{1.6998}(F_{t-1} \times L_{t-1})$$

$$[R^2 = .9821]$$

<u>March</u>

$$H_t = 47.5854 - \underset{(-2.2519)}{.0059B_t} + \underset{(2.9579)}{.03721I_t} - \underset{(-4.1202)}{.02126S_t} - \underset{(-6.4260)}{1.7623}(F_{t-1} \times L_{t-1}) - \underset{(-.4967)}{.0374W_t}$$

$$[R2 = .9615]$$

April

$$H_t = 42.03088 + .02392I_t - .02005S_t - 3.6914\,(F_{t-2} \times L_{t-2})$$
$$\qquad (9.7683) \quad (-4.3793) \quad (-6.9157)$$
$$[R^2 = .9458]$$

July

$$H_t = 15.9703 + .02384I_t + .73003H_{t-1} - 2.5659(F_{t-2} \times L_{t-2})$$
$$\qquad (3.2416) \quad (7.8282) \quad (-3.7155)$$
$$[R^2 = .9400]$$

September

$$H_t = 54.0523 + .03839I_t' - .05257S_t' - .7067(F_{t-1} \times L_{t-1})' - 5.5221P_t'$$
$$\qquad (-4.8780) \quad (-7.1427) \quad (-4.3955) \quad (-2.8494)$$
$$[R^2 = .9197]$$

December

$$H_t = 14.7181 - .01172S_t + .02933I_t + .85097H_{t-1} - 1.8254(F_{t-1} \times L_{t-1})$$
$$\qquad (-1.6784) \quad (3.1086) \quad (8.8556) \quad (-4.7109)$$
$$[R^2 = .9899]$$

The values of R^2 for the equations ranged between .92 to .99. The pig crop variable, $F_{t-1} \times L_{t-1}$, or $F_{t-2} \times L_{t-2}$, appeared in each equation with the expected negative coefficient which was highly significant. In all monthly equations with the exception of that for July, the beginning storage stocks of pork (S_t) affected live hog prices inversely. The coefficient for S_t in these equations was also highly significant. When storage stocks at the beginning of the period are large, the available market supply for the month would tend to be large, ceteris paribus. This would eventually lead to a decline in the prices of pork and live hogs during the period. The income variables, I_t and/or ΔI_t, indicated the expected direct effect on hog prices. Consumption of substitute meat (B_t or P_t) was included in the equations for February, March, and September when it appeared with a negative coefficient. These two variables were eliminated from the other monthly price equations because of inconsistent signs of the associated coefficients.

The ordinary least squares equations for live hog prices were used to generate price estimates for the months within the period of fit. The estimated prices along with the actual prices are included in Appendix, Table C. The error magnitude of these monthly price estimates did not exceed 2 cents per pound for any of the 56 monthly observations. Furthermore, 46 monthly price estimates during the period were within 1 cent of corresponding actual prices. Thus, the ordinary least squares equations appeared to have performed with a high degree of accuracy in terms of live hog price estimates inside the period of fit.

With reference to monthly price predictions beyond the period of fit, a comparison of predicted and observed monthly prices for 1972, 1973 and 1974 is presented in Table 8. Price predictions beyond the period of fit

Table 8. Predicted and Actual Monthly Live Hog Prices, Cents/Pound, for Years Beyond the Period of Fit, 1972-1974, 7 Months [a/]

Months	1972 $\hat{H}_t$	1972 H_t	1973 $\hat{H}_t$	1973 H_t	1974 $\hat{H}_t$	1974 H_t
January	23.4	25.8	30.2	33.8	26.4	42.1
February	30.1	26.7	35.1	37.5	33.0	41.0
March	35.1	24.4	39.0	38.6	39.3	35.7
April	22.4	23.7	28.1	36.5	28.9	32.3
July	28.7	29.6	38.6	45.6	32.5	38.1
September	31.1	29.5	32.3	44.2	32.3	36.2
December	32.8	32.1	27.9	44.4	41.9	41.3

a/ Predicted prices were obtained from the ordinary least squares equation for H_t for each of the specified 7 months.

involved substantially larger errors than those obtained for the sample period. For instance, 8 out of a total of 21 predictions involved errors in the range of 4 to 16.5 cents. Relatively large errors occurred when there was a substantial rise in actual prices. The prediction equations seemed to have failed to respond to these changes, generally resulting in errors of underestimation. Of the 13 predictions with errors less than 4 cents, 6 predictions indicated an error magnitude of less than 2 cents.

SUMMARY AND CONCLUSIONS

The U.S. hog-pork sector in recent decades has been characterized by pronounced short-run variations in prices of pork and live hogs. The objective of the study was to develop econometric models to explain the underlying causes of variations in live hog prices and to predict such prices by quarters and months.

A simultaneous equation model of four structural relations was developed to identify the price determination process within the hog-pork sector. The first structural relation represented consumption of pork as a function of retail pork price, consumers' disposable income, and consumption of substitute meat products such as beef and poultry. The second equation included the price of live hogs as a function of retail pork prices, wage rates in meat packing plants, and pork production reflecting the demand for marketing services. The end-of-period storage stock of pork products in the third relation was expressed as a function of expected levels of both production and consumption of pork one and two periods ahead. While expected production was assumed to depend on lagged pig crops, expected consumption was postulated to be influenced by expectations of future prices and income. The final equation of the model was an identity which equated pork consumption with pork production and the net storage movement of pork during the period.

The stochastic relations of the model were estimated on the basis of quarterly and monthly data for the period 1957 through 1971. The three-stage least squares procedure was applied to obtain estimates of the structural equations. Alternative models were evaluated with regard to predictions by means of Theil's inequality (U_2) coefficient. The structural models for seven of the calendar months produced unacceptable results, especially in terms of accuracy of estimates of live hog prices. Hence, ordinary least squares price prediction equations were developed for these months.

The results of selected structural models for 4 quarters and 5 months (May, June, August, October and November) indicated fairly "stable" relations among most of the major variables. Several relatively minor variables, such as beef and poultry consumption, wage rates in meat packing plants etc., were excluded from the estimated equations for some quarters or months because of inconsistent signs of related coefficients. It may be observed as a methodological note that the predictive accuracy of the structural models appeared to improve when the first-round ordinary least squares equations included, instead of all exogenous variables in the model, only a subset of selected exogenous variables which yielded signs consistent with logical expectations.

The estimates of quarterly live hog prices obtained from the models for the period of fit (1957-1971) exhibited a high degree of accuracy. Only 3 estimated prices out of a total of 60 observations indicated an error of 2 cents or more. Furthermore, the error magnitude for 42 estimates was less than or equal to 1 cent. The errors of live hog price estimates were generally less than the errors in retail pork price estimates, and the estimated values of pork consumption and end-of-quarter storage stocks were also reasonable. Predictions of quarterly live hog prices for three years (1972, 1973 and 1974) outside the period of fit appeared to be reasonable, especially in view of the unusual market condition and price aberrations of this period.

The five selected monthly models, particularly those for August and November, yielded fairly accurate estimates for live hog prices for years inside the period of fit. The retail pork price estimates, however, involved substantial errors. Predictions of monthly prices for these five months for the three years following the period of fit were less than satisfactory with large errors for several of the 15 monthly observations.

The ordinary least squares (OLS) price prediction equations for the remaining seven months (January, February, March, April, July, September, and December) indicated superior fit with R^2-values ranging between .92 and .99. The major predictors in these equations included the pig crop variables, beginning storage stocks, and consumers' disposable income. None of the estimation errors for the 56 monthly observations exceeded 2 cents, and 46 of these price estimates remained within 1 cent of the corresponding actual values. However, as in the case of structural monthly models, the ordinary least squares price equations also failed to produce accurate predictions beyond the period of fit.

Although the monthly structural models and the OLS price equations performed adequately inside the period of fit, price predictions beyond the sample period obtained from the same models and equations produced substantial errors. The selected three years (1972, 1973, and 1974) beyond the period of fit belonged to a period of abnormal market conditions characterized by an unprecedented rise in feed prices, drastic changes in prices of meat products and interruptions in the free market forces through the price freeze. The monthly models and equations generally failed to respond to these events and the resulting effects on hog prices, since these models were based on data for years prior to this period. However, the selected quarterly models seemed to be responsive enough to capture the price fluctuations during this period, in spite of the prevailing unusual market conditions.

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APPENDIX

Table A. Observed and Estimated Values of Endogenous Variables by Quarters

Table B. Observed and Estimated Values of Endogenous Variables by Months, 5 Months

Table C. Observed and Estimated Values of Live Hog Prices in Cents/Pound by Months, 7 Months

Table A. Observed and Estimated Values of Endogenous Variables by Quarters

Quarter and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, pounds, (C'_t)		End-of-quarter storage stocks, pounds, (S'_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
First Quarter:[a]								
1957	17.8	17.9	27.2	27.9	14.2	13.7	4.3	4.8
1958	20.6	21.9	30.2	31.3	13.4	13.0	4.3	4.7
1959	16.8	15.2	28.4	26.2	14.2	14.9	6.3	5.6
1960	14.5	15.1	25.3	26.2	14.8	15.0	6.3	6.1
1961	18.4	18.6	29.0	29.6	14.4	14.0	4.4	4.7
1962	17.4	18.7	28.9	29.7	13.9	14.2	5.1	4.8
1963	15.7	15.1	28.1	26.7	14.8	15.0	5.8	5.6
1964	15.6	13.8	27.2	25.9	15.1	15.8	7.2	6.5
1965	17.8	18.5	28.6	30.0	15.8	14.9	5.1	6.0
1966	28.1	27.2	39.8	38.5	12.9	13.1	3.9	3.7
1967	20.5	20.2	33.4	33.1	15.2	15.3	5.4	5.3
1968	20.0	21.8	33.7	34.9	15.4	15.1	5.4	5.6
1969	21.5	20.6	34.8	34.7	16.4	15.8	4.5	5.1
1970	28.4	28.3	41.7	42.2	13.9	14.2	4.7	4.4
1971	18.4	18.8	35.4	35.0	17.2	17.4	6.1	5.9

Table A. (Continued)

Quarter and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, million pounds, (C_t)		End-of-quarter stocks, million pounds, (S'_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
Second Quarter:[b]								
1957	19.1	21.4	28.4	30.5	2320.0	2484.0	629.0	465.0
1958	22.6	21.0	31.6	30.1	2445.0	2535.0	532.0	443.0
1959	17.0	16.6	28.0	26.7	2871.0	2855.0	781.0	795.0
1960	17.2	15.4	27.2	26.0	2909.0	2969.0	866.0	806.0
1961	17.7	17.8	28.3	28.7	2816.0	2797.0	566.0	582.0
1962	17.2	17.1	28.2	27.7	2972.0	2967.0	711.0	717.0
1963	16.2	16.6	27.1	27.1	3093.0	3063.0	817.0	846.0
1964	16.3	16.0	27.2	27.1	3253.0	3187.0	963.0	1032.0
1965	21.6	23.2	30.7	33.8	3007.0	2853.0	534.0	690.0
1966	25.3	25.0	36.4	35.5	2864.0	2887.0	533.0	508.0
1967	22.0	22.9	33.5	34.4	3193.0	3092.0	730.0	833.0
1968	21.0	21.5	34.0	34.1	3399.0	3307.0	767.0	858.0
1969	24.5	23.7	36.5	46.8	3419.0	3267.0	610.0	761.0
1970	25.2	24.5	40.8	39.3	3304.0	3323.0	777.0	756.0
1971	18.3	18.5	35.3	35.4	3530.0	3808.0	1378.0	1102.0

Table A (Continued)

Quarter and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, million pounds, (C_t)		End-of-quarter stocks, million pounds, (S_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
<u>Third Quarter:</u>[b]								
1957	20.8	20.6	31.3	32.3	2337.0	2380.0	436.0	393.0
1958	21.8	20.5	39.0	32.6	2313.0	2343.0	446.0	415.0
1959	14.6	15.5	27.6	26.6	2641.0	2636.0	572.0	578.0
1960	17.7	15.6	23.7	27.3	2948.0	2855.0	455.0	551.0
1961	18.6	20.1	29.2	31.8	2511.0	2504.0	458.0	466.0
1962	19.2	21.3	30.3	32.4	2651.0	2664.0	512.0	499.0
1963	17.9	17.2	29.3	27.0	2807.0	2855.0	670.0	620.0
1964	17.9	18.5	29.0	28.0	2888.0	2914.0	681.0	652.0
1965	24.7	25.0	35.8	36.7	2616.0	2529.0	396.0	481.0
1966	25.5	24.7	37.6	36.0	2621.0	2618.0	528.0	528.0
1967	22.0	21.9	35.5	33.5	2891.0	2969.0	732.0	657.0
1968	21.7	21.9	35.1	35.4	3109.0	3079.0	656.0	687.0
1969	27.3	26.3	39.4	41.7	3000.0	2977.0	596.0	619.0
1970	23.2	24.1	40.3	41.7	3171.0	3204.0	760.0	728.0
1971	19.8	19.3	36.6	35.7	3857.0	3833.0	953.0	976.0

Table A (Continued)

Quarter and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, million pounds, (C_t)		End-of-quarter stocks, million pounds, (S_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
Fourth Quarter:[b]								
1957	18.1	18.3	28.3	28.6	2478.0	2490.0	640.0	621.0
1958	19.0	18.3	29.8	28.5	2422.0	2556.0	763.0	633.0
1959	13.1	12.5	25.9	25.6	2867.0	2831.0	918.0	962.0
1960	18.2	19.3	28.5	29.0	2647.0	2639.0	606.0	606.0
1961	17.4	18.5	28.6	29.7	2790.0	2684.0	645.0	748.0
1962	17.5	17.0	28.9	28.7	2895.0	2823.0	754.0	821.0
1963	15.7	15.1	27.7	27.3	2993.0	3021.0	992.0	970.0
1964	16.4	15.9	27.9	28.6	3046.0	3094.0	999.0	973.0
1965	26.4	27.8	36.6	37.1	2623.0	2668.0	491.0	438.0
1966	22.2	21.7	35.1	34.4	2976.0	3004.0	781.0	762.0
1967	19.2	19.9	33.3	32.9	3256.0	3263.0	867.0	857.0
1968	19.9	20.1	34.2	35.6	3440.0	3310.0	770.0	894.0
1969	27.7	25.6	40.0	39.2	3237.0	3234.0	659.0	667.0
1970	17.3	18.4	36.3	36.3	3640.0	3648.0	1025.0	1011.0
1971	20.8	20.4	36.9	37.0	3784.0	3836.0	986.0	938.0

[a] The quantity variables, C_t and S_{t+1}, are in per capita terms for the first quarter

[b] The quantity variables, C_t and S_{t+1}, are in total terms for the second, third and fourth quarters.

Table B. Observed and Estimated Values of Endogenous Variables by Months, 5 Months

Month and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, pounds, (C'_t)		End-of-quarter storage stocks, pounds, (S'_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
May:[a]								
1957	18.8	21.0	25.8	26.9	4.8	4.8	1.9	1.9
1958	23.0	24.1	31.8	29.9	4.4	4.4	1.4	1.3
1959	28.3	21.3	28.3	28.5	4.8	4.7	2.1	2.2
1960	17.0	16.7	27.5	25.3	5.1	5.2	2.2	2.1
1961	17.6	17.0	28.5	26.1	5.1	5.1	1.5	1.5
1962	16.6	15.9	28.5	25.1	5.2	5.3	1.9	1.7
1963	16.0	16.3	27.2	25.6	5.4	5.4	1.9	1.9
1964	16.2	21.8	27.5	31.1	4.9	4.9	2.5	2.5
1965	21.6	28.4	29.0	37.1	4.4	4.3	1.5	1.7
1966	25.4	25.6	36.8	34.9	4.6	4.7	1.4	1.3
1967	23.6	25.3	32.2	35.4	5.1	4.9	1.7	1.9
1968	20.7	18.7	33.8	31.1	5.5	5.6	2.0	1.9
1969	25.0	24.6	36.3	36.8	5.3	5.2	1.5	1.6
1970	25.2	26.3	40.8	40.2	5.0	5.0	1.8	1.7
1971	18.2	18.8	35.0	35.1	5.7	5.7	2.5	2.5

Table B. (Continued)

Month and Year	Price of live hogs, cents per pound, (Ht)		Retail price of pork, cents per pound, (R_t)		Consumption of pork pounds, (C'_t)		End-of-period storage stocks, pounds, (S'_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
June:[a]								
1957	20.2	24.5	27.1	32.4	4.2	4.2	1.6	1.6
1958	23.7	21.7	33.0	30.2	4.3	4.4	1.2	1.1
1959	17.0	15.0	28.5	24.9	5.0	4.9	1.8	1.8
1960	17.8	14.3	28.4	24.8	5.0	5.1	2.0	1.9
1961	17.8	15.4	28.5	26.2	4.9	4.9	1.3	1.3
1962	18.1	16.9	28.7	27.2	4.9	4.9	1.6	1.7
1963	18.2	21.9	28.0	31.6	4.6	4.6	1.7	1.7
1964	17.3	19.5	27.8	30.2	4.9	4.9	2.2	2.2
1965	24.6	26.1	31.9	35.8	4.6	4.5	1.2	1.2
1966	26.4	25.9	36.0	35.7	4.7	4.7	1.1	1.1
1967	23.5	24.3	34.4	35.0	5.0	4.9	1.5	1.5
1968	22.1	26.9	33.8	38.2	4.9	4.9	1.7	1.7
1969	26.8	25.4	38.1	37.0	5.1	5.1	1.2	1.3
1970	25.5	25.6	40.8	39.3	5.1	5.2	1.5	1.4
1971	19.6	14.4	35.7	30.7	6.0	6.2	2.3	2.3

Table B (Continued)

Month and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, million pounds, (C_t)		End-of-period stocks, million pounds, (S_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
August:								
1957	21.4	21.4	32.5	32.1	751.0	752.0	147.0	137.0
1958	21.4	21.4	33.1	32.6	742.0	754.0	149.0	129.0
1959	14.9	17.2	27.6	29.4	856.0	847.0	184.0	187.0
1960	17.7	13.8	29.3	26.7	923.0	925.0	221.0	211.0
1961	18.7	17.4	29.6	29.2	894.0	885.0	137.0	137.0
1962	19.1	17.7	30.6	29.0	919.0	917.0	182.0	171.0
1963	18.0	18.9	29.7	29.9	910.0	922.0	220.0	200.0
1964	17.9	22.2	28.7	33.2	906.0	893.0	229.0	233.0
1965	25.4	27.6	35.2	37.8	847.0	838.0	135.0	137.0
1966	26.4	25.7	36.9	36.3	918.0	916.0	140.0	134.0
1967	21.8	19.7	35.3	32.0	1049.0	1057.0	199.0	183.0
1968	21.2	21.4	34.7	35.1	1045.0	1044.0	196.0	190.0
1969	27.8	27.3	39.7	41.0	971.0	969.0	168.0	161.0
1970	22.8	24.6	40.7	40.7	1045.0	1046.0	218.0	209.0
1971	19.6	18.2	36.7	35.7	1223.0	1225.0	332.0	322.0

Table B. (Continued)

Month and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, million pounds, (C_t)		End-of-period stocks, million pounds, (S_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
October:								
1957	17.5	16.7	29.3	29.3	931.0	929.0	138.0	140.0
1958	19.3	21.1	30.8	30.4	925.0	921.0	134.0	137.0
1959	13.3	14.8	27.1	26.1	1038.0	1043.0	185.0	180.0
1960	28.0	24.7	28.9	32.8	899.0	892.0	144.0	150.0
1961	17.6	20.3	29.8	30.6	985.0	976.0	136.0	146.0
1962	17.6	15.6	30.2	27.2	1070.0	1077.0	161.0	155.0
1963	16.1	15.6	28.8	27.6	1111.0	1096.0	209.0	223.0
1964	16.5	15.4	29.0	28.2	1102.0	1125.0	222.0	199.0
1965	24.4	29.4	34.9	39.4	918.0	908.0	128.0	138.0
1966	22.7	24.9	36.4	36.9	1009.0	1010.0	171.0	170.0
1967	19.3	19.4	34.3	33.5	1106.0	1134.0	251.0	223.0
1968	19.7	16.2	34.8	32.5	1224.0	1214.0	222.0	232.0
1969	26.8	21.4	40.0	37.3	1160.0	1159.0	202.0	203.0
1970	18.5	18.3	38.0	36.1	1242.0	1246.0	246.0	242.0
1971	20.2	23.4	36.6	40.7	1210.0	1201.0	312.0	323.0

Table B (Continued)

Month and Year	Price of live hogs, cents per pound, (H_t)		Retail price of pork, cents per pound, (R_t)		Consumption of pork, million pounds, (C_t)		End-of-period stocks, million pounds, (S_{t+1})	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
November:								
1957	17.5	19.0	28.2	29.5	839.0	833.0	164.0	172.0
1958	18.9	19.9	30.0	30.4	808.0	825.0	184.0	167.0
1959	13.3	12.9	26.2	26.7	989.0	979.0	224.0	235.0
1960	18.2	17.4	28.7	28.5	946.0	930.0	154.0	168.0
1961	16.8	16.1	28.8	28.1	977.0	981.0	193.0	188.0
1962	17.5	16.0	29.5	27.9	1001.0	1013.0	212.0	202.0
1963	15.5	15.9	28.1	28.4	1034.0	1032.0	250.0	252.0
1964	15.8	16.0	28.3	28.9	1053.0	1071.0	275.0	257.0
1965	25.6	25.8	34.7	35.3	921.0	913.0	142.0	150.0
1966	21.8	20.3	34.9	32.7	1059.0	1057.0	206.0	207.0
1967	19.1	19.5	33.4	32.7	1113.0	1111.0	279.0	281.0
1968	19.5	20.6	34.0	34.9	1128.0	1106.0	237.0	257.0
1969	27.4	27.6	39.7	40.4	984.0	991.0	221.0	215.0
1970	16.6	17.7	36.1	36.1	1187.0	1215.0	304.0	284.0
1971	20.2	19.1	36.6	36.9	1281.0	1271.0	327.0	337.0

[a] The quantity variables, C_t and S_{t+1} are in per capita terms for the months of May and June. The two variables are in total terms for August, October and November.

Table C. Observed and Estimated Values of Live Hog Prices in Cents/Pound by Months, 7 Months

Months	Observed or Estimated	Years							
		1964	1965	1966	1967	1968	1969	1970	1971
January	Observed	15.8	17.4	29.6	21.2	19.6	21.1	28.9	17.3
	Estimated	15.4	18.5	29.1	20.9	19.5	20.6	28.3	18.4
February	Observed	15.7	17.9	29.1	20.8	20.6	21.6	29.2	20.1
	Estimated	15.1	19.1	29.1	20.8	21.2	21.4	28.7	20.0
March	Observed	15.4	18.0	25.7	19.6	20.0	21.9	27.0	17.7
	Estimated	14.6	19.5	25.9	19.1	19.9	21.2	26.1	18.9
April	Observed	15.3	18.7	24.1	18.8	20.1	21.8	25.0	17.1
	Estimated	15.1	19.9	24.7	19.2	19.7	21.0	24.3	17.6
July	Observed	18.3	25.1	26.0	23.9	22.8	27.3	26.1	20.7
	Estimated	19.0	24.5	27.3	25.0	23.0	26.5	26.0	20.3
September	Observed	17.6	23.6	24.1	20.3	21.1	26.7	20.8	19.2
	Estimated	17.5	24.9	22.7	20.7	20.8	26.3	21.9	18.5
December	Observed	16.9	29.2	22.1	19.1	20.4	28.8	16.9	21.9
	Estimated	16.8	28.5	22.9	19.9	20.4	28.9	16.8	21.4