A SIMULTANEOUS EQUATION ANALYSIS OF SELECTED TERMINAL HOG MARKETS

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by

Robert E. Zellner, Jr.

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The undersigned, appointed by the Dean of the Graduate Faculty, have examined a thesis entitled

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presented by Robert E. Zellner, Jr.

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and hereby certify that in their opinion it is worthy of acceptance.

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

For many years, terminal hog markets have served as price reflecting points for the rest of the hog economy, reflecting market conditions for hogs. During the last decade, however, the percentage of packers' purchases made from terminal markets has declined from about thirty percent to approximately eighteen percent, while direct buying and purchases through auction markets have increased. As the volume of hogs traded in terminal markets declines, the protection of consumers' welfare, as well as that of farmers and packers, becomes increasingly important since equilibrium prices and quantities for such markets may not be competitively determined. Fresh egg markets of a few years ago offer an example of how markets can lose their role as price reflecting points when their volume of trade falls to a small percentage of total trade.

In looking to the future, Breimyer (1970) emphasized the important role of terminal markets in noting that

> In all the economy if not all society, certain persons and institutions and practices become virtually a proxy for a larger body... In livestock marketing, there must be a central value determining mechanism if we are to have an exchange system. Total decentralization is bedlam and unworkable. Even as central markets fade out of the limelight, I find it necessary to defend their

> significant role. They have served as the price making mechanism, or a big part of it, for a much larger volume of trading than actually takes place on the markets themselves.

In spite of their importance, terminal hog markets have received little attention separate from the rest of the hog economy.

Although the relative volume handled by terminal markets has been declining, their role in the pricing of hogs may even be increasing. For example, production of slaughter hogs has become and is becoming more coordinated and integrated vertically. A current form of closer coordination in the production and marketing of hogs are contractual agreements between producers of hogs and various corporations. These contracts differ depending upon whom the contracting corporation is, but the general purpose of the contracts is to stabilize hog supplies so that the buyers and sellers may operate under less uncertainty, whether the buyer be a feed manufacturer or a packer. Diverse as these contracts may be, they usually involve at some stage of production the purchase or sale of hogs whose price is determined by the current slaughter hog price at a specified terminal market. As the incidence of such agreements increases, the importance of terminal markets as price reflecting points may be expected to increase. Should the importance of terminal hog markets in the value determining mechanism increase, should these markets become proxies for many buyers and sellers, understanding the structure of

these markets may become crucial to the protection of consumers' welfare. This study sought to help provide such an understanding.

The purpose of this paper was to describe the structure of demand and supply for slaughter hogs, on a monthly basis, at eight terminal markets. Structure was used in an econometric sense, i.e., a model with each equation representing an autonomous sector of an economic problem, such as demand and supply, with parameters having specific values. The markets studied were Chicago, Indianapolis, Kansas City, Omaha, St. Louis, Sioux City, South St. Joseph, and South St. Paul. An effort was made to specify demand and supply relationships in accordance with those established in the agricultural economics literature, so that the usefulness of these relationships in understanding the monthly behavior of terminal markets might be determined empirically.

This literature is surveyed in the following chapter. In accordance with this literature, a model of the demand for and supply of slaughter hogs is presented in Chapter III. For each of the eight markets, demand and supply equations were estimated by applying three-stage least squares to the principal components of the predetermined variables. The theory behind this estimation procedure is presented in Chapter IV. Then in Chapter V, the results of the analysis are presented, followed by conclusions in Chapter VI.

CHAPTER II

REVIEW OF LITERATURE

The literature cited in this chapter was included not only because of its representative nature, but also because of its role in determining the form of the model specified in Chapter III. Though little has been done regarding demand and supply at terminal markets for slaughter hogs, supply and demand for hogs in general have been well researched.

As early as 1942, Schultz and Brownlee stated what has been a dominant theme in the literature, that producers are more influenced by past hog prices than by current prices. The persistence of this phenomenon combined with the biological nature of hog production and quite inelastic short run supply, supposedly led to the cyclical pattern in the production of hogs. Breimyer (1959) noted the emergence of this cyclical behavior, pointing out the role varying corn prices played in causing cyclical hog supplies by affecting producers' profit expectations. Both theories, the role of lagged hog prices and of lagged corn prices in affecting hog supplies, were used by Dean and Heady (1958) in hypothesizing the hog cycle to be an example of Ezekiel's (1938) cobweb theorem. Harlow (1962) emphasized the importance of the price and supply of corn in affecting the hog

cycle by stating that producers' breeding decisions were influenced primarily by corn price and supply.

Using the hypothesis that producers' expectations of profit were affected by lagged prices, Nerlove (1958) provided a method for empirically evaluating this hypothesis. The development by Nerlove of a supply response theory, and the distributed lag model associated with it, firmly established in the agricultural economics methodology the principle that producers' expectations are influenced by past prices.

Though these studies were concerned with quarterly and annual behavior of the hog economy, Leuthold (1969) demonstrated the effect of lagged hog prices on both buyers and sellers in daily transactions. Using monthly data for the entire United States, Myers (1969) concluded that producers' expectations were most affected by lagged hog prices. The literature supports the theory that lagged hog and corn prices are crucial in affecting hog supplies.

The demand for hogs has typically been considered only vis-a-vis the demand for pork. Shephard and Thompson-Barahona (1965) compared the long-run demand for pork and the supply of hogs with long-run demand for competing meats. During a twenty year post war period, they found that the demand for pork had changed little because the per capita demand for and supplies of beef and poultry had increased, while pork exhibited a low income elasticity of demand and hog supplies had not increased proportionately to those of

other meats. The relevance of their work to this study is that it is typical in specifying pork as a good competitive with beef and poultry, and as having a low (negative) income elasticity of demand. These factors were incorporated in the model of demand estimated in this study.

A recent study by Crom (1970) typifies the impact of the above theories. In developing a dynamic model of the beef and pork sectors, Crom incorporated the theory that supplies of livestock are affected by decisions producers make at least several months prior to production, and that these decisions are largely influenced by past price behavior of livestock. With respect to demand, Crom's model considered the effect retail prices of competing meats have on the demand for beef and pork, and on the demand for cattle and hogs.

In summary, the literature has supported the theory that farmers are affected by the price of hogs and corn in making their production plans. Demand for slaughter hogs has been characterized as being determined by the demand for pork. The literature has acknowledged the impact of consumers' incomes and of retail meat prices on the demand for slaughter hogs. These theories were included in the model described in the following chapter.

CHAPTER III

SPECIFICATION OF THE MODEL

The form of the demand and supply relationships estimated in this study embodied the theories and principles presented in the literature cited. An important difference was that this study focused upon only terminal markets and their monthly behavior. If the same demand and supply relationships that have been developed for the hog economy as a whole apply to terminal hog markets in particular, then the use of monthly data may result in more precise estimates of market behavior. On the other hand, conventional models may not be applicable to terminal markets in particular or to their monthly behavior. Although these questions were not actually answered until the results of the analysis were examined, their importance was recognized in formulating the model used.

An individual's ordinal utility function for n goods with n prices, $p_1,\ldots,p_n$, may be specified as

$$U = u(x_1,\ldots,x_n).$$

The demands $(x_1,\ldots,x_n)$ are determined such that U is maximized subject to an income constraint $M = p_1x_1 + \ldots + p_nx_n$. By defining a Lagrangean function L, demands are determined by the condition

$$\text{Max. } L = U - q(p_1x_1 + \ldots + p_nx_n - M),$$

where q is a Lagrangean multiplier. Differentiating with respect to the x_i and q yields the equations

$$u_i = q\, p_i \quad (i = 1,\ldots,n),$$

$$p_1x_1 + \ldots + p_nx_n = M,$$

where u_i is the partial derivative of U with respect to x_i. From these (n + 1) equations, q and the demands $(x_1,\ldots,x_n)$ may be determined.

The demand for any good, x_i, is a function of the price of that good, the price of other goods in the consumer's utility function, and money income M. Only relative prices and income are relevant; if all prices and M change proportionately, the demand for a good is unchanged. Only real income changes are important to consider. There is no guarantee that the demand functions are linear, or that the effects of prices and income are additive.

The demand functions estimated in this study were similar to the above in that the quantity of slaughter hogs demanded was hypothesized to be a function of the price of hogs, the price of other goods, and income. The functions were given a linear form. However, the important decision as to what other prices would be included was made on a pragmatic rather than theoretical basis. Prices for competing meats such as beef, lamb, chicken, and turkey were included in order to be consistent with relationships predominating in the literature. Implicit in the exclusion of

retail pork prices was the belief that the margin between retail pork prices and slaughter hog prices was too great to allow changes in pork prices to affect hog prices within the same month. In the demand model used, the effect of pork prices on hog prices works through the effect of other meat prices on hog prices.

Demand for slaughter hogs is a derived demand, derived from the demand for pork. The prices for other meats used in the model are actually prices of meats which compete with pork. Income was included since consumers' demand for pork should be affected by their income, as explained above, and packers' demand for hogs is derived from consumers' demand for pork. What constitutes "packers' income" is unclear, although the price margin between slaughter hogs and pork would probably be a reasonable proxy. Inclusion of this price margin was disallowed due to the unreliability of monthly data for this margin. However, a sum of cold storage holdings of pork and frozen pork, labeled "stocks," was used as an indicator of packers' ability and desire to purchase hogs. The inclusion of this variable is not without precedent, as Crom (1970) and Maki and Crom (1965) included similar variables.

In summary, a demand equation was estimated simultaneously with a supply equation for each of the eight markets. The form of the demand equations was

$$P_{Ht} = F(P_{Bt}, P_{Lt}, P_{Ct}, P_{Tt}, I_t, S_t, Q_{Ht}),$$

where,

P_{Ht} = The price of slaughter hogs at a given market at time t;

P_{Bt} = The retail price of beef at time t;

P_{Lt} = The retail price for lamb at time t;

P_{Ct} = The retail price for chicken at time t;

P_{Tt} = The retail price for turkey at time t;

I_t = Personal income at time t;

S_t = The sum of cold storage holdings of pork and frozen pork at time t;

Q_{Ht} = Marketings of hogs at a given market at time t.

In price theory, a producer's supply curve is his marginal cost curve above its intersection with the minimum of the average cost curve. Marginal cost is the change in a producer's total cost per unit change in output. The supply relationships in the literature cited in the previous chapter bear only an indirect relationship to a firm's supply curve of price theory. In most studies of the hog economy, supply relationships have modeled producers' formation of profit expectations; that is, supply models have attempted to represent what makes a producer commit himself to supplying (producing) hogs. This is a reasonable approach since once a farmer commits himself to producing hogs the cost of changing his mind is usually prohibitive. The supply equations estimated in this study were no

different. To make the form of the supply equations used comprehensible, the economic relationships affecting hog production are first discussed.

A farmer's decision to produce hogs is based on his expectation of the profitability of doing so. Aside from the initial investment in sows and the costs of breeding them, by far the most important cost of production is the price of corn. For this reason, corn prices and hog prices have long been regarded as the major determinants of farrowings of litters of pigs. The average gestation period for hogs is four months. Hogs are usually from six to eight months of age upon reaching market. Therefore a producer must decide to produce hogs from ten to twelve months before hogs reach market. For this reason, the quantity of hogs supplied in a given month was assumed to be partially a function of corn prices and hog prices ten, eleven, and twelve months before a given month. Monthly differences in weights to which hogs are finished were considered implicitly by using monthly data for prices and marketings which represent an average of hogs weighing 180-220 pounds, grades one and two, sold in a particular market.

The number of sows that have farrowed has been used in many studies, e.g., Harlow (1962), Maki and Crom (1965), and Crom (1970), as a standard indicator of the number of hogs expected to reach market six to eight months later.

Farrowings multiplied by pigs per litter gives the number of pigs born at a given time. Therefore supplies in a given month were also hypothesized to be a function of farrowings and pigs per litter six, seven, and eight months prior to a given month.

A word is appropriate here concerning the so-called hog-corn ratio. The model used in this study did not employ this ratio. The value of using this variable is that when the ratio of corn and slaughter hog prices is favorable, one would expect to see an increase in farrowings as producers respond to conditions favorable to profitable hog production. This study did not use the ratio of hog prices to corn prices but instead used these prices separately, because using a ratio of these prices automatically weights them equally. A parameter estimate for a hog-corn ratio must be made under an implicit restriction that the effect of hog and corn prices on the endogenous variables is equal. A model was used which did not contain such a restriction since separate parameter estimates were made for the effect of hog prices and of corn prices on equilibrium prices and quantities.

A related reason for not using the hog-corn ratio is that as hog production has become less tied to annual corn production due to grain storage, producers' expectations concerning hog prices have become more important than their expectations concerning corn prices. Estimating parameters

for separate prices for corn and hogs allows for this difference of importance.

In summary, for each of the eight markets considered a supply equation was estimated simultaneously with demand. The form of this equation was

$$P_{Ht} = G(P_{Ht-i}, P_{Ct-i}, F_{t-j}, L_{t-j}, Q_{Ht}),$$

where,

P_{Ht} = The price of slaughter hogs at a given market time t;

P_{Ht-i} = The price of slaughter hogs at Omaha at time t-i, i = 10, 11, 12;

P_{Ct-i} = The price of corn at Omaha at time t-i, i = 10, 11, 12;

F_{t-j} = Farrowings in the North Central states at time t-j, j = 6, 7, 8;

L_{t-j} = Pigs per litter in the North Central states at time t-j, j = 6, 7, 8;

Q_{Ht} = Marketings of hogs at a given market at time t.

In general, most studies of the hog economy have been quarterly ones. The form of the supply equations estimated in this study derives mainly from quarterly supply models, since one question this study sought to answer empirically was whether traditional supply specifications of the hog economy are applicable to modeling the monthly behavior of

terminal markets. Traditional specifications may model a structure significantly different from that characteristic of terminal markets' monthly behavior. A better evaluation of this point is possible when the results of the analysis are examined in Chapter V.

The data employed in estimating the model used in this study was of reasonably high quality in the sense that most of the data were based upon actual observation of the behavior of specific markets. Nevertheless, certain compromises were necessary.

In order to simplify data collection and classification of variables, differences in hog weights and grades were not explicitly considered. However, the data used for market quantities and prices of slaughter hogs did implicitly consider seasonal variation in monthly weights and grades of hogs marketed, since the average price and quantity used for a particular market was an average of all hogs marketed in a given month. Thus, if in one month heavier hogs were marketed than in another month, this would appear in the monthly average price. In general, differences in weights and values of hogs from month to month are reflected in such an average.

Monthly slaughter hog marketings and prices for each of the terminal markets studied were taken from the weekly Livestock Meat and Wool Reports, published by the Statistical Reporting Service of the United States Department of

Agriculture. Summaries for each month are published in the issue for the first complete week following the month. Prices quoted by SRS are an average of barrows and gilts marketed during a given month at a given market, for the weight range 180-220 pounds, grades one and two.

Retail prices for beef, lamb, and pork were taken from SRS Statistical Bulletin No. 333, Supplement for 1969, published in July of 1970. Retail beef prices were calculated by SRS from prices published by the Bureau of Labor Statistics and prices reported by a group of retail food chains. Retail lamb prices were also calculated from prices furnished by the Bureau of Labor Statistics and a group of retail food chains. The variable "stocks" was derived from a sum of frozen and cold storage holdings of pork on a monthly basis, end of month, for forty-eight states, as quoted in SRS Bulletin Number 333 of July, 1970. Personal income data were taken from issues of the Survey of Current Business published by the United States Office of Business Economics of the United States Department of Commerce. Care was taken to be sure that all data had the same seasonal adjustments. Deflation of income and price data was not used due to the relatively short period analyzed.

Prices for chicken and turkey at retail were taken from Selected Statistical Series For Poultry And Eggs Through 1968, published by the Economic Research Service of

the USDA, and from later poultry and egg situation reports. Chicken prices used were for frying chickens in retail stores in fifty urban areas, monthly average per pound, as reported by the Bureau of Labor Statistics. Turkey prices used were taken from a sample of retail stores in thirty-five urban areas, sampling a three day period in each month, using prices for eight to sixteen pound birds. Data used for turkeys was also furnished by the Bureau of Labor Statistics. All of the prices furnished by the Bureau of Labor Statistics used by SRS were part of the prices used to calculate the quarterly cost of living index for the United States, the Consumer Price Index.

For the supply equations, corn prices were for number three yellow corn, price per bushel at Omaha, taken from ERS Feed Situation Reports. Omaha corn prices were used since the lagged hog prices in the supply equations were Omaha prices taken from the weekly Livestock Meat and Wool Reports. Data for farrowings and pigs per litter were taken from issues of the Pig Crop Report published by SRS. Data for both of these variables pertained to ten selected states: Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, South Dakota, Nebraska, and Kansas. While farrowing data were monthly, data on pigs per litter were quarterly. For each month of a quarter, the quarterly figure was used. This interpolation was the most serious compromise in the data used.

CHAPTER IV

METHODS OF ESTIMATION

For each of the terminal markets studied, parameter estimates of supply and demand relationships were obtained by applying three-stage least squares to the principle components of the predetermined variables and untransformed jointly determined variables. In this chapter, the estimation procedures used are discussed.

Linear Models And Least Squares

For each pair of supply and demand equations, parameters of both equations were estimated simultaneously. The sense in which these estimates were simultaneously made is more apparent by examining simultaneous equation models in general and least squares estimation in particular.

All variables were categorized as being jointly determined or predetermined. Chow (1964), in an excellent discussion of alternative simultaneous equation estimators, has presented an interesting generalization of least squares estimation, viewed geometrically. In the conventional econometric model proposed by the Cowles Commission, a column vector y of jointly determined variables is hypothesized to be a sum of a linear combination of predetermined vectors of the set $Z = (z_1,\ldots,z_k)$ and a disturbance term, u, orthogonal to Z. The least squares method of

deriving estimates of the coefficients of this linear combination calls for minimizing the difference $Yb'-Zd'$ with respect to the scalar b' and the column vector of coefficients d', subject to the restriction that the variance of Yb' equals some positive constant c. This principle may be extended to a model with a set of vectors $Y = (y_1,\ldots,y_G)$, where some linear combination of the y's, Yb', is hypothesized to be a sum of a linear combination of the vectors in Z plus disturbance terms. The least squares method then calls for minimizing the difference $Yb'-Zd'$ with respect to b' (now a column vector) and d', subject to the restriction that the variance of Yb' equals c. Solving this problem provides a solution unique only to some scalar transformation of b', so one must normalize on one of the elements of b'. One may logically extend this second model to one in which many linear combinations, $Yb_1',\ldots,Yb_G'$ of the set of y vectors are hypothesized to be equal to linear combinations $Zd_1',\ldots,Zd_G'$ of vectors in Z, plus disturbance terms. Then least squares estimates will be derived by minimizing the generalized variance of the differences $Yb_1'-Zd_1',\ldots,Yb_G'-Zd_G'$, that is, by minimizing the G differences simultaneously, subject to the restriction that the generalized variance of $Yb_1',\ldots,Yb_G'$ equals c.

The model used in this study is the last one of the above paragraph. For a given observation and a given

equation the model is

$$(1) \qquad b_{i1}y_{t1} + \ldots + b_{iG}y_{tG} = d_{i1}z_{t1} + \ldots + d_{iK}z_{tK} + u_{ti}$$
$$(t = 1,\ldots,T;\ i = 1,\ldots,G).$$

For all observations on the equations, the model may be written in G equations as

$$(2) \qquad Yb_i' = Zd_i' + u_i \quad (i = 1,\ldots,G).$$

All T observations and G equations may be written as

$$(3) \qquad Y(b_1'\ldots Yb_G') = Z(d_1'\ldots d_G') + (u_1\ldots u_G)$$

or

$$(4) \qquad YB' = ZD' + U.$$

For the i^{th} equation of this model, the assumption is made that u_i is orthogonal to the vector space (Z). The disturbance terms $u_{t1},\ldots,u_{tG}$ are random variables with a G-variate distribution with means equal to zero and covariance matrix Q. Furthermore, it is assumed that each u_{ti} is independent of $u_{s1},\ldots,u_{sG}$ $(s \neq t)$.

An interesting question is why this generalization treats all jointly determined variables, y_i, as one composite variable, Yb_i'. The answer is that the model gives no basis for treating any of the y_i differently, a rule overlooked by most simultaneous equation estimators. The manner in which this omission takes place is important to examine further.

Any vector may be seen as a line connecting the origin with a point defined by the vector's coordinates. Suppose the vector y_i has two orthogonal components, one being a linear combination of certain vectors z_i spanning a space (Z), the other a disturbance term, but that the coefficients of the linear combination are not known. If one seeks to determine the linear combination in such a fashion that the square of the disturbance orthogonal to (Z) is minimized, the obvious solution is to choose the linear combination of the z_i which is the projection of the y_i on (Z). This is what the least squares method does.

Rather than projecting some y_i on (Z) one might project a linear combination of several y_i, Yb'. Then minimization of the variance is achieved by finding the appropriate b_i' and d_i'. In selecting the elements of the column vector b' satisfying the constraint that the variance of Yb' equals c, the direction of the Yb' to be projected on the space (Z) is determined. Thus the manner of normalization, which b_i is the basis of normalization, affects the direction of Yb'.

Both two-stage and three-stage least squares, the most common estimation methods used for simultaneous equation systems, begin by normalizing on a particular y_i of a set $Y = (y_1, y_2, \ldots)$, that is, by selecting some b_i of Yb'-Zd' on which to normalize. Depending upon which b_i is chosen, one will get different solutions to the minimization of the

variance of Yb'-Zd' subject to the constraint that the variance of Yb' equals c. Chow calls this type of normalization "direction normalization," as distinguished from "scale normalization."

Three-Stage Least Squares

Three-stage least squares, developed by Zellner and Theil (1962), is an extension of two-stage least squares as developed by Theil (1953) and Basmann (1957). As mentioned above, both begin by normalizing on the coefficient of a particular y vector of a set of vectors $Y = (y_1, y_2, \ldots)$ of jointly determined variables. This is done by projecting the y chosen on a specified subset of $Z = (z_1, \ldots, z_K)$. The subset of Z is specified by identification restrictions. Let the projection of some y_i on Z be y_i^*. The second stage of two-stage least squares then projects each y_i on the specified subset of Z and all y_j^* $(i \neq j)$. By choosing a particular y_i to project on a subset of Z and the y_j^*, the direction for minimizing the variance is chosen. Depending on which y_i of $Y = (y_1, y_2, \ldots)$ is chosen for the second stage, different results will be obtained.

Three-stage least squares also begins by projecting each y_i on a specified subset of Z. This defines all y_i as linear combinations of some z_i in a subset of Z, plus some orthogonal error u_i. Let each of these projections on Z be y_i^*, as above. Then each y_i^* may be defined to be equal to a linear combination of the other y*, say y_j^* $(i \neq j)$, plus a

linear combination of the z_i in the i^{th} equation, plus the disturbance of the i^{th} equation, u_i. This is equivalent to the second stage of two-stage least squares. The G differences $u_i^* = y_i^* - (Y_i^* b_i' + Z_i d_i')$ represent the difference between the estimate y_i^* and a linear combination of the y_j^* and the z_K appearing in the i^{th} equation. At this point three-stage least squares improves on the two-stage method by minimizing the generalized variance of the $(u_i^*,\ldots,u_G^*)$. It is in this sense that the three-stage method is more simultaneous than the two-stage method. Both are simultaneous in the sense that when a y_i is projected on some subset of Z and on the y_j^*, all jointly determined variables of Y are brought into play. Yet both techniques suffer from sharing the same second stage, since the model contains no normalization criteria to decide which y_i of $Y = (y_1, y_2 \ldots)$ will be projected on a subset of Z and the y_j^*.

Principle Components

Principle component analysis is a technique applied to several variables which yields linear combinations of the variables having more desirable properties. By far the most common motivation for applying principle component analysis to a set of variables in a multivariate regression model is to obtain a smaller set of variables which are linear combinations of the original variables, yet which contain most of the variance of the original variables.

There are two other advantages in applying component analysis to multivariate models, less widely presented, which will be discussed.

Many of the ideas behind component analysis were presented by Hotelling (1933). Anderson (1958) and Tintner (1952) have given two different but thorough presentations, the former of the theory, the latter of the method. Though the economic literature has not been as thorough as the biological and psychological literature in its treatment of principle components, several recent articles are of interest.

Kloek and Mennes (1960) examined the application of principle components to the predetermined variables of a simultaneous equation model and concluded that the advantage of the method was its ability to concentrate sets of variables into smaller sets, thereby reducing the numbers of parameters to be estimated with limited degrees of freedom. This is the most obvious and conventional application of principle components. Another development of this theme was presented by Amemiya (1966), in which the actual gain in reducing the set of predetermined variables was explored from the viewpoint of decision theory as developed by Wald (1950).

In section four of Amemiya's paper, the basis for an important rule in applying principle components to multivariate models was developed, yet the rule was not clearly

stated. This rule is that one should not attempt to apply principle components to sets of explanatory variables if the correlation between the sets is low. Otherwise, when these two sets are replaced by their principle components, the variation within the set will be sufficiently great that the standard errors of the estimated parameters of the components will be large; larger than if components of the separate sets were used. Thus, one runs the risk of finding parameters to be statistically insignificant for variables which would logically be expected to account for much of the systematic variation.

In his paper on the application of principle components to multivariate models, Massy (1965) gave two alternative criteria for eliminating variables from the model:

> (i) Delete those components which account for the smallest portion of the variance of the original variables;
>
> (ii) Delete those components which prove insignificant in accounting for the variation in jointly dependent variables, regardless of the amount of variation in the predetermined variables they account for.

Actually, these alternatives are not mutually exclusive, as the t-test for significance of the estimated parameters embodies both these criteria.

For testing the hypothesis that the k^{th} parameter equals zero, the t statistic is the ratio of b_k, the estimated coefficient of the k^{th} variate, over s_{bk}, the estimated standard error of b_k. Since the variates are

orthogonal

$$b_k = (Z_k'Z_k)^{-1} Z_k'y.$$

By definition,

$$s_{bk} = s\ (s_{kk})^{1/2},$$

where s^2 is the estimate of the common variance of all the variates, and s_{kk} is the k^{th} diagonal element of $(Z'Z)^{-1}$, $(Z_k'Z_k)^{-1}$. Since b_k may be written as

$$b_k = s_{kk}\ Z_k'y,$$

it is clear that

$$t = (Z_k'y)/s\ (s_{kk})^{-1/2}.$$

Thus, the numerator of the t statistic, the covariance between the k^{th} variate and the endogenous variable y, embodies the principle of alternative (ii). The denominator, the proportion of the sample variance attributable to the k^{th} variate, embodies the principle of alternative (i). One of the advantages of using component analysis to make exogenous variables orthogonal, is that in testing their significance the t-test nicely combines criteria (i) and (ii). Without orthogonal variates, s_{kk} would only partially represent the contribution of the k^{th} variate to the sample variance, since Z'Z would not be diagonal, and the meaning of the t statistic would be less clear.

Before discussing the other reasons for applying component analysis to multivariate models, Massy's explanation of the method will be given to help provide insight into the usefulness of principle components.

Suppose that an original set of vectors is standardized and that the standardized variates are now vectors of X. Then the principle components of X are defined by the transformation Z = M'X. Assume that the rank of X is G. Both Z and X have T rows and G columns, where T is the number of observations per equation and G is the number of equations. In defining the matrix M of the transformation on X yielding the principle components Z, two properties of the principle components are sought:

(i) The principle components, vectors of Z, must be orthogonal in the sample;

(ii) The components must be ordered such that each accounts for more of the variance in X than its succeeding component.

A logical consequence of (ii) is that all of the components together account for all of the variance in X, consistent with the requirement that the components are orthogonal.

To determine the matrix of the transformation M, we begin by postmultiplying Z by Z',

(5) $ZZ' = M'XX'M.$

Let XX' = R. Since X is a matrix of standardized variates, R is the matrix of simple correlations between the original variables. Let C = ZZ'. Since C = M'RM is diagonal, M'RM

is an orthogonal similarity transformation of R. Such transformations are nicely presented by Smirnov (1961), while similarity in general is given a thorough treatment by Thrall and Tornheim (1957).

Since M'RM is an orthogonal similarity transformation, by a well known theorem of linear algebra (Hadley, 1961):

(i) M has an orthonormal set of eigenvectors of R as its columns;

(ii) C has eigenvalues of R as its diagonal.

Also, $M' = M^{-1}$, since the columns of M' are orthogonal. Therefore, $Z = M'X$ implies $Z = M^{-1}X$, which in turn implies that $MZ = X$. The second property desired of principle components is achieved by the fact that the eigenvector corresponding to the greatest eigenvalue of R will be the coefficients of the principle component that explains most of the variation in X, while the component corresponding to the second largest eigenvalue of R will account for the second largest portion of the variance in X, etc.

From a geometric point of view, the matrix M may be seen as a transformation which rotates the axes of the space spanned by the vectors in X. The principle components of X are the axes after rotation. It is obvious that after rotation, as before, there will in general be some interdependence between the G vectors corresponding to the G columns of X. Thus the space corresponding to the time series of G variables is in general a convolution of

orthogonal components plus some cross-components. Principle component analysis works most successfully on models with little significant non-linearity, as opposed to the application of spectral analysis, for example, to models in which there are strong non-linear effects. Regarding this latter type of model, though the principle components would account for "all of the variation" in the original variables, its failure to account for cross-components would be equivalent to a specification error, an error which could be troublesome. Empirical evidence of the existence of cross-effects between components which are linearly independent is provided by the occurrence of non-zero correlations between them.

Two additional applications of principle components have been mentioned. The first is a clear extension of using component analysis to reduce the number of exogenous variables in a model, since this will be successful only when strong correlations between exogenous variables are present. This application is the use of principle components to separate highly correlated variables into orthogonal vectors whose estimated standard errors will be smaller than those of the correlated variables. In such a case, one gains even from using all components of the original variables and consequently not gaining degrees of freedom, since the transformed variables will appear as

orthogonal vectors in the matrix of transformed exogenous variables. One gains since orthogonality of the variates is desirable in itself, as the above discussion of the t statistic and orthogonality illustrates. In general, however, one would not expect significant gains from an orthogonal transformation of the variates without a deletion of variables and a consequent gain in degrees of freedom, since significant gains come only with relatively high correlation between the untransformed variates; in such a case the original set of variates should be able to be expressed by a reduced set.

Another application generally overlooked is the application of component analysis to several lagged exogenous variables. Not only does such an application help reduce multicollinearity between such variables, but the calculation of several linearly independent components provides the opportunity for using several different lag structures for a set of correlated lagged variables, e.g., the same price lagged different time periods. Even the improvements on Koyck lags, such as Jorgensen (1966) and Almon (1965) have suggested, ultimately require the selection of one structure to the lag. In allowing several different lag structures to be used for the same series of lagged variables, principle component analysis proves to be quite useful.

Principle Component Analysis And Simultaneous Equations

The effect of applying principle component analysis to the predetermined variables of a simultaneous equation model follows directly from the above comments. The following applies just as readily to taking the components of jointly determined variables, though this study used the components of the predetermined variables. Since the matrix for transforming standardized variables into their principle components rotates the axes of the original space, applying component analysis to predetermined variables (the set Z of the first of this chapter) simply rotates the original space. Then the Z upon which the vectors y_i and their linear combinations Yb' are projected is the space whose axes are the principle components of the original space of standardized vectors. Applying component analysis to the jointly determined variables performs a similar rotation of the axes of the space Y spanned by the vectors y_i.

In conclusion, we examine the effect of principle component analysis on the identification of simultaneous equation models. Identification restrictions in general have the effect of determining which of the z_i of the set Z will appear in each of the G equations of the model. These restrictions define the "selected subset" of Z referred to earlier. Since each of these subsets onto which some Yb'

is projected has a unique disturbance term u_i orthogonal to it (if each did not then the equations would have no unique solutions) then defining the errors and relations between them a priori is sufficient to define the subsets of Z onto which projections are made. In other words, identification may be achieved by putting restrictions on the variances and covariances of the equations, as well as by defining subsets of Z.

The first issue concerning principle components and identification is whether the linear combinations of the original standardized variates will violate identification restrictions. Can one begin with identified relationships and, by using the principle components of the initial variates, end up with relationships not identified? Suppose that this is possible. Then principle component analysis must define a subset of Z different from the subset of Z compatible with identification restrictions. Quite obviously, if one begins with some subset of Z it is impossible to define oneself out of the superset Z, but if principle components of all the Z are derived together it is possible to define oneself out of the subset of Z permissable for each equation without leaving Z. The solution is to use the principle components of just one equation, that is, to apply component analysis to each equation after identification restrictions have been made on the original untransformed equation. Then component analysis will only

rearrange the variates of each equation into orthogonal linear combinations.

The second issue is whether the use of components of variables may help identification. After restrictions have been made on the equations, some of the z_i in Z may have been eliminated from certain equations. One may go further by specifying that the z_i in the subset of Z specified by identification restrictions have a certain relationship among themselves. In addition to exclusion restrictions, one may use the specification of identities to further aid identification of equations. The derivation of principle components of variables in an equation after the elimination of other variables to aid identification, is equivalent to the use of identities to aid identification. This is true since principle components are linear combinations of the original variables and a linear combination by nature specifies a certain relationship between the original vectors. We conclude that principle component analysis, applied to individual equations after exclusion restrictions have been made, does not violate identification restrictions but in fact helps to identify the equations.

CHAPTER V

RESULTS OF THE ANALYSIS

From the results of this study, a monthly model of terminal hog markets would seem to require a specification different from traditional models of the hog economy viewed as a whole. Although most of the markets appear to be similar in structure, their dissimilarities are of interest.

Preliminary to estimating relationships for individual markets, the assumption that retail pork prices do not affect slaughter hog prices within the same month was examined. This was done by computing the simple correlation between retail pork prices and Omaha slaughter hog prices within the same month, that is, using no lags. Using monthly data from the first of 1966 to the end of 1969, the correlation coefficient was found to be -.18, representing a very weak negative correlation. Thus, if retail pork prices do affect slaughter hog prices within the same month the effect would seem to be a negative one.

In the first stage of the three-stage least squares regressions, prices and quantities of slaughter hogs for each of the eight markets were regressed on all predetermined variables. Using a critical value of the t-statistic corresponding to an alpha of .10, statistically significant coefficients were selected. The resultant equations were

then transformed from "component" form to a "solved" form by substituting principle components into the estimated equations and using only statistically significant coefficients. The results for the solved reduced form equations for all eight markets are presented on the following pages. Results for all estimates, both reduced form and three-stage least squares structural equations, are presented in component form in Appendix One. The principle components of the original variables are presented in Appendix Two.

The reduced form equation with price as the dependent variable indicates the importance of retail meat prices in affecting equilibrium prices for slaughter hogs. Retail meat prices appear in all eight of the reduced form price equations since at least one meat component was significant in all eight of the component reduced form price equations. Furthermore, all meat prices have positive signs, as does income. If these meats compete with pork, one would expect that the positive cross-elasticity of demand for pork and these meats would imply a negative sign to these retail meat price coefficients, as long as retail pork and slaughter hog prices are positively related. The fact that these meat prices have positive signs supports a hypothesis that there is a negative relationship between retail pork and slaughter hog prices within a one month period. The hypothesis made in this study was that a one month period is too brief for retail pork prices to substantially affect slaughter hog prices. The signs of the meat price coefficients in the

REDUCED FORM, DEP VAR PRICE HOGS

CHICAGO	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.188	.0447	.0328	.0820
	PRTRKY	INCOME	STOCKS	FRWG-6
	.1564	.0099	-.0913	-.0454
	FRWG-7	FRWG-8		
	-.0696	-.0451		
INDIANAPOLIS	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.188	.0427	.0303	.0830
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0814	.0066	-.0945	-.0450
	FRWG-7	FRWG-8		
	-.0690	-.0447		
KANSAS CITY	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.138	.0408	.0289	.0795
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0781	.0062	-.0869	-.0508
	FRWG-7	FRWG-8		
	-.0778	-.0504		
OMAHA	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.143	.0035	.0308	.0809
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0781	.0080	-.0261	-.0510
	FRWG-7	FRWG-8		
	-.0781	-.0506		
ST. LOUIS	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.166	.3502	.0260	.0813

	PRTRKY	INCOME	STOCKS	FRWG-6
	.0835	.0023	-.0951	
	FRWG-7	FRWG-8		

SIOUX CITY	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.148	.0412	.0291	.0805
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0793	.0061	-.0918	-.0510
	FRWG-7	FRWG-8		
	-.0781	-.0506		
S. ST.JOSEPH	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.140	.0427	.0305	.0820
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0799	.0072	-.0930	-.0513
	FRWG-7	FRWG-8		
	-.0786	-.0509		
S. ST.PAUL	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	2.160	.0046	.0031	.0798
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0741	.0110	-.0880	-.0508
	FRWG-7	FRWG-8		
	-.0779	-.0504		

****

REDUCED FORM, DEP VAR QUANTITY HOGS

CHICAGO	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	6.872	1.509	-.7634	-.7309
	PRTRKY	INCOME	STOCKS	FRWG-6

	-.0277	-1.496	.1398	.3878
	FRWG-7	FRWG-8	LITR-6	LITR-7
	.5943	.3848		
	LITR-8			
INDIANAPOLIS	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	7.246	-.2124	-.2136	-.1336
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0410	-.1997	.0341	
	FRWG-7	FRWG-8	LITR-6	LITR-7
	LITR-8			
KANSAS CITY	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	7.759	1.578	-.3329	-.6301
	PRTRKY	INCOME	STOCKS	FRWG-6
	-.3635	-.9152	.3540	
	FRWG-7	FRWG-8	LITR-6	LITR-7
	LITR-8			
OMAHA	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	13.65	1.997	-.8345	-.8345
	PRTRKY	INCOME	STOCKS	FRWG-6
	-.0570	-1.756	.1556	.7019
	FRWG-7	FRWG-8	LITR-6	LITR-7
	1.076	.6963		

	LITR-8			
ST. LOUIS	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	12.47	-.1950	-.4972	-.3384
	PRTRKY	INCOME	STOCKS	FRWG-6
	.0957	-.2001	.2439	.3140
	FRWG-7	FRWG-8	LITR-6	LITR-7
	.4813	.3116		
	LITR-9			
SIOUX CITY	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	12.92			
	PRTRKY	INCOME	STOCKS	FRWG-6
				.5539
	FRWG-7	FRWG-8	LITR-6	LITR-7
	.8488	.5495		
	LITR-8			
S. ST.JOSEPH	INTRCPT	PRBEEF	PRLAMB	PRCHKN
	8.988			
	PRTRKY	INCOME	STOCKS	FRWG-6
				.4298
	FRWG-7	FRWG-8	LITR-6	LITR-7
	.6586	.4264		
	LITR-9			
S. ST.PAUL	INTRCPT	PRBEEF	PRLAMB	PRCHKN

	9.972			
	PRTRKY	INCOME	STOCKS	FRWG-6
				.3896
	FRWG-7	FRWG-8	LITR-6	LITR-7
	.5971	.3866	-.5774	.0081
	LITR-8			
	.5618			

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3SLS DEMAND, DEP VAR PRICE HOGS

CHICAGO	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	2.901	.0032	-.0080	.0517
	PRTRKY	INCOME	STOCKS	QYHOGS
	.0788	-.0267	-.0781	-.1032
INDIANAPOLIS	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	3.905	.0033	-.0082	.0528
	PRTRKY	INCOME	STOCKS	QYHOGS
	.0805	-.0273	-.0798	-.2366
KANSAS CITY	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	3.670	.0303	.0305	.0191
	PRTRKY	INCOME	STOCKS	QYHOGS
	-.0058	.0285	-.0049	-.1975
OMAHA	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	2.982	.0032	-.0079	.0510
	PRTRKY	INCOME	STOCKS	QYHOGS
	.0776	-.0263	-.0769	-.0611
ST. LOUIS	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	3.558	.0058	-.0072	.0464

	PRTRKY	INCOME	STOCKS	QYHOGS
	.0706	-.0239	-.0700	-.1114
SIOUX CITY	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	2.798	.0320	.0212	.0687
	PRTRKY	INCOME	STOCKS	QYHOGS
	.0715	.0011	-.0810	-.0501
S. ST.JOSEPH	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	2.996	.0275	.0168	.0657
	PRTRKY	INCOME	STOCKS	QYHOGS
	.0720	-.0030	-.0800	-.0946
S. ST.PAUL	INTERCPT	PRBEEF	PRLAMB	PRCHKN
	3.100	.0339	.0241	.0654
	PRTRKY	INCOME	STOCKS	QYHOGS
	.0287	.0056	-.0758	-.0942

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3SLS SUPPLY, DEP VAR PRICE HOGS

CHICAGO	INTERCPT	PHG-10	PHG-11	PHG-12
	3.088			
	LITR-6	LITR-7	LITR-8	QYHOGS
	-.0467	-.0554	-.0564	-.1315
INDIANAPOLIS	INTERCPT	PHG-10	PHG-11	PHG-12
	4.139			
	LITR-6	LITR-7	LITR-8	QYHOGS
				-.2699
KANSAS CITY	INTERCPT	PHG-10	PHG-11	PHG-12
	3.708			
	LITR-6	LITR-7	LITR-8	QYHOGS

				-.2021
UMAHA	INTERCPT	PHG-10	PHG-11	PHG-12
	4.423	.1665	-.0018	-.1640
	LITR-6	LITR-7	LITR-8	QYHOGS
	-.0575	-.0681	-.0581	-.1673
ST. LOUIS	INTERCPT	PHG-10	PHG-11	PHG-12
		.1504	-.0016	-.1482
	LITR-6	LITR-7	LITR-8	QYHOGS
SIOUX CITY	INTERCPT	PHG-10	PHG-11	PHG-12
	4.790			
	LITR-6	LITR-7	LITR-8	QYHOGS
				-.2048
S. ST.JOSEPH	INTERCPT	PHG-10	PHG-11	PHG-12
	NO T-VALUES GREATER THAN OR EQUAL			
	LITR-6	LITR-7	LITR-8	QYHOGS
	TO 3.078, ALPHA = .10.			
S. ST.PAUL	INTERCPT	PHG-10	PHG-11	PHG-12
	5.619			
	LITR-6	LITR-7	LITR-8	QYHOGS
				-.3474

LABELS

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INTRCPT = INTERCEPT

PRBEEF = PRICE OF BEEF, RETAIL.

PRLAMB = PRICE OF LAMB, RETAIL.

PRCHKN = PRICE OF CHICKEN, RETAIL.

PRTRKY = PRICE OF TURKEY, RETAIL.

INCOME = PERSONAL INCOME.

STOCKS = COLD STORAGE HOLDINGS PLUS FROZEN PORK.

FRWG-6 = FARROWINGS, LAGGED 6 MONTHS.

FRWG-7 = FARROWINGS, LAGGED 7 MONTHS.

FRWG-8 = FARROWINGS, LAGGED 8 MONTHS.

LITR-6 = PIGS PER LITTER, LAGGED 6 MONTHS.

LITR-7 = PIGS PER LITTER, LAGGED 7 MONTHS.

LITR-8 = PIGS PER LITTER, LAGGED 8 MONTHS.

PHG-10 = PRICE SLAUGHTER HOGS, LAGGED 10 MONTHS.

PHG-11 = PRICE SLAUGHTER HOGS, LAGGED 11 MONTHS.

PHG-12 = PRICE SLAUGHTER HOGS, LAGGED 12 MONTHS.

price reduced form equation, combined with the computed simple correlation of -.18 between retail pork and slaughter hog prices, would seem to indicate that retail pork prices in fact have a negative relationship with slaughter hog prices. Perhaps the existence of no relationship between these prices is easier to accept than a negative one. The existence of either would seem to be due to the absence of lags in all these price relations. With proper lags, pork and hog prices would probably be positively related. The necessity for a lag is probably due to the wide margin between retail pork prices and slaughter hog prices.

The positive signs for the income coefficients is not consistent with a negative income elasticity for pork, as long as pork and hog prices are positively related within a one month period. Thus, the positive sign on income also supports the belief that unlagged pork and hog prices are negatively related. The negative sign on stocks indicates that as inventories increase, hog prices decline within the same month. This was hypothesized in the formulation of the model.

Farrowings were significant for all markets except St. Louis. Their negative sign is logical since when farrowings increase six to eight months prior to a given month, marketings should increase during the month given, resulting in lower prices. Table 1 summarizes the signs of the significant coefficients of the price reduced form equations in solved form.

TABLE 1. REDUCED FORM, DEP VAR PRICE OF HOGS (SOLVED)

SUMMARY, SIGNS OF VARIABLES

	PRBEEF	PRLAMB	PRCHKN	PRTRKY	INCOME	STOCKS
CHICAGO	+	+	+	+	+	−
INDIANAPOLIS	+	+	+	+	+	−
KANSAS CITY	+	+	+	+	+	−
OMAHA	+	+	+	+	+	−
ST. LOUIS	−	−	−	+	−	+
SIOUX CITY	+	+	+	+	+	−
S. ST.JOSEPH	+	+	+	+	+	−
S. ST.PAUL	+	+	+	+	+	−

	FRWG-6	FRWG-7	FRWG-8
CHICAGO	−	−	−
INDIANAPOLIS	−	−	−
KANSAS CITY	−	−	−
OMAHA	−	−	−
ST. LOUIS			
SIOUX CITY	−	−	−
S. ST.JOSEPH	−	−	−
S. ST.PAUL	−	−	−

LABELS, SUMMARY TABLES (SOLVED)

PRBEEF = PRICE OF BEEF, RETAIL.

PRLAMB = PRICE OF LAMB, RETAIL.

PRCHKN = PRICE OF CHICKEN, RETAIL.

PRTRKY = PRICE OF TURKEY, RETAIL.

INCOME = PERSONAL INCOME.

STOCKS = COLD STORAGE HOLDINGS PLUS FROZEN PORK.

FRWG-6 = FARROWINGS, LAGGED 6 MONTHS.

FRWG-7 = FARROWINGS, LAGGED 7 MONTHS.

FRWG-8 = FARROWINGS, LAGGED 8 MONTHS.

LITR-6 = PIGS PER LITTER, LAGGED 6 MONTHS.

LITR-7 = PIGS PER LITTER, LAGGED 7 MONTHS.

LITR-8 = PIGS PER LITTER, LAGGED 8 MONTHS.

PHG-10 = PRICE SLAUGHTER HOGS, LAGGED 10 MONTHS.

PHG-11 = PRICE SLAUGHTER HOGS, LAGGED 11 MONTHS.

PHG-12 = PRICE SLAUGHTER HOGS, LAGGED 12 MONTHS.

In Table 2 are summarized the signs of the significant coefficients of the quantity reduced form equations in solved form. Comparison of these two tables provides interesting information. In most instances, the meat price coefficients have opposite signs for the price and quantity reduced form equations. Lamb price coefficients, for example, have opposite signs for the Chicago, Indianapolis, Kansas City, Omaha, and St. Louis markets. This is logical if the price and quantity of slaughter hogs are inversely related to lamb prices and to each other. Beef prices are an exception, however, as their coefficients have positive signs in both the price and quantity equations for the Chicago, Kansas City, and Omaha markets. Assuming that there is a positive cross-elasticity of demand for pork and beef, and that for these markets slaughter hog prices are inversely related to retail pork prices within a one month period, then slaughter hog marketings would also seem to be inversely related to retail pork prices within a one month period. This means that there is no lag in the relationship between hog marketings and retail pork prices; hog marketings respond to retail pork price changes more quickly than hog prices. Hog prices in these markets change in response to changes in hog marketings. It is not clear whether marketings' response to changes in retail prices of competitive meats is initiated by sellers or buyers. Only in the Chicago and St. Louis markets does the stocks

TABLE 2. REDUCED FORM,DEP VAR QUANTITY HOGS (SOLVED)

SUMMARY, SIGNS OF VARIABLES

	PRBEEF	PRLAMB	PRCHKN	PRTRKY	INCOME	STOCKS
CHICAGO	+	-	-	-	-	-
INDIANAPOLIS	-	-	-	+	-	+
KANSAS CITY	+	-	-	-	-	+
OMAHA	+	-	-	-	-	+
ST. LOUIS	+	+	+	+	+	-
SIOUX CITY						
S. ST.JOSEPH						
S. ST.PAUL						

	FRWG-6	FRWG-7	FRWG-8	LITR-6	LITR-7	LITR-8
CHICAGO	+	+	+			
INDIANAPOLIS						
KANSAS CITY						
OMAHA	+	+	+			
ST. LOUIS	+	+	+			
SIOUX CITY	+	+	+			
S. ST.JOSEPH	+	+	+			
S. ST.PAUL	+	+	+	-	+	+

coefficient have a negative sign in the quantity equation. Only in these markets do marketings decrease within the same month that stocks increase, so it is unclear whether sellers or buyers predominate in initiating changes in marketings in terminal markets as a whole.

The positive signs on lagged farrowings coefficients in the quantity reduced form equations are logical since increases in farrowings six to eight months prior to a given month will lead to an increase in marketings in the given month. In general, pigs per litter coefficients were not significant, probably because of the relatively small variation in pigs per litter through time.

The complete absence of statistical significance to the lagged hog and corn prices provides important insight into a defect in the model used. Hog and corn prices were lagged ten, eleven, and twelve months. Monthly observations were used from the first of 1966 to the end of 1969, almost a complete hog price cycle. Hog prices during 1966, 1967, 1968, and 1969 were regressed on hog prices and corn prices during the previous years. The falling 1966 hog prices were regressed on rising 1965 prices. The next year, 1967, rising prices were regressed on falling prices.

Direction of Price Change During the Year

	1965	1966	1967	1968	1969
Hogs	+	-	+	+	+
Corn	+	-	$\pm$	+	

But then rising prices were regressed on rising prices two years consecutively, 1968 and 1969. As a result, any systematic effect of hog prices of one year on hog prices the next year was nullified. Corn prices have moved as hog prices have, except in 1967 when they rose for six months then fell for six months.

The model of supply was too near to quarterly models in its specification, since lagged hog and corn prices were all in the third quarter (ten, eleven, and twelve months) before a given month. Using hog and corn prices with shorter lags should allow a supply model of monthly terminal hog market behavior to be more successful in showing how these lagged prices affect marketings.

Before discussing the demand and supply estimates, the problem of determining the significance of three-stage least squares structural parameter estimates must be discussed. The fact is that the distribution for finite populations of parameters estimated in the third stage of three-stage least squares has not been established. One must appeal to large sample properties of the estimators in order to justify the applicability of the t-statistic in testing the significance of estimated parameters. This provides cold comfort when one's sample is finite. In the absence of evidence that the parameters one is estimating are nearly normally distributed, there is little justification for eliminating estimated parameters from a model as insignificant or for accepting their significance because of the size

of their estimated standard errors relative to the magnitude of their respective parameters. Nevertheless, one's intuition (a direct apprehension of truth without reasoning) may be warmed by embracing as significant those parameters whose standard errors are relatively small.

The choice in this study was to have things both ways. First, "significant" parameters were selected from demand and supply component regressions, where significance was determined vis-a-vis t; then these equations were transformed into a "solved" form employing the original variables. Alternatively, no decision was made regarding the significance of or the magnitude of the coefficients. The demand and supply estimates from the component regressions were then interpreted by examining only the sign of the estimated coefficients of the components.

Tables 3 and 4 summarize the signs of coefficients of solved demand and supply equations, selected using a t-statistic corresponding to an alpha of .10. The signs on stocks and quantities of slaughter hogs (not included in the table) were negative for all eight demand equations. Both of these signs are logical, since stocks and quantities of hogs marketed should be directly related, while quantities marketed should be inversely related to prices. Beef, turkey, and chicken retail prices have positive signs in most of the demand equations, the opposite of what one might expect if these meats substitute for pork and have positive cross-elasticities with pork. Again, a negative correlation

TABLE 3. DEMAND, DEP VAR PRICE HOGS (SOLVED)

SUMMARY, SIGNS OF VARIABLES

	PRBEEF	PRLAMB	PRCHKN	PRTRKY	INCOME	STOCKS
CHICAGO	+	−	−	+	−	−
INDIANAPOLIS	+	−	+	+	−	−
KANSAS CITY	+	+	+	−	+	−
OMAHA	+	−	+	+	−	−
ST. LOUIS	+	−	+	+	−	−
SIOUX CITY	+	+	+	+	+	−
S. ST.JOSEPH	+	+	+	+	+	−
S. ST.PAUL	+	+	+	+	+	−

TABLE 4. SUPPLY, DEP VAR PRICE OF HOGS (SOLVED)

SUMMARY, SIGNS OF VARIABLES

	PHG-10	PHG-11	PHG-12	LITR-6	LITR-7	LITR-8
CHICAGO				-	-	-
INDIANAPOLIS						
KANSAS CITY						
OMAHA	+	-	-	-	-	-
ST. LOUIS	+	-	-			
SIOUX CITY						
S. ST.JOSEPH						
S. ST.PAUL						

between unlagged pork and hog prices would seem to remedy this apparent discrepancy. The fact that the quantity of hogs marketed has a negative sign in all eight demand equations is consistent with this explanation.

The fact that retail lamb price coefficients and income coefficients have differing signs for the markets is probably due to the fact that lamb consumption varies regionally. Consumption of lamb depends partially upon consumers' tastes and preferences and their income. That preferences for lamb, as well as income, differ between the regions served by the markets is plausible and probable. There should consequently be differences between the markets as to the effect of retail lamb prices and consumer's incomes on the demand for hogs.

The supply results presented in Table 4 would seem to indicate that the markets differ significantly in their supply structures, but this is probably not so. Lagged corn prices were not significant for any of the markets, but this is undoubtedly due to an improper lag specification, as explained above. For most of the markets, lagged hog prices were not significant either. This too is due to an improper lag specification. Although virtually identical supply specifications have been used with success for the hog economy in general, the lags used were probably too great for a model of supply to terminal markets. Modeling farmers' supply decisions and behavior is not sufficient since farmers have alternative buyers other than terminal markets.

A model of supply for terminal markets must include factors that indicate what makes farmers decide to sell at terminal markets instead of elsewhere. Probably the best indicator would be the price of hogs at each market one month prior to a given date.

For all of the supply equations, the quantity of hogs coefficient had a negative sign. This contradicts the positive slope of conventional supply equations of price theory. However, these equations were estimated using equilibrium price and quantity combinations indicative of the intersection of demand and supply functions through time. Data for all of the markets showed a strong inverse relationship between hog prices and marketings. Because these data were used to estimate the supply equations, quantity coefficients had negative signs.

As an alternative to using the t-statistic to establish the significance of estimated parameters, no decision was made concerning the significance of parameters. Instead, the sign of the estimated parameters of the demand and supply equations in component form were examined. Since no tests of significance were made, no inferences about the magnitude of the parameter estimates were made, other than to accept the sign of estimated parameters. No attempt was made to transform these equations to a "solved" form, since to do so would be to accept implicitly the hypothesis that the true parameter values were equal to their

estimates. Though only examining signs of the estimated parameters is a conservative approach, it was thought to be a safe alternative to using the t-statistic.

The results of this alternative are presented in Tables 3A and 4A. In both tables, signs for the quantity of hogs are not shown. For all eight supply and demand equations the quantity coefficient had a negative sign. Table 3A shows a strong homogeneity between the markets with respect to the signs of the demand principle components. Only the fourth component of demand (PCDM04) shows substantial variation in its sign. These results would lend credence to the belief that all eight markets have similar demand structure. This is reasonable since these markets sell a homogeneous product to buyers with fairly comparable demands. Though each market sells various grades of hogs to different types of packers, all eight of these markets probably sell these various grades to the same different types of packers.

Table 4A indicates that the markets are fairly homogeneous with respect to their supply structures, more homogeneous than Table 4 would seem to indicate. Yet certain components, e.g., the first farrowing component (PCFW01), the first corn component (PCPC01), and the third pigs per litter component (PCLR03), display irregularity in their signs for the eight markets. Furthermore, there are no subsets of these markets which show complete homogeneity with respect to sign. The fact that the signs of the first

TABLE 3A. DEMAND, DEP VAR PRICE HOGS (COMPONENT)

SUMMARY, SIGNS OF VARIABLES

	PCDM01	PCDM02	PCDM03	PCDM04	PCDM05
CHICAGO	-	-	+	-	-
INDIANAPOLIS	-	-	+	+	-
KANSAS CITY	+	-	+	+	-
OMAHA	+	-	+	-	-
ST. LOUIS	+	-	+	-	-
SIOUX CITY	+	-	+	+	-
S. ST.JOSEPH	+	-	+	-	-
S. ST.PAUL	+	-	-	+	-

TABLE 4A. SUPPLY, DEP VAR PRICE HOGS (COMPONENT)

SUMMARY, SIGNS OF VARIABLES

	PCPH01	PCPH02	PCPH03	PCPC01	PCPC02	PCPC03
CHICAGO	-	+	-	+	+	+
INDIANAPOLIS	-	+	-	+	-	+
KANSAS CITY	-	+	-	-	+	+
OMAHA	-	+	-	+	-	+
ST. LOUIS	+	+	+	+	+	+
SIOUX CITY	-	+	-	-	+	-
S. ST.JOSEPH	-	+	-	+	+	+
S. ST.PAUL	-	-	-	-	+	-

	PCFW01	PCFW02	PCFW03	PCLR01	PCLR02	PCLR03
CHICAGO	+	+	+	-	-	-
INDIANAPOLIS	-	+	+	-	-	-
KANSAS CITY	-	+	-	-	-	-
OMAHA	+	+	+	-	-	+
ST. LOUIS	+	+	+	-	+	+
SIOUX CITY	+	+	+	-	-	-
S. ST.JOSEPH	-	+	+	-	-	-
S. ST.PAUL	+	+	+	-	-	+

LABELS, SUMMARY TABLES (COMPONENT)

PCOMOK = KTH PRINCIPLE COMPONENT OF BEEF, LAMB, CHICKEN, TURKEY PRICES, PLUS STOCKS AND INCOME.

PCPHOK = KTH PRINCIPLE COMPONENT OF SLAUGHTER HOG PRICES LAGGED 10, 11, 12 MONTHS.

PCPCOK = KTH PRINCIPLE COMPONENT OF CORN PRICES LAGGED 10, 11, 12 MONTHS.

PCFWOK = KTH PRINCIPLE COMPONENT OF FARROWINGS LAGGED 6, 7, 8 MONTHS.

PCLROK = KTH PRINCIPLE COMPONENT OF PIGS PER LITTER LAGGED 6, 7, 8 MONTHS.

corn and farrowing components vary between markets is evidence that these markets have different supply structures. This is reasonable, given the different sizes of these markets, their different proximities to urban areas, the different areas they serve, and their different competitive environments. Moreover, one would expect greater variation between markets in supply structure than in demand structure, as this study has shown, since many of the buyers in different markets are directly interrelated while the sellers are not.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was concerned with examining the structure affecting determination of equilibrium prices and quantities of slaughter hogs at eight major terminal markets. The model used was similar to those commonly used to describe the structure of the hog economy in general.

The most obvious and significant result of this study are the differences between the markets in the manner in which equilibrium prices and marketings are determined. Even though their prices are highly correlated, the terminal markets examined in this study did not have identical structures with respect to demand, supply, or the determination of equilibrium prices and quantities. In general, retail meat prices for beef, lamb, chicken, and turkey significantly affected equilibrium prices and marketings for slaughter hogs. In all markets except St. Louis, beef, lamb, and chicken price coefficients in price reduced form equations had positive signs, supporting the conclusion that unlagged retail pork prices were negatively related to slaughter hog prices. The exception of St. Louis suggests that in this market retail meat price changes affected slaughter hog prices more quickly than in the other markets. St. Louis also had a negative sign to its income coefficient. If hogs had a negative income elasticity of demand,

then St. Louis hog prices responded more quickly, i.e., within one month, to income changes than the other markets did.

For all markets except St. Louis, an increase in farrowings six to eight months prior to a given month resulted in an increase in hog marketings and a decrease in hog prices. For St. Louis, knowledge of farrowings six to eight months prior to a given month was not sufficient to predict marketings.

Signs of significant coefficients affecting marketings of hogs in the quantity reduced form equations for Chicago, Indianapolis, Kansas City, and Omaha suggest that at these points marketings of hogs reacted more directly and more quickly than hog prices to changes in retail prices of pork and other meats. The St. Louis results indicate that prices and marketings of hogs at St. Louis both responded within a one month period to changes in retail pork and other meat prices.

An important difference between St. Louis and the other markets is that a much higher percentage of hogs bought at St. Louis, as opposed to other markets, have been shipped live to other areas. This reflects the fact that hogs bought at St. Louis are transportable within a given time period to more major urban areas within the continental United States than hogs bought at the other markets. St. Louis buyers had more alternative sources of supply

than buyers in other markets. This would explain why hog marketings and prices responded at St. Louis more quickly to changes in retail prices of other meats and to income than marketings and prices at other markets did.

The small negative correlation of -.18 between unlagged retail pork prices and slaughter hog prices provides rather weak evidence for concluding that there is a negative relationship between these prices. The signs of the estimated coefficients for meat prices and income in the reduced form equations, however, strengthen the evidence for making such a conclusion. The existence of anything other than a positive relationship is probably due to the relatively wide margin between retail pork and slaughter hog prices.

In spite of the consistency of the supply results for the markets, the supply equations are not as informative as they might be. Part of their deficiency is that the supply model is too nearly a quarterly model. All of the predetermined variables were lagged six to eight months before a given month, i.e., three quarters before. A model of this type models what makes farmers decide to produce hogs, but fails to account for what makes them sell to terminal markets rather than elsewhere. This is a significant omission since most of the hogs farmers sell are not sold at terminal markets. The supply model used is competitive in nature while terminal markets exhibit oligopolistic characteristics.

As with most models of hog supply, the model used in this study was more an expectations model of supply than a marginal cost model of supply. Expectations models of this type, the type common in agricultural economics literature of the recent past, have a theoretical basis in the sense that they embody hypotheses as to how supply is determined, theories as to what makes farmers produce. Yet such theories are often based upon observation and inductive logic, rather than being deductively formulated. As such, one may only reject or fail to reject hypotheses implicit in one's model rather than being able to test certain deductively logical premises. With supply models of the kind typified in this study, one not only must decide to reject or not reject the significance of estimated parameters but also the significance of hypotheses concerning one's model, leaving little ground for further generalizations about the supply of a commodity.

The supply model used in this study could be improved both pragmatically and theoretically by inclusion of hog and corn prices lagged one month and more. Not only would this indicate better why farmers decide to sell to terminal markets, but the model would more nearly represent producers' marginal cost.

With respect to demand, margins between retail pork and slaughter hog prices would help greatly to reflect market conditions affecting packers' demand. Since such

margin data are not available and probably never will be, a reasonable proxy might be monthly differences between retail pork and slaughter hog prices at each market. Retail pork prices could also be included directly as an element in the principle components for other meat prices and income.

Should vertical integration and coordination of hog production through contractual agreement continue to grow, and should the role of terminal markets in the value determining mechanism for hogs and pork be sustained, the nature of structural differences between the markets will need to be studied in greater depth. The fact that terminal markets have different structures should be encouraging to those who fear hog prices could come to be manipulated, since several structural parameters would have to be controlled. Yet it is apparent that guaranteeing the competitive structure of one market would not necessarily be sufficient to protect other markets.

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APPENDIXES

APPENDIX ONE:

TERMINAL MARKET PARAMETERS ESTIMATED BY APPLYING THREE-STAGE LEAST SQUARES PROCEDURE TO PRINCIPLE COMPONENTS OF PREDETERMINED VARIABLES

CHICAGO MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.8715 1-R2 0.1285

DF 30 SE2 0.5290

	0) CONST.	1) PCDM01	2) PCDM02
B	6.872D 00	-6.239D-01	-7.376D-02
SD	1.060D-01	1.113D-01	1.140D-01
	3) PCDM03	4) PCDM04	5) PCDM05
B	5.857D-01	1.873D-01	-2.294D 00
SD	2.773D-01	2.800D-01	6.129D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	2.475D-01	1.060D-01	-6.820D-01
SD	1.102D-01	3.205D-01	5.976D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	-2.249D-01	9.339D-02	-2.018D-01
SD	1.278D-01	1.413D-01	2.400D-01
	12) PCFW01	13) PCFW02	14) PCFW03
B	8.073D-01	-2.714D-02	5.526D-01
SD	1.401D-01	1.752D-01	2.643D-01
	15) PCLR01	16) PCLR02	17) PCLR03
B	4.743D-02	-1.260D-01	-6.465D-02
SD	1.376D-01	1.809D-01	2.490D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8854 1-R2 0.1146

DF 30 SE2 0.0168

	0) CONST.	1) PCDM01	2) PCDM02
B	2.188D 00	7.555D-02	-1.361D-01

SD	1.892D-02	1.985D-02	2.034D-02
	3) PCDM03	4) PCDM04	5) PCDM05
B	-1.120D-01	1.199D-02	1.352D-01
SD	4.949D-02	4.996D-02	1.094D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	-4.503D-02	1.667D-01	3.131D-02
SD	1.967D-02	5.718D-02	1.066D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	3.672D-02	-2.933D-02	-2.046D-04
SD	2.281D-02	2.522D-02	4.283D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-9.464D-02	-6.115D-02	4.168D-03
SD	2.499D-02	3.126D-02	4.715D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-6.091D-02	1.592D-02	-1.401D-02
SD	2.454D-02	3.227D-02	4.444D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	2.901D 00	-5.764D-03	-1.256D-01
SD	1.636D-01	1.868D-02	1.590D-02
B/SD	1.773D 01	-3.085D-01	-7.900D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	7.626D-02	-2.151D-02	-2.677D-01
SD	3.031D-02	3.389D-02	9.051D-02
B/SD	2.516D 00	-6.347D-01	-2.958D 00
	20) QYHHAT		

B	-1.032D-01
SD	2.366D-02
B/SD	-4.362D 00

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02
B	3.088D 00	-7.978D-03	1.941D-01
SD	2.660D-01	2.842D-02	6.998D-02
B/SD	1.161D 01	-2.807D-01	2.773D 00

	8) PCPH03	9) PCPC01	10) PCPC02
B	-1.250D-01	3.319D-02	1.148D-02
SD	1.643D-01	2.904D-02	3.907D-02
B/SD	-7.608D-01	1.143D 00	2.937D-01

	11) PCPC03	12) PCFW01	13) PCFW02
B	3.425D-02	5.615D-03	3.566D-02
SD	6.579D-02	4.384D-02	4.063D-02
B/SD	5.206D-01	1.281D-01	8.778D-01

	14) PCFW03	15) PCLR01	16) PCLR02
B	8.372D-02	-8.650D-02	-1.163D-02
SD	7.584D-02	2.803D-02	4.674D-02
B/SD	1.104D 00	-3.086D 00	-2.489D-01

	17) PCLR03	20) QYHHAT
B	-2.267D-02	-1.315D-01
SD	7.077D-02	3.875D-02
B/SD	-3.203D-01	-3.393D 00

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INDIANAPOLIS MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.7178 1-R2 0.2822

DF 30 SE2 0.3091

	0) CONST.	1) PCDM01	2) PCDM02
B	7.246D 00	-3.891D-01	-1.953D-02
SD	8.106D-02	8.505D-02	8.713D-02

	3) PCDM03	4) PCDM04	5) PCDM05
B	3.241D-01	-5.803D-02	-5.349D-01
SD	2.120D-01	2.140D-01	4.685D-01

	6) PCPH01	7) PCPH02	8) PCPH03
B	2.655D-02	-1.437D-01	-9.127D-02
SD	8.426D-02	2.450D-01	4.569D-01

	9) PCPC01	10) PCPC02	11) PCPC03
B	-8.910D-02	-1.455D-01	4.781D-03
SD	9.774D-02	1.080D-01	1.835D-01

	12) PCFW01	13) PCFW02	14) PCFW03
B	2.407D-01	3.432D-01	-1.381D-02
SD	1.071D-01	1.339D-01	2.020D-01

	15) PCLR01	16) PCLR02	17) PCLR03
B	2.005D-02	-1.905D-01	5.843D-02
SD	1.052D-01	1.383D-01	1.904D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8950 1-R2 0.1050

DF 30 SE2 0.0155

	0) CONST.	1) PCDM01	2) PCDM02
B	2.188D 00	7.155D-02	-1.418D-01
SD	1.817D-02	1.907D-02	1.953D-02

	3) PCDM03	4) PCDM04	5) PCDM05
B	-1.061D-01	5.350D-03	1.271D-01
SD	4.753D-02	4.798D-02	1.050D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	-4.953D-02	1.637D-01	2.363D-02
SD	1.889D-02	5.492D-02	1.024D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	3.683D-02	-2.953D-02	-3.734D-04
SD	2.191D-02	2.422D-02	4.114D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-9.372D-02	-6.362D-02	7.610D-03
SD	2.400D-02	3.002D-02	4.529D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-5.773D-02	1.017D-02	-1.607D-02
SD	2.357D-02	3.099D-02	4.268D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	3.905D 00	-1.875D-02	-1.283D-01
SD	4.997D-01	2.710D-02	1.813D-02
B/SD	7.815D 00	-6.918D-01	-7.078D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	7.644D-02	3.018D-02	-1.613D-01
SD	3.556D-02	3.774D-02	9.467D-02
B/SD	2.150D 00	7.997D-01	-1.704D 00
	20) QYHHAT		
B	-2.366D-01		

SD	6.894D-02		
B/SD	-3.432D 00		

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02
B	4.139D 00	-7.635D-03	1.649D-01
SD	5.665D-01	2.866D-02	7.039D-02
B/SD	7.307D 00	-2.664D-01	2.343D 00

	8) PCPH03	9) PCPC01	10) PCPC02
B	-7.050D-02	3.698D-02	-1.308D-03
SD	1.699D-01	3.069D-02	4.304D-02
B/SD	-4.149D-01	1.205D 00	-3.039D-02

	11) PCPC03	12) PCFW01	13) PCFW02
B	4.419D-02	-2.140D-02	8.074D-02
SD	6.878D-02	4.030D-02	4.832D-02
B/SD	6.424D-01	-5.311D-01	1.671D 00

	14) PCFW03	15) PCLR01	16) PCLR02
B	4.042D-02	-6.915D-02	-1.769D-03
SD	7.458D-02	2.967D-02	4.955D-02
B/SD	5.420D-01	-2.331D 00	-3.571D-02

	17) PCLR03	20) QYHHAT
B	-2.297D-03	-2.699D-01
SD	7.390D-02	7.836D-02
B/SD	-3.109D-02	-3.445D 00

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KANSAS CITY MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.7778 1-R2 0.2222

DF 30 SE2 0.3954

	0) CONST.	1) PCDM01	2) PCDM02
B	7.644D 00	1.875D-01	4.226D-01
SD	9.168D-02	9.619D-02	9.854D-02
	3) PCDM03	4) PCDM04	5) PCDM05
B	-3.603D-03	-7.849D-02	-1.174D 00
SD	2.398D-01	2.421D-01	5.299D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	2.197D-01	-3.865D-02	-2.181D-01
SD	9.530D-02	2.771D-01	5.167D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	-8.631D-02	-1.351D-02	-3.475D-01
SD	1.105D-01	1.222D-01	2.075D-01
	12) PCFW01	13) PCFW02	14) PCFW03
B	3.521D-01	1.373D-01	-1.372D-01
SD	1.211D-01	1.515D-01	2.285D-01
	15) PCLR01	16) PCLR02	17) PCLR03
B	1.181D-01	3.470D-01	4.586D-02
SD	1.189D-01	1.564D-01	2.153D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8928 1-R2 0.1072

DF 30 SE2 0.0159

	0) CONST.	1) PCDM01	2) PCDM02
B	2.137D 00	6.936D-02	-1.362D-01
SD	1.839D-02	1.929D-02	1.976D-02
	3) PCDM03	4) PCDM04	5) PCDM05

B	-9.520D-02	1.721D-03	1.288D-01
SD	4.809D-02	4.855D-02	1.063D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	-4.879D-02	1.554D-01	3.401D-02
SD	1.911D-02	5.557D-02	1.036D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	3.693D-02	-3.105D-02	-6.340D-04
SD	2.217D-02	2.451D-02	4.163D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-1.050D-01	-5.406D-02	-4.216D-03
SD	2.429D-02	3.038D-02	4.582D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-5.557D-02	7.070D-03	-1.358D-02
SD	2.385D-02	3.136D-02	4.319D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	3.678D 00	6.559D-02	-4.374D-02
SD	3.075D-01	1.427D-02	2.535D-02
B/SD	1.196D 01	4.597D 00	-1.725D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	2.721D-02	1.141D-02	-1.237D-01
SD	3.328D-02	3.419D-02	8.900D-02
B/SD	8.176D-01	3.338D-01	-1.390D 00
	20) QYHHAT		
B	-2.011D-01		
SD	4.014D-02		

B/SD -5.010D 00

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02
B	3.484D 00	-4.470D-02	7.029D-02
SD	4.790D-01	2.651D-02	7.076D-02
B/SD	7.273D 00	-1.686D 00	9.934D-01

	8) PCPH03	9) PCPC01	10) PCPC02
B	-3.423D-02	-1.559D-02	1.087D-02
SD	1.632D-01	2.967D-02	3.927D-02
B/SD	-2.098D-01	-5.255D-01	2.768D-01

	11) PCPC03	12) PCFW01	13) PCFW02
B	5.335D-04	-3.432D-02	2.706D-02
SD	7.111D-02	4.008D-02	4.141D-02
B/SD	7.502D-03	-8.565D-01	6.536D-01

	14) PCFW03	15) PCLR01	16) PCLR02
B	-2.925D-03	-3.050D-02	-3.478D-02
SD	7.341D-02	2.951D-02	4.891D-02
B/SD	-3.985D-02	-1.034D 00	-7.111D-01

	17) PCLR03	20) QYHHAT
B	-2.266D-02	-1.753D-01
SD	7.038D-02	6.233D-02
B/SD	-3.220D-01	-2.812D 00

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OMAHA MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.8689 1-R2 0.1311

DF 30 SE2 1.1161

	0) CONST.	1) PCDM01	2) PCDM02
B	1.365D 01	-5.645D-01	3.922D-01
SD	1.540D-01	1.616D-01	1.655D-01
	3) PCDM03	4) PCDM04	5) PCDM05
B	3.780D-01	-1.906D-01	-2.860D 00
SD	4.029D-01	4.067D-01	8.903D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	7.212D-02	6.866D-01	-8.507D-01
SD	1.601D-01	4.655D-01	8.681D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	-1.180D-01	1.468D-02	-1.017D-01
SD	1.857D-01	2.053D-01	3.487D-01
	12) PCFW01	13) PCFW02	14) PCFW03
B	1.461D 00	5.437D-01	2.582D-01
SD	2.035D-01	2.545D-01	3.839D-01
	15) PCLR01	16) PCLR02	17) PCLR03
B	-1.342D-01	-5.487D-01	3.225D-01
SD	1.998D-01	2.627D-01	3.618D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8875 1-R2 0.1125

DF 30 SE2 0.0172

	0) CONST.	1) PCDM01	2) PCDM02
B	2.143D 00	7.197D-02	-1.365D-01
SD	1.914D-02	2.009D-02	2.058D-02
	3) PCDM03	4) PCDM04	5) PCDM05
B	-1.019D-01	8.362D-04	1.341D-01

SD	5.007D-02	5.055D-02	1.107D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	-4.987D-02	1.609D-01	4.548D-02
SD	1.990D-02	5.786D-02	1.079D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	3.929D-02	-2.977D-02	2.433D-03
SD	2.308D-02	2.552D-02	4.334D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-1.061D-01	-5.205D-02	-7.564D-03
SD	2.529D-02	3.163D-02	4.771D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-5.883D-02	1.216D-02	-1.338D-02
SD	2.484D-02	3.266D-02	4.497D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	2.982D 00	2.582D-02	-1.237D-01
SD	1.761D-01	1.351D-02	1.702D-02
B/SD	1.694D 01	1.912D 00	-7.270D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	6.581D-02	-1.956D-02	-1.889D-01
SD	2.977D-02	3.279D-02	8.476D-02
B/SD	2.211D 00	-5.967D-01	-2.229D 00
	20) QYHHAT		
B	-6.114D-02		
SD	1.280D-02		
B/SD	-4.775D 00		

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02
B	4.423D 00	-1.435D-02	2.337D-01
SD	4.263D-01	2.411D-02	6.550D-02
B/SD	1.038D 01	-5.950D-01	3.569D 00
	8) PCPH03	9) PCPC01	10) PCPC02
B	-1.546D-01	4.334D-02	-6.268D-03
SD	1.540D-01	2.730D-02	3.688D-02
B/SD	-1.003D 00	1.587D 00	-1.699D-01
	11) PCPC03	12) PCFW01	13) PCFW02
B	3.246D-02	1.565D-01	5.721D-02
SD	6.162D-02	5.896D-02	3.792D-02
B/SD	5.268D-01	2.653D 00	1.509D 00
	14) PCFW03	15) PCLR01	16) PCLR02
B	7.047D-02	-1.064D-01	-8.397D-02
SD	6.777D-02	2.691D-02	4.658D-02
B/SD	1.040D 00	-3.956D 00	-1.802D 00
	17) PCLR03	20) QYHHAT	
B	2.296D-02	-1.673D-01	
SD	6.746D-02	3.125D-02	
B/SD	3.404D-01	-5.352D 00	

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SAINT LOUIS MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.7941 1-R2 0.2059

DF 30 SE2 0.7532

	0) CONST.	1) PCDM01	2) PCDM02
B	1.247D 01	-4.599D-01	3.484D-01
SD	1.265D-01	1.328D-01	1.360D-01
	3) PCDM03	4) PCDM04	5) PCDM05
B	6.034D-01	-1.070D-01	-1.085D 00
SD	3.309D-01	3.341D-01	7.314D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	1.130D-01	3.792D-01	3.175D-01
SD	1.315D-01	3.824D-01	7.131D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	-1.705D-01	1.161D-01	-1.174D-01
SD	1.526D-01	1.687D-01	2.864D-01
	12) PCFW01	13) PCFW02	14) PCFW03
B	6.537D-01	2.831D-01	1.307D-02
SD	1.672D-01	2.090D-01	3.153D-01
	15) PCLR01	16) PCLR02	17) PCLR03
B	-2.822D-02	7.502D-02	3.723D-01
SD	1.641D-01	2.158D-01	2.972D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8976 1-R2 0.1024

DF 30 SE2 0.0151

	0) CONST.	1) PCDM01	2) PCDM02
B	2.166D 00	6.400D-02	-1.439D-01
SD	1.790D-02	1.878D-02	1.924D-02
	3) PCDM03	4) PCDM04	5) PCDM05
B	-9.550D-02	3.409D-03	1.255D-01
SD	4.682D-02	4.727D-02	1.035D-01

	6) PCPH01	7) PCPH02	8) PCPH03
B	-4.926D-02	1.554D-01	2.271D-02
SD	1.861D-02	5.410D-02	1.009D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	3.167D-02	-2.807D-02	-1.985D-03
SD	2.159D-02	2.386D-02	4.053D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-9.698D-02	-5.262D-02	-1.975D-04
SD	2.365D-02	2.958D-02	4.462D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-5.611D-02	3.101D-03	-1.581D-02
SD	2.322D-02	3.054D-02	4.205D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	3.558D 00	1.106D-02	-1.126D-01
SD	2.732D-01	1.445D-02	1.704D-02
B/SD	1.302D 01	7.648D-01	-6.608D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	8.835D-02	-1.094D-02	-9.445D-02
SD	2.879D-02	2.933D-02	7.257D-02
B/SD	3.068D 00	-3.730D-01	-1.301D 00
	20) QYHHAT		
B	-1.114D-01		
SD	2.187D-02		
B/SD	-5.095D 00		

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02
B	5.041D 00	1.060D-02	2.112D-01
SD	4.787D-01	2.282D-02	6.082D-02
B/SD	1.053D 01	4.646D-01	3.472D 00
	8) PCPH03	9) PCPC01	10) PCPC02
B	7.597D-02	2.776D-02	2.377D-02
SD	1.390D-01	2.381D-02	3.253D-02
B/SD	5.467D-01	1.166D 00	7.309D-01
	11) PCPC03	12) PCFW01	13) PCFW02
B	2.173D-02	5.677D-02	3.553D-02
SD	5.446D-02	3.879D-02	3.450D-02
B/SD	3.989D-01	1.464D 00	1.030D 00
	14) PCFW03	15) PCLR01	16) PCLR02
B	9.752D-03	-6.813D-02	3.595D-02
SD	5.952D-02	2.358D-02	4.015D-02
B/SD	1.638D-01	-2.890D 00	8.955D-01
	17) PCLR03	20) QYHHAT	
B	5.147D-02	-2.310D-01	
SD	6.138D-02	3.843D-02	
B/SD	8.385D-01	-6.010D 00	

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SIOUX CITY MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.7767 1-R2 0.2233

DF 30 SE2 1.9702

	0) CONST.	1) PCDM01	2) PCDM02

B	1.296D 01	-3.466D-01	2.829D-01
SD	2.046D-01	2.147D-01	2.200D-01
	3) PCDM03	4) PCDM04	5) PCDM05
B	2.992D-01	-9.729D-01	-2.246D 00
SD	5.352D-01	5.404D-01	1.183D 00
	6) PCPH01	7) PCPH02	8) PCPH03
B	-3.632D-01	4.317D-01	-7.969D-01
SD	2.127D-01	6.185D-01	1.153D 00
	9) PCPC01	10) PCPC02	11) PCPC03
B	-2.451D-01	-9.282D-02	-3.417D-01
SD	2.467D-01	2.728D-01	4.633D-01
	12) PCFW01	13) PCFW02	14) PCFW03
B	1.111D 00	3.027D-01	1.330D-01
SD	2.703D-01	3.381D-01	5.100D-01
	15) PCLR01	16) PCLR02	17) PCLR03
B	2.688D-01	-2.403D-01	1.213D-01
SD	2.655D-01	3.491D-01	4.806D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8901 1-R2 0.1099

DF 30 SE2 0.0169

	0) CONST.	1) PCDM01	2) PCDM02
B	2.150D 00	7.145D-02	-1.391D-01
SD	1.896D-02	1.990D-02	2.038D-02
	3) PCDM03	4) PCDM04	5) PCDM05
B	-9.745D-02	-3.104D-03	1.323D-01
SD	4.960D-02	5.007D-02	1.096D-01
	6) PCPH01	7) PCPH02	8) PCPH03

B	-5.077D-02	1.575D-01	5.169D-02
SD	1.971D-02	5.731D-02	1.069D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	3.628D-02	-2.840D-02	1.119D-04
SD	2.286D-02	2.528D-02	4.293D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-1.081D-01	-5.398D-02	-1.075D-02
SD	2.505D-02	3.133D-02	4.726D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-5.497D-02	1.168D-02	-9.409D-03
SD	2.460D-02	3.235D-02	4.454D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	2.766D 00	5.570D-02	-1.270D-01
SD	1.789D-01	1.294D-02	1.966D-02
B/SD	1.546D 01	4.305D 00	-6.461D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	5.196D-02	4.902D-03	-1.157D-01
SD	3.350D-02	3.680D-02	9.057D-02
B/SD	1.551D 00	1.332D-01	-1.277D 00
	20) QYHHAT		
B	-4.723D-02		
SD	1.371D-02		
B/SD	-3.444D 00		

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02

B	4.903D 00	-7.681D-02	1.888D-01
SD	9.729D-01	3.988D-02	1.019D-01
B/SD	5.039D 00	-1.926D 00	1.852D 00
	8) PCPH03	9) PCPC01	10) PCPC02
B	-2.052D-01	-2.253D-03	2.985D-03
SD	2.521D-01	4.214D-02	5.945D-02
B/SD	-8.140D-01	-5.347D-02	5.021D-02
	11) PCPC03	12) PCFW01	13) PCFW02
B	-7.707D-03	2.028D-01	1.167D-02
SD	9.989D-02	1.169D-01	6.321D-02
B/SD	-7.716D-02	1.735D 00	1.846D-01
	14) PCFW03	15) PCLR01	16) PCLR02
B	6.869D-02	-5.216D-02	-5.765D-02
SD	1.098D-01	4.055D-02	7.153D-02
B/SD	6.259D-01	-1.286D 00	-8.059D-01
	17) PCLR03	20) QYHHAT	
B	-1.167D-02	-2.125D-01	
SD	1.069D-01	7.515D-02	
B/SD	-1.092D-01	-2.828D 00	

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SOUTH ST. JOSEPH MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.8141 1-R2 0.1859

DF 30 SE2 0.5869

	0) CONST.	1) PCDM01	2) PCDM02
B	8.988D 00	3.694D-02	9.775D-02

SD	1.117D-01	1.172D-01	1.201D-01
	3) PCDM03	4) PCDM04	5) PCDM05
B	1.378D-01	-2.140D-01	-1.156D 00
SD	2.921D-01	2.949D-01	6.456D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	2.045D-01	2.917D-01	-4.447D-01
SD	1.161D-01	3.376D-01	6.295D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	-5.137D-02	-1.566D-02	-3.650D-01
SD	1.347D-01	1.489D-01	2.529D-01
	12) PCFW01	13) PCFW02	14) PCFW03
B	8.946D-01	9.903D-02	9.444D-02
SD	1.476D-01	1.845D-01	2.784D-01
	15) PCLR01	16) PCLR02	17) PCLR03
B	2.267D-02	2.650D-01	1.459D-02
SD	1.449D-01	1.905D-01	2.623D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8929 1-R2 0.1071

DF 30 SE2 0.0167

	0) CONST.	1) PCDM01	2) PCDM02
B	2.140D 00	7.170D-02	-1.394D-01
SD	1.883D-02	1.976D-02	2.024D-02
	3) PCDM03	4) PCDM04	5) PCDM05
B	-1.001D-01	-2.518D-04	1.319D-01
SD	4.926D-02	4.973D-02	1.089D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	-5.241D-02	1.595D-01	4.119D-02

SD	1.958D-02	5.692D-02	1.061D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	3.878D-02	-2.839D-02	1.422D-03
SD	2.271D-02	2.510D-02	4.264D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-1.067D-01	-5.554D-02	-3.695D-03
SD	2.488D-02	3.111D-02	4.694D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-5.810D-02	7.679D-03	-1.178D-02
SD	2.443D-02	3.213D-02	4.423D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	2.996D 00	4.467D-02	-1.222D-01
SD	1.864D-01	1.248D-02	1.704D-02
B/SD	1.607D 01	3.579D 00	-7.171D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	6.212D-02	-2.282D-02	-1.469D-01
SD	3.180D-02	3.628D-02	8.918D-02
B/SD	1.953D 00	-6.289D-01	-1.647D 00
	20) QYHHAT		
B	-9.460D-02		
SD	2.058D-02		
B/SD	-4.596D 00		

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02
B	2.989D 00	-3.553D-02	1.448D-01

SD	1.275D 00	3.833D-02	9.065D-02
B/SD	2.345D 00	-9.269D-01	1.598D 00
	8) PCPH03	9) PCPC01	10) PCPC02
B	-8.741D-02	1.134D-03	2.497D-02
SD	2.080D-01	3.457D-02	4.821D-02
B/SD	-4.203D-01	3.281D-02	5.179D-01
	11) PCPC03	12) PCFW01	13) PCFW02
B	2.054D-02	-2.491D-02	5.122D-02
SD	9.391D-02	1.391D-01	5.034D-02
B/SD	2.187D-01	-1.790D-01	1.017D 00
	14) PCFW03	15) PCLR01	16) PCLR02
B	2.776D-02	-6.483D-02	-1.833D-02
SD	8.879D-02	3.425D-02	6.330D-02
B/SD	3.127D-01	-1.893D 00	-2.896D-01
	17) PCLR03	20) QYHHAT	
B	-2.776D-02	-9.388D-02	
SD	8.705D-02	1.417D-01	
B/SD	-3.189D-01	-6.624D-01	

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SOUTH ST. PAUL MARKET

REDUCED FORM, DEP VAR QUANTITY HOGS

R2 0.8049 1-R2 0.1951

DF 30 SE2 0.7184

	0) CONST.	1) PCDM01	2) PCDM02
B	9.972D 00	-3.589D-01	1.063D-01
SD	1.236D-01	1.297D-01	1.328D-01

	3) PCDM03	4) PCDM04	5) PCDM05
B	3.985D-01	-7.635D-01	-6.080D-01
SD	3.232D-01	3.263D-01	7.142D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	-2.800D-01	-7.833D-01	-6.721D-02
SD	1.284D-01	3.735D-01	6.964D-01
	9) PCPC01	10) PCPC02	11) PCPC03
B	-3.019D-01	6.358D-02	-5.415D-01
SD	1.490D-01	1.647D-01	2.797D-01
	12) PCFW01	13) PCFW02	14) PCFW03
B	8.111D-01	3.953D-01	1.936D-02
SD	1.632D-01	2.041D-01	3.080D-01
	15) PCLR01	16) PCLR02	17) PCLR03
B	1.165D-01	-8.057D-01	4.278D-01
SD	1.603D-01	2.108D-01	2.902D-01

REDUCED FORM, DEP VAR PRICE HOGS

R2 0.8956 1-R2 0.1044

DF 30 SE2 0.0157

	0) CONST.	1) PCDM01	2) PCDM02
B	2.160D 00	7.552D-02	-1.308D-01
SD	1.830D-02	1.920D-02	1.967D-02
	3) PCDM03	4) PCDM04	5) PCDM05
B	-1.081D-01	1.130D-02	1.578D-01
SD	4.785D-02	4.831D-02	1.058D-01
	6) PCPH01	7) PCPH02	8) PCPH03
B	-4.949D-02	1.641D-01	5.179D-02
SD	1.902D-02	5.530D-02	1.031D-01

	9) PCPC01	10) PCPC02	11) PCPC03
B	3.762D-02	-2.302D-02	4.490D-03
SD	2.206D-02	2.439D-02	4.142D-02
	12) PCFW01	13) PCFW02	14) PCFW03
B	-1.058D-01	-6.057D-02	-6.094D-03
SD	2.417D-02	3.023D-02	4.560D-02
	15) PCLR01	16) PCLR02	17) PCLR03
B	-6.689D-02	1.465D-02	-1.700D-02
SD	2.374D-02	3.121D-02	4.297D-02

THREE STAGE LEAST SQUARES, DEMAND & SUPPLY

DEMAND, DEP VAR PRICE HOGS

	0) CONST.	1) PCDM01	2) PCDM02
B	3.100D 00	5.688D-02	-1.113D-01
SD	2.088D-01	1.231D-02	1.781D-02
B/SD	1.485D 01	4.621D 00	-6.250D 00
	3) PCDM03	4) PCDM04	5) PCDM05
B	-1.440D-03	1.522D-02	-7.955D-02
SD	3.415D-02	3.356D-02	8.329D-02
B/SD	-4.217D-02	4.535D-01	-9.551D-01
	20) QYHHAT		
B	-9.420D-02		
SD	2.092D-02		
B/SD	-4.504D 00		

SUPPLY, DEP VAR PRICE HOGS

	0) CONST.	6) PCPH01	7) PCPH02
B	5.619D 00	-4.840D-02	-9.771D-02
SD	9.071D-01	3.223D-02	1.045D-01

B/SD	6.194D 00	-1.502D 00	-9.350D-01
	8) PCPH03	9) PCPC01	10) PCPC02
B	-7.005D-02	-3.710D-02	4.834D-02
SD	2.026D-01	3.628D-02	4.924D-02
B/SD	-3.458D-01	-1.023D 00	9.817D-01
	11) PCPC03	12) PCFW01	13) PCFW02
B	-8.333D-02	2.334D-01	7.510D-02
SD	8.890D-02	9.796D-02	5.076D-02
B/SD	-9.374D-01	2.383D 00	1.479D 00
	14) PCFW03	15) PCLR01	16) PCLR02
B	5.275D-02	-4.935D-02	-1.798D-01
SD	8.946D-02	3.444D-02	8.022D-02
B/SD	5.896D-01	-1.433D 00	-2.241D 00
	17) PCLR03	20) QYHHAT	
B	9.108D-02	-3.474D-01	
SD	9.631D-02	9.112D-02	
B/SD	9.457D-01	-3.812D 00	

LABELS, PRINCIPLE COMPONENT REGRESSION

CONST. = CONSTANT.

PCOMOK = KTH PRINCIPLE COMPONENT OF BEEF, LAMB, CHICKEN, TURKEY PRICES, PLUS STOCKS AND INCOME.

PCFWOK = KTH PRINCIPLE COMPONENT OF FARROWINGS LAGGED 6, 7, 8 MONTHS.

PCLROK = KTH PRINCIPLE COMPONENT OF PIGS PER LITTER LAGGED 6, 7, 8 MONTHS.

PCPHOK = KTH PRINCIPLE COMPONENT OF SLAUGHTER HOG PRICES LAGGED 10, 11, 12 MONTHS.

PCPCOK = KTH PRINCIPLE COMPONENT OF CORN PRICES LAGGED 10, 11, 12 MONTHS.

QYHHAT = QUANTITY SLAUGHTER HOGS AS ESTIMATED IN THE REDUCED FORM.

APPENDIX TWO:

PRINCIPLE COMPONENTS

OF PREDETERMINED DEMAND

AND SUPPLY VARIABLES

PRINCIPLE COMPONENTS

CORRELATION COEFFICIENT MATRIX

	PRBEEF	PRLAMB	PRCHKN	PRTRKY	INCOME	STOCKS
PRBEEF	1.0000	0.9464	0.5892	-0.1223	0.8716	-0.1600
PRLAMB	0.9464	1.0000	0.4967	-0.2201	0.9457	-0.0975
PRCHKN	0.5892	0.4967	1.0000	0.2414	0.2901	-0.3942
PRTRKY	-0.1223	-0.2201	0.2414	1.0000	-0.3294	-0.4907
INCOME	0.8716	0.9457	0.2901	-0.3294	1.0000	0.0630
STOCKS	-0.1600	-0.0975	-0.3942	-0.4907	0.0630	1.0000

EIGEN VALUES

3.19147 1.77379 0.49840 0.44865 0.06451 0.02316

CUMULATIVE PROPORTION OF TOTAL VARIANCE

0.53	0.83	0.91	0.99	1.00	1.00

EIGEN VECTORS

	1	2	3	4	5	6
PRBEEF	0.5460	-0.0257	-0.0053	-0.1007	-0.8061	-0.2032
PRLAMB	0.5495	0.0639	-0.1203	-0.1061	0.1834	0.7966
PRCHKN	0.3434	-0.4122	0.7377	0.3279	0.2254	-0.1007
PRTRKY	-0.1053	-0.6275	0.0307	-0.7697	0.0407	0.0156
INCOME	0.5131	0.2125	-0.2476	-0.2374	0.5126	-0.5579
STOCKS	-0.0878	0.6217	0.6157	-0.4715	-0.0369	0.0494

EIGEN VALUE CHECK MATRIX

	PRBEEF	PRLAMB	PRCHKN	PRTRKY	INCOME	STOCKS
PRBEEF	3.1915	0.0000	0.0000	-0.0000	0.0000	-0.0000
PRLAMB	0.0000	1.7738	-0.0004	0.0000	-0.0000	-0.0000
PRCHKN	0.0000	-0.0004	0.4984	0.0000	0.0000	0.0000
PRTRKY	-0.0000	0.0000	0.0000	0.4487	-0.0000	0.0000

INCOME	0.0000	-0.0000	0.0000	-0.0000	0.0645	-0.0000
STOCKS	-0.0000	-0.0000	0.0000	0.0000	-0.0000	0.0232

CORRELATION COEFFICIENT MATRIX

	PHG-10	PHG-11	PHG-12
PHG-10	1.000	0.8713	0.6584
PHG-11	0.8713	1.000	0.8768
PHG-12	0.6584	0.8768	1.000

EIGEN VALUES

2.6083879 0.3416062 0.0500057

CUMULATIVE PROPORTION OF TOTAL VARIANCE

0.87 0.98 1.00

EIGEN VECTORS

	1	2	3
PHG-10	0.5599	0.7123	0.4233
PHG-11	0.6094	-0.0078	-0.7929
PHG-12	0.5614	-0.7019	0.4384

EIGEN VALUE CHECK MATRIX

	PHG-10	PHG-11	PHG-12
PHG-10	2.6084	-0.000	0.000000
PHG-11	-0.0000	0.3416	0.000000
PHG-12	0.0000	0.0000	0.0500

CORRELATION COEFFICIENT MATRIX

	PCN-10	PCN-11	PCN-12
PCN-10	1.000	0.6545	0.3387
PCN-11	0.6545	1.000	0.6622
PCN-12	0.3387	0.6622	1.0000

EIGEN VALUES

2.1156406 0.6613328 0.2230252

CUMULATIVE PROPORTION OF TOTAL VARIANCE

0.71 0.93 1.00

EIGEN VECTORS

	1	2	3
PCN-10	0.5412	0.7127	0.4463
PCN-11	0.6407	-0.0058	-0.7678
PCN-12	0.5446	-0.7015	0.4597

EIGEN VALUE CHECK MATRIX

	PCN-10	PCN-11	PCN-12
PCN-10	2.1156	-0.0000	-0.0000
PCN-11	-0.000	0.6613	-0.0000
PCN-12	-0.0000	-0.0000	0.2230

CORRELATION COEFFICIENT MATRIX

	FRWG-6	FRWG-7	FRWG-8
FRWG-6	1.000	0.5125	-0.1220
FRWG-7	0.5125	1.000	0.5096
FRWG-8	-0.1220	0.5096	1.000

EIGEN VALUES

1.6643019 1.1220045 0.2136930

CUMULATIVE PROPORTION OF TOTAL VARIANCE

0.55 0.93 1.00

EIGEN VECTORS

	1	2	3
FRWG-6	0.4804	0.7050	0.5217
FRWG-7	0.7362	-0.0010	-0.6767
FRWG-8	0.4766	-0.7092	0.5195

EIGEN VALUE CHECK MATRIX

	FRWG-6	FRWG-7	FRWG-8
FRWG-6	1.6643	-0.00000	-0.0000
FRWG-7	-0.0000	1.1220	-0.0000
FRWG-8	0.00000	-0.0000	0.2137

CORRELATION COEFFICIENT MATRIX

	LITR-6	LITR-7	LITR-8
LITR-6	1.0000	0.6681	0.3511
LITR-7	0.6681	1.00000	0.6817
LITR-8	0.3511	0.6817	1.0000

EIGEN VALUES

2.1460676 0.6489579 0.2049628

CUMULATIVE PROPORTION OF TOTAL VARIANCE

0.72 0.93 1.00

EIGEN VECTORS

	1	2	3
LITR-6	0.5404	0.7167	0.4407
LITR-7	0.6400	-0.0101	-0.7683
LITR-8	0.5462	-0.6973	0.4641

EIGEN VALUE CHECK MATRIX

	LITR-6	LITR-7	LITR-8
LITR-6	2.1461	-0.000	-0.0000
LITR-7	-0.000	0.6490	0.000
LITR-8	-0.000	0.0000	0.2050

LABELS, PRINCIPLE COMPONENTS

PRBEEF = PRICE OF BEEF, RETAIL.

PRLAMB = PRICE OF LAMB, RETAIL.

PRCHKN = PRICE OF CHICKEN, RETAIL.

PRTRKY = PRICE OF TURKEY, RETAIL.

INCOME = PERSONAL INCOME.

STOCKS = COLD STORAGE HOLDINGS PLUS FROZEN PORK.

PHG-10 = PRICE SLAUGHTER HOGS, LAGGED 10 MONTHS.

PHG-11 = PRICE SLAUGHTER HOGS, LAGGED 11 MONTHS.

PHG-12 = PRICE SLAUGHTER HOGS, LAGGED 12 MONTHS.

PCN-10 = PRICE OF CORN, LAGGED 10 MONTHS

PCN-11 = PRICE OF CORN, LAGGED 11 MONTHS

PCN-12 = PRICE OF CORN, LAGGED 12 MONTHS

FRWG-6 = FARROWINGS, LAGGED 6 MONTHS.

FRWG-7 = FARROWINGS, LAGGED 7 MONTHS.

FRWG-8 = FARROWINGS, LAGGED 8 MONTHS.

LITR-6 = PIGS PER LITTER, LAGGED 6 MONTHS.

LITR-7 = PIGS PER LITTER, LAGGED 7 MONTHS.

LITR-8 = PIGS PER LITTER, LAGGED 8 MONTHS.

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