QUANTITATIVE MODELS TO PREDICT MONTHLY SLAUGHTER HOG PRICES IN CONJUNCTION WITH RELATED HEDGING STRATEGIES

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PREFACE

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CHAPTER I

INTRODUCTION

Current Situation

The hog production industry is constantly exposed to variation in hog prices. This variation is a result of a well defined hog cycle and seasonal production patterns as well as other associated factors such as feed grain prices.

Historically, live hog prices are extremely variable over years as well as within any given year. While there has been a definite general upward trend in hog prices in at least the last decade, cyclical and seasonal factors have caused large price changes within relatively short time periods. Factors affecting seasonal hog price patterns include weather, feed grain harvesting periods, and seasonal consumption patterns. The cyclical price pattern is attributed to biological time lags inherent to hog production as well as producer reaction to a change in the price level.

Price data in recent years give evidence of these large variations in hog prices (Figure 1). For example, in June, 1970 the price for U.S. #1-3, 220-240 pound class hogs at Omaha was $24.04 per hundredweight (cwt.). Only six months later in December the price had dropped $8.37 to $15.67 per cwt. Earlier, in April of 1969, the price was $20.38 per cwt. By August of 1969, the price had risen by $6.53 to $26.91 per cwt.

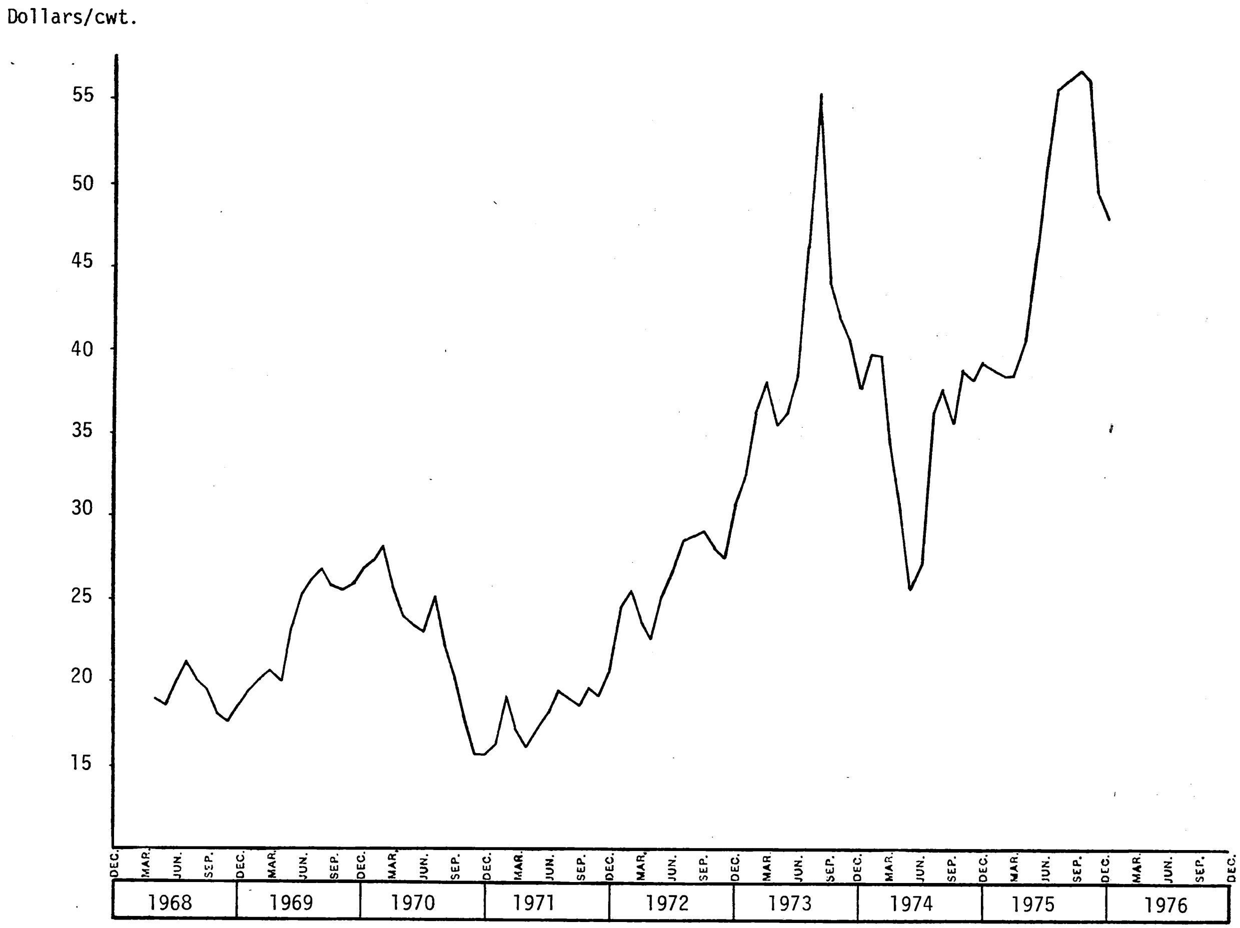

Figure 1. Hog Prices, U. S. #1-3, 220-240 Pound Slaughter Hogs at Omaha, April 1968-December 1976

While these price variations are significant, they are overshadowed by the slaughter hog price variation in 1973-74. In January of 1973 the price was $32.53 per cwt. for Omaha hogs, but by the following August the price had climbed to a new record high of $56.68 per cwt. By May, 1974, the price had dropped to $26.90 per cwt. These large price variations greatly increase the risk to the hog producer.

Historically, the futures market has also shown large variations in slaughter hog prices. For example, in November, 1973, the December, 1973 futures contract for live hogs was trading at $23.60 per cwt., while in August of 1973 the price of the same contract was $55.40 per cwt. Such large price variations pose problems to the hog producer who wishes to use the hedging mechanism to avert price risk. Figure 2 shows how futures prices have varied over the past several years in comparison with cash prices.

Not only have prices been highly variable in recent years, the cost of production has climbed to new record levels. High production costs combined with highly variable slaughter hog prices have caused the hog producers' profit margin to become highly variable. Figure 3 shows how profit margins have varied over recent years (Profit = Value of U.S. #1-3, 220-240 pound slaughter hog at Omaha - [Corn Price x 9.3 bushels] - [Meal Price x .052]). Note that in several short time periods between 1970 and 1975 it has generally been unprofitable to produce hogs.

The Problem

The large variation of slaughter hog prices in recent years has meant that hog producers have encountered considerable price risk in

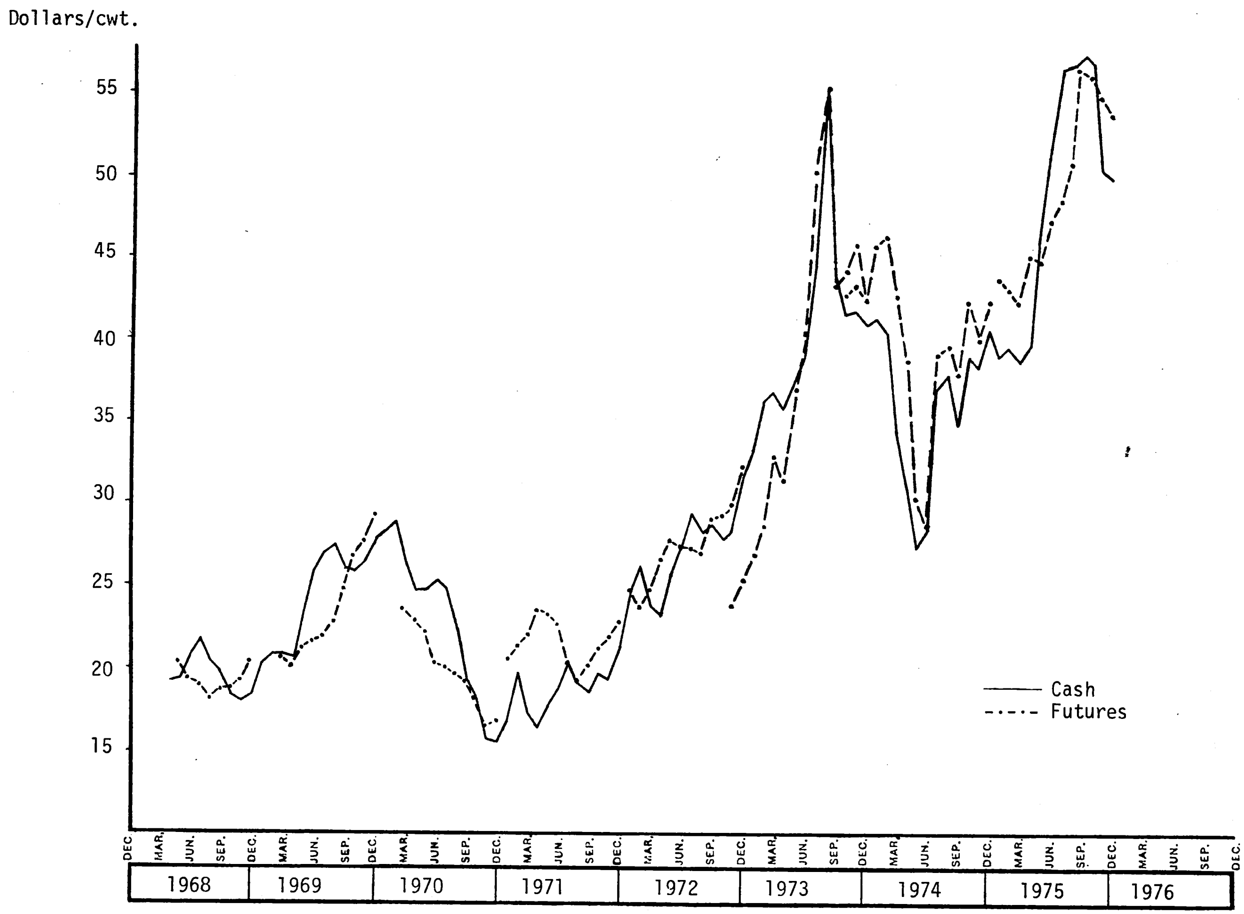

Figure 2. Cash Hog Prices U. S. #1-3, 220-240 Pound Slaughter Hogs at Omaha and Live Hog Futures December Contract Prices, Chicago Mercantile Exchange, April 1968 to December 1975

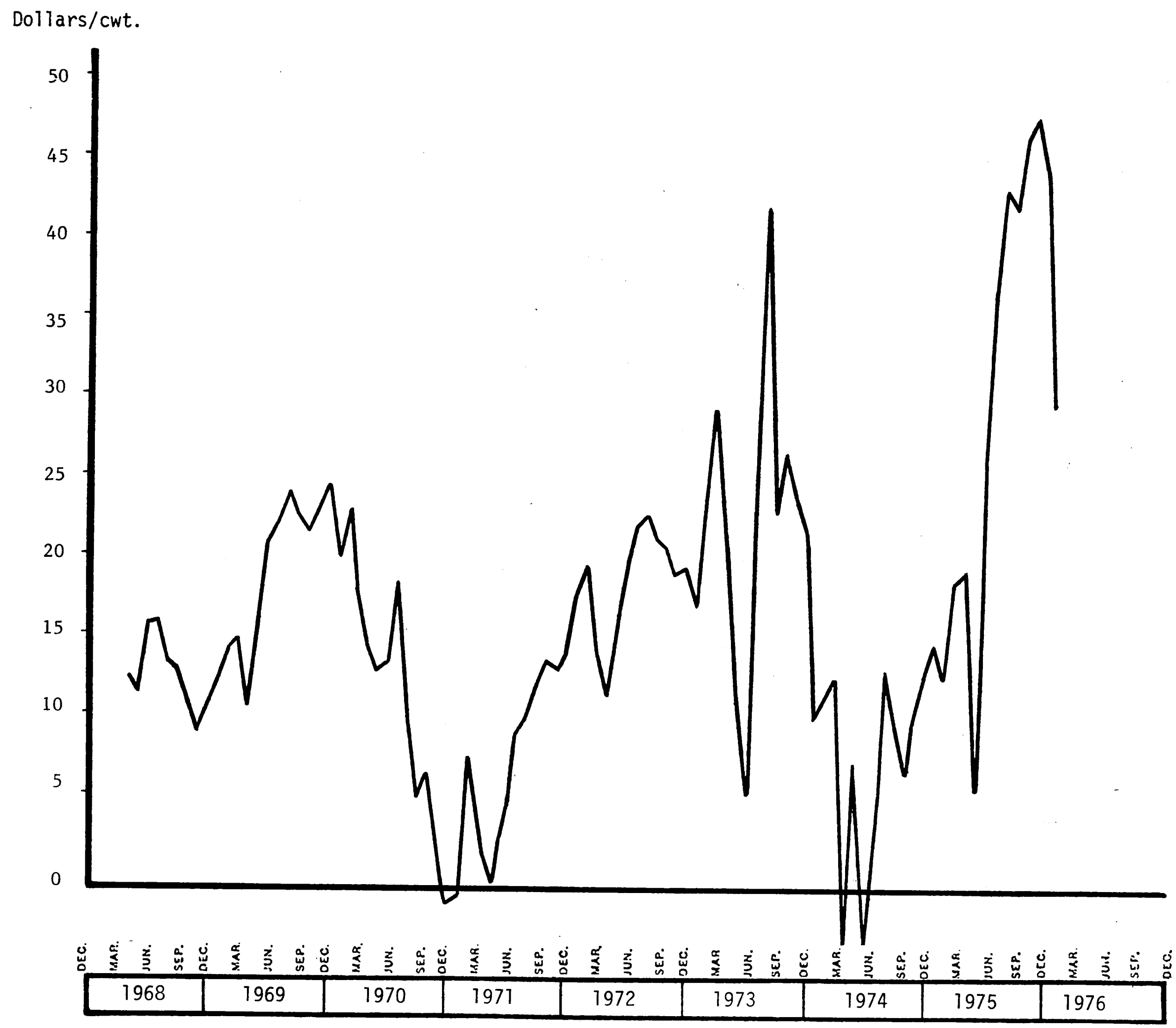

Figure 3. Monthly Profits of U. S. Hog Producers, April 1968-December 1975

the marketing of hogs. It has been difficult for the hog producer to make effective marketing decisions.

Given currently accepted feeding rates and slaughter weights, a producer must decide up to six months in advance of market time how many hogs to produce for market. Even though forward cash contracting as well as futures trading on the Chicago Mercantile Exchange have provided a means of price risk transfer, the use of these tools has not become widespread among producers. Some possible explanations for this are possible high margin costs, lack of knowledge about futures trading, and fear of large potential losses or reduced net returns.

Short-run, monthly hog price forecasts would be of great value to hog producers in their marketing decisions. Little has been done in the area of developing simple, effective methods to predict cash price of hogs. At present, mathematical forecast models are not extensively used by hog producers or by extension personnel because the methods either have not been reliable or are very complex and not localized. Forecast methods that are simple to use and which accurately forecast hog prices from one to six months in the future are needed. In addition, producers need to be informed of effective hedging strategies using the futures market to help avert price risks in the cash hog market.

Review of Literature

A survey of the literature quickly shows that little has been done in the area of short-run (one to six months) price predictions for hogs. However, several studies do merit review. Several articles pertaining to the hedging aspect of the hog industry will also be reviewed.

Hog Price Forecasting

In a comparative study on the short run demand for farm products, Fox[1] found that multiple and single equation models, when using ordinary least squares, differ by less than one standard error. The author concluded that the simplicity of single equation models in relation to multiple equation systems allow single equation models to be used much more readily when attempting to predict price by ordinary least squares.

Hayenga and Hacklander[2] attempted to predict Chicago cash hog prices one to six months in advance by the use of least squares regression. Many independent variables were first estimated for the same time period that price predictions were desired. These estimated variables included (1) beef and pork production divided by the number of fully utilized slaughter days in the price prediction month, (2) U. S. population at mid-month, and (3) cold storage holdings of frozen and cured pork in the 48 contiguous states during the previous month.

Hayenga and Hacklander thus produced one to eight month predictive models that explained 96 percent of the variation in monthly prices of U. S. #1 and 2 slaughter hogs at Chicago during the April, 1963 through June, 1968, time period. The authors predicted a set of prices outside the data range during the July-December, 1968 period to show the true predictive powers of the model. The authors state that better estimates of pork production are necessary in order to improve the accuracy of the price models.

Moore[3] in trying to predict monthly prices of Choice steers, found it necessary first to predict pork production. The independent variables used included five different weight classes of hogs, starting with the less than 60 pound class and ending with the greater than 220 pound class, each class encompassing a 60 pound increment. Also included were the number of fully utilized slaughter days in the month being predicted and eleven monthly dummy variables to account for otherwise unspecified seasonal variation in production. Moore used eight models, one for each month a prediction was desired (one to eight months into the future). The squared correlation coefficients (R^2) ranged from a high of .89 for the three month model to a low of .75 for the eight month model. The author noted that the lower R^2's in the later months could result from hogs in class 1 (less than 60 pounds) having been slaughtered by the seventh and eighth month.

Crom and Sullivan[4] developed a simulation procedure to estimate pork production and slaughter hog price as far into the future as 1985. The study was done to assess the effect of vertical coordination on pork production and price. Seven alternative vertical structures were simulated, none of which caused abnormal patterns in either production or price. The authors found that none of the alternatives tested predicted a price difference of greater than $2.65 per cwt. from that predicted by a non-integrated simulation.

Hedging Strategies on the Futures Market

Tomek and Gray[6] state "the function of a futures market for commodities without continuous inventories is to provide a price for a forthcoming delivery month". The authors show the the cash-future price relationships between continuous inventory commodities and non-inventory commodities are significantly different. The authors further conclude "the introduction of a futures market into a situation in which one did not previously exist may reduce the variability of prices if the market becomes viable".

Purcell, Holland and Hague[5] tested seven different hedging strategies for cattle feeders by the use of mean-variance analysis. The authors tested several hedging strategies which increased the mean net return and reduced the variance of that return compared to not hedging. The hedging strategies include (1) a no-hedge strategy, (2) a seasonal hedging strategy, (3) hedging when the expected lock-in margin is greater than or equal to the return of a no-hedge feeding operation, and (4) a seasonal hedge with a correction mechanism for adverse price change. The no-hedge feeding operation produced a mean of $10.16 per head and a variance of 454.71. The seasonal hedging operation produced a mean net return of $10.96 per head and a variance of 407.97. The strategy based on the lock-in margin yielded a mean net return of $10.32 per head and a variance of 301.95. The corrective hedging strategy yielded the highest mean of all strategies tested, $11.63 per head, but also had a large variance, 438.85, denoting a large amount of risk. The authors state "further work, especially involving the incorporation of more refined short-tun price projection techniques would appear to be very promising".

Peck[7] analyzed the performance of the futures market in increasing producer returns in the egg industry. The study used a portfolio approach which consisted of analyzing net returns to producers in conjunction with the amount of risk associated with a specific net return a producer might receive. The author notes "optimal hedging strategies, derived from a portfolio approach, reduced markedly the

the producer's exposure to unpredictable price variation". It was found in the study that use of the futures market did stabilize producer returns and, if used in conjunction with cash price forecasts, could possibly increase producers income and reduce the risk associated with the expected increased income. The author concluded that there is a need to evaluate this and other approaches using other commodities to determine if the possibility exists for providing producers higher and more stable incomes via the futures market.

Ward and Flecher[8] attempted to distinguish between hedging and speculation by means of preference functions for risk aversion for both producer and consumer market agencies. The preference function, coupled with a set of price expectations and a probability distribution for these prices led to the development of an optimal position in both the cash and futures market. The article contrasted differences between futures hedging and forward contracting. However, no formal decision criteria for choosing bewteen these two methods of risk aversion were presented. The authors concluded "the implications of the micro model for aggregate market determination of price, output and profits of buyers and sellers remain to be explored".

Objectives

The general objective of this study was to develop a mathematical hog price forecasting model which can be used to aid hog producers in making marketing decisions and to determine the feasibility of selected futures market hedging strategies which include the forecasting model.

Specific sub-objectives were:

(1) to develop econometric models to forecast average monthly

prices of U.S. #1-3, 220-240 pound slaughter hogs at Omaha for one to six months into the future;

(2) to illustrate and evaluate the accuracy of the price forecasting models;

(3) to incorporate the price outlook models in examining the feasibility of several alternative hedging strategies in the live hog futures market; and

(4) to infer possible advantages of using the model in arriving at marketing decisions by hog producers.

Procedure

In order to obtain econometric models to forecast 220-240 pound slaughter hogs, multiple regression was employed to analyze time series price and production data. The average monthly price of U.S. #1-3, 220-240 pound slaughter hogs at Omaha was regressed on several explanatory variables associated with supply and demand for hogs. The explanatory variables included those to which price displays a lagged response and variables to which price responds in the current time period.

To illustrate and evaluate the accuracy of the price forecasting models, graphic analysis was employed to compare predicted with actual cash prices for each monthly model. Both backcasting and forecasting comparisons were made.

Several different futures market hedging strategies were developed and evaluated according to mean net returns and variances (a measure of risk).

In order to demonstrate uses of the price forecast models when making marketing decisions, subjective inferences were drawn as to the use of the price prediction modesl as an aid to the hog producer in his marketing decisions. Also, inferences were drawn as to the possible use of different hedging mechanisms to remove some of the price risk the hog producer must face.

FOOTNOTES

[1]Fox, Karl A. The Analysis of Demand for Farm Products, USDA Technical Bulletin 1081, September, 1953.

[2]Hayenga, Marvin and Duane Hacklander. Short-Run Livestock Price Prediction Models, Michigan Agr. Exp. Sta. Bul. 25, East Lansing, 1970.

[3]Moore, W. W. "Quantitative Models to Predict Prices of Choice Steers". Unpublished M.S. Thesis, Oklahoma State University, 1975.

[4]Crom, Richard and James Sullivan. Effects of Changes in Vertical Integration on Pork Production and Price, USDA-ERS Agr. Econ. Rep. 303, August, 1975.

[5]Holland, David, Wayne D. Purcell and Terry M. Hague. Economic Evaluation of Alternative Hedging Strategies for the Cattle Feeder, Oklahoma Agr. Exp. Sta. Bul. B-702, September, 1972.

[6]Tomek, William G. and Roger Gray. "Temporal Relationships Among Prices and Commodity Futures Markets: Their Allocative and Stabilization Roles", Amer. J. of Agr. Econ. 52(1970):372-380.

[7]Peck, Anne E. "Hedging and Income Stability: Concepts, Implications and an Example", Amer. J. of Agr. Econ. 57(1975):410-419.

[8]Ward, Ronald W. and Lehman B. Fletcher. "From Hedging to Pure Speculative: A Micro Model of Optimal Futures and Cash Positions", Amer. J. of Agr. Econ. 53(1971):71-78.

CHAPTER II

CONCEPTUAL FRAMEWORK OF FORECASTING SLAUGHTER HOG PRICES

When dealing with any economic subject, the economic theory that affects the particular subject must be considered. When dealing with price forecasting, an important guide for model formulation is the economic theory enveloping price determination, price discovery and the difference between the two concepts. This chapter attempts to describe the economic framework within which the hog producer operates when marketing hogs and within which hog prices are forecast or discovered.

Price Determination and Price Discovery

When making a distinction between price determination and price discovery it is useful to draw an analogy from meteorology. The meteoroligist "discovers" the weather but natural factors "determine" or cause it. On the other hand, the factors that determine price are primarily (1) the structure of the industry and (2) how the laws of supply and demand interact within that structure. Individuals attempt to discover that respective price given their knowledge of the determining factors.

Price Determination

The structure of the hog production industry in the United States closely approaches pure competition. Theoretically, pure competition exists when three conditions are met: (1) the relative insignificance of the individual firm's input and output units in relation to the total market, (2) homogeneity of the product, and (3) open entry and exit to and from the industry. The hog producing sector of the economy generally meets these criteria. The exception occurs when a producer can buy supplies or sell products in a restricted market in which he plays a large part. When pure competition exists, the producer is forced into the role of a price taker. He has no direct part in deciding what price he will receive for his hogs when he takes them to market. The price of hogs is determined by the market demand for and the market supply of slaughter hogs.

Demand. The demand for live hogs is "derived" from the demand for pork products at the retail level. The grocery retailer observes the price that consumers are currently willing to pay for pork at the quantities traded, and he then decides what he is able to pay the wholesaler for a given quantity of pork products. The retailer calculates his wholesale "bid" by subtracting operating cost and a "normal economic return" on his investment from the retail price of pork. The wholesaler and packer go through the same procedure and the packer calculates the price he offers the hog producer. Therefore, the factors which influence demand (and price) at the retail level also affect demand at the farm level. These factors or "demand shifters" include, (1) consumer income, (2) taste and preferences of consumers, and (3) prices and availability of substitute goods. Each of these demand factors must be considered when discussing the factors which determine price.

Supply. It can be shown that an individual producer's supply function is that portion of the producer's marginal cost curve that lies above the average variable cost curve (in the short run) (Figure 4). The marginal cost (supply) curve is determined primarily by the price on inputs and prevailing technology. A change in any of these factors will cause a shift in supply.[1] The market supply curve is the summation of the individual producers' supply (marginal cost) curves. Note that in Figure 4, a change in the price of the good Y produces a change in the quantity supplied, not a change in supply.

The quantity of a good supplied is primarily determined by what producers expect the price to be for the good when that goos is marketed. However, once the hog producer has estimated what the price of hogs will be when they are ready for slaughter and he has farrowed his sows accordingly, the future quantity of slaughter hogs produced is relatively fixed. The interaction of this relatively inelastic supply with derived demand determines price.

Demand-Supply Interaction. The interaction of supply and demand over time may cause certain price patterns to develop. Observation and analysis of these patterns can be useful to a price forecaster. Such price patterns exist for slaughter hog prices and are commonly separated into secular (trend), cyclical, and seasonal variation.

When viewed over the long run, there exists a clear upward trend in hog prices in the last 20 years. Demand has increased with

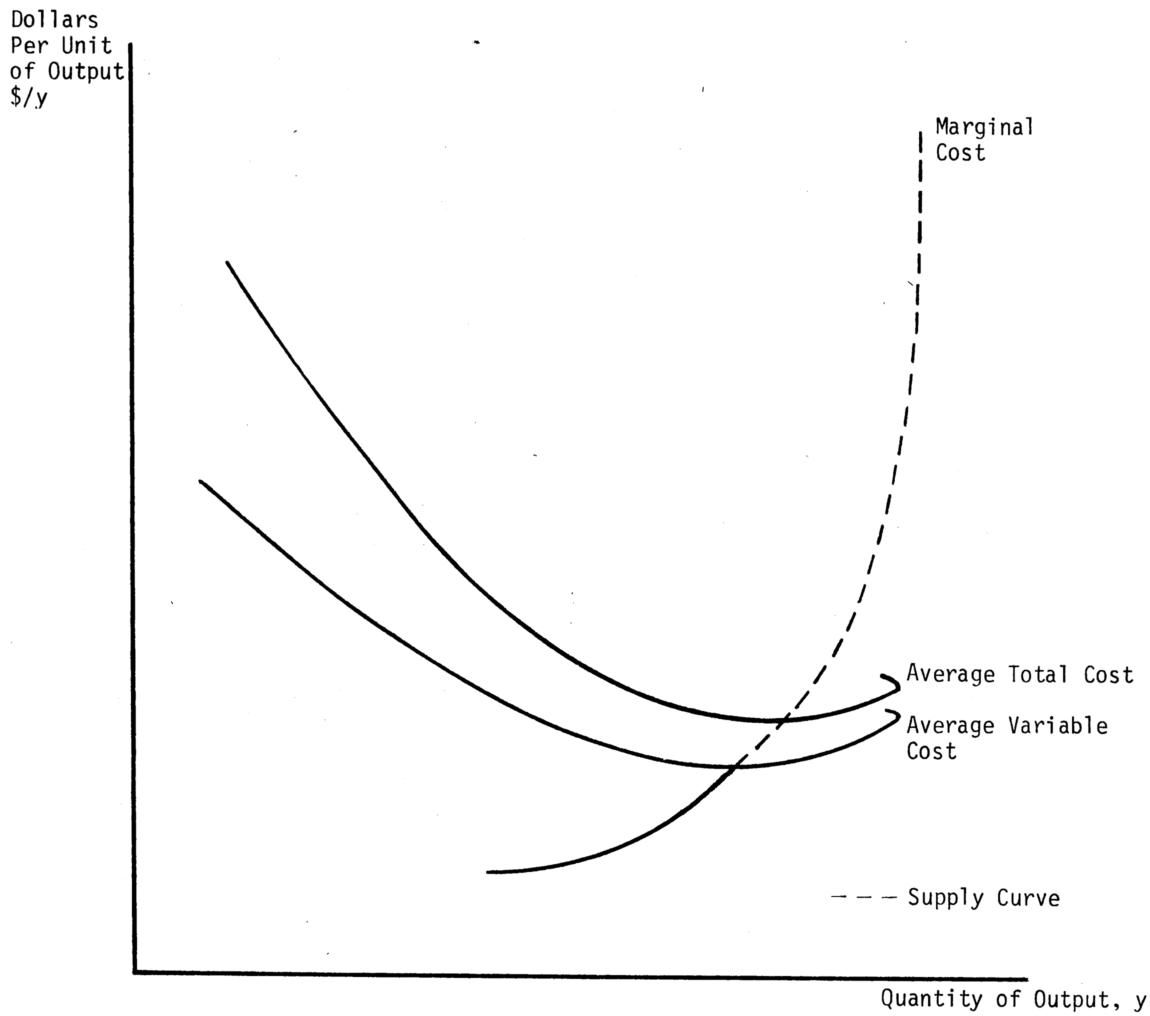

Figure 4. Derivation of a Supply Curve from Cost Curves

population and income increases; and to a lesser extent, supply has increased because of technological advancement. This supply-demand interaction, along with inflation, has caused slaughter hog prices to steadily increase through recent years.

When viewing a shorter time span of four to five years, it becomes readily apparent that a price cycle exists in the hog industry. This cycle is primarily the result of the biological nature of hog production and a lagged response to prices by producers. A time lag exists between the time the hog producer makes a decision to change production levels on the basis of expected price and the time that the change in production appears on the market. This lag has caused a fairly regular four year hog cycle to develop and maintain itself over an extremely long time period (1900-Present). This series of cycles has been interrupted by several wars and a major depression but has always returned to approximately a four year cycle. The length and amplitude of the cycle vary slightly as economic conditions change. Figure 5 shows the cycle phenomenon from 1953 to 1972.

Seasonal variation also plays an important role in hog prices. This yearly variation can be viewed as a mini-cycle occurring within one year. Figure 5 reveals that there is generally a small peak in slaughter hog prices during the month of February and a larger peak in the July-August area. The seasonal low generally occurs around the October-November time period. This seasonal pattern can be attributed primarily to a variation in the costs of production within the year and the seasonal consumption patterns of consumers.

Even though the trend, cycle, and seasonal patterns account for most of the variation in slaughter hog prices over time, there remains

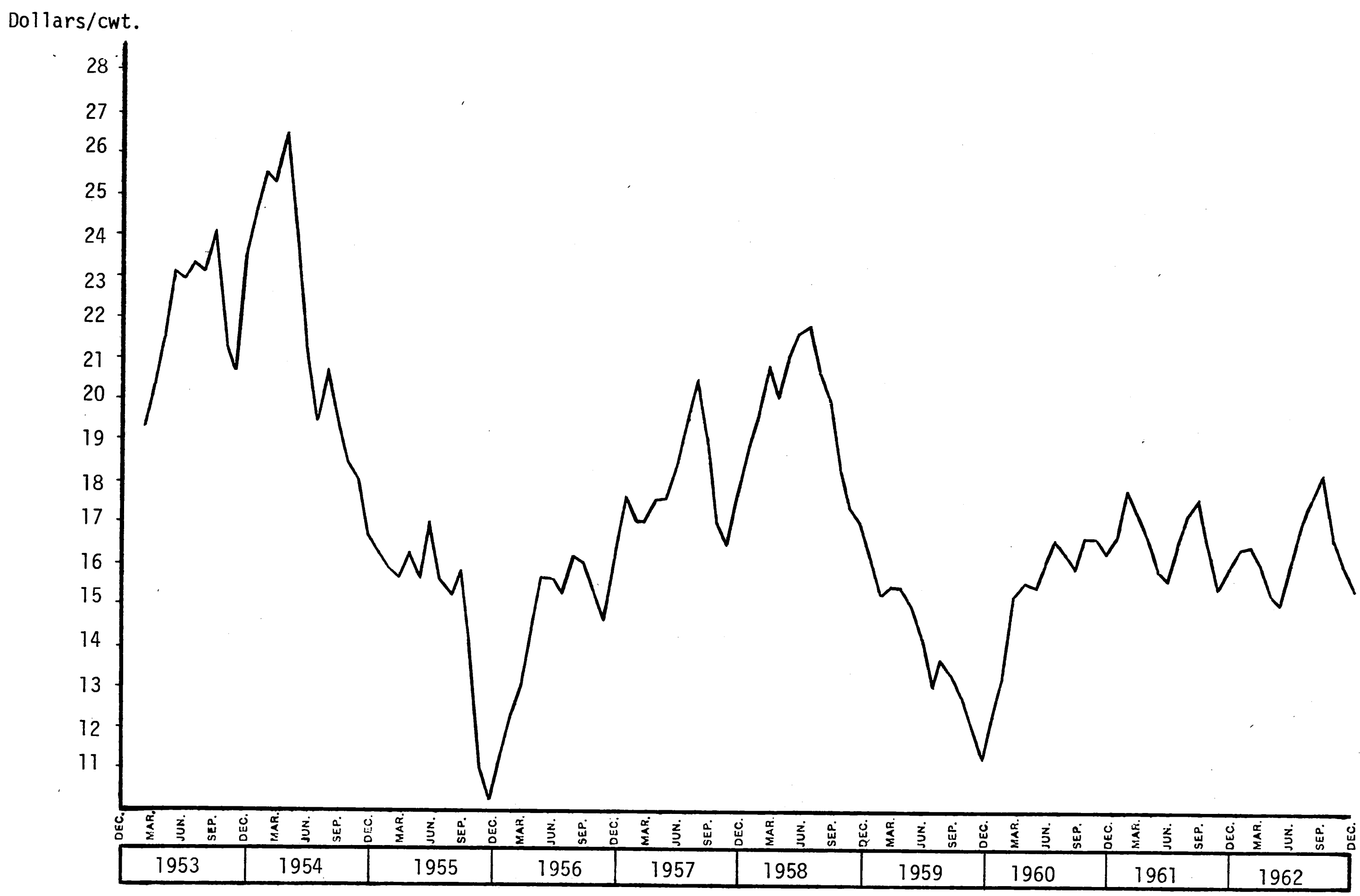

Figure 5. U. S. #1 and 2, 220-240 Pound Slaughter Hog Prices at Omaha, 1953-72

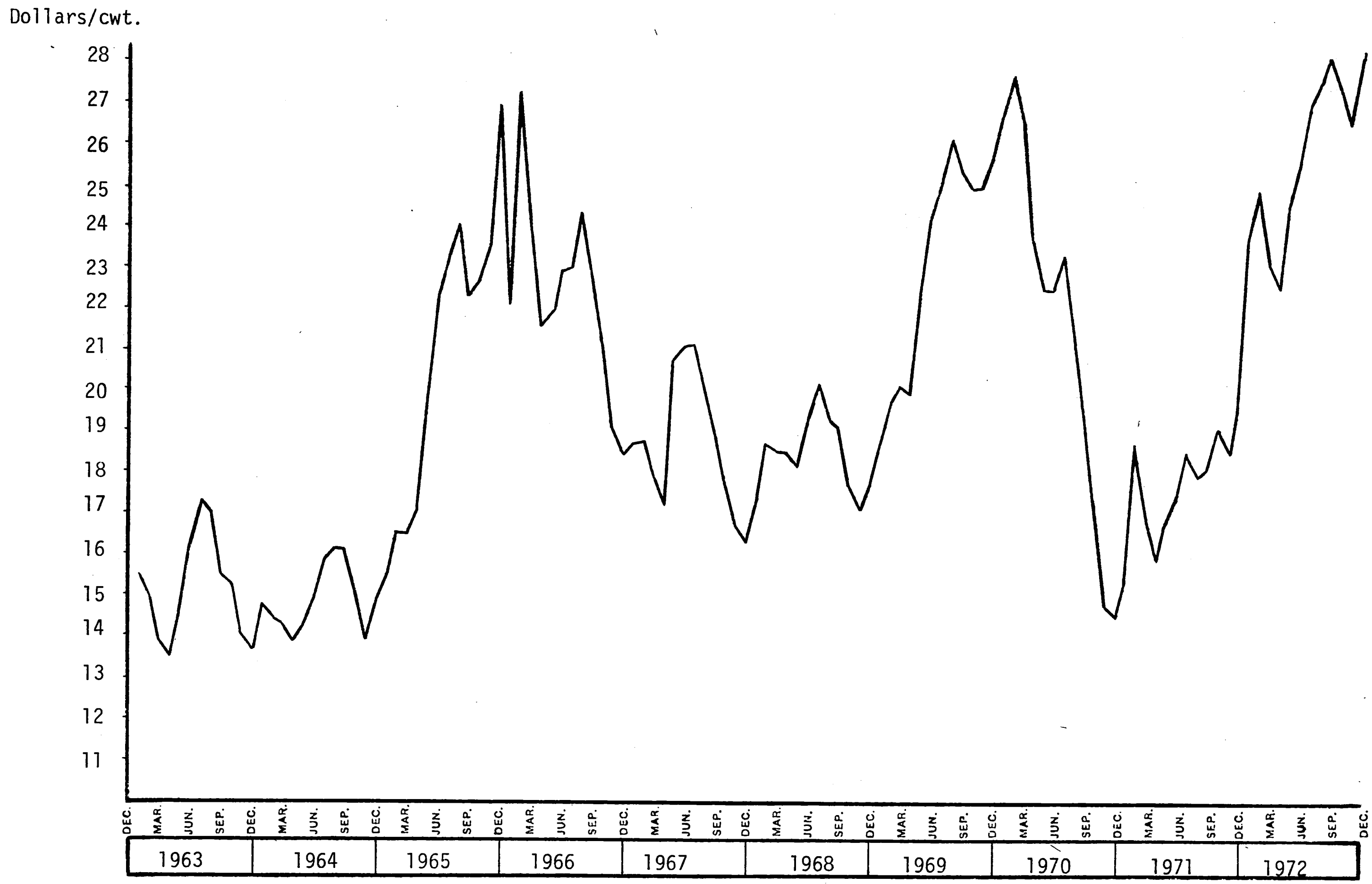

Figure 5 (Continued)

a small part of variation that can only be explained by irregular phenomenon. These variations are primarily the result of weather, but can occur when there is any unusual occurrence. A good example of this is the price freeze of 1973. While these irregular factors affect supply and demand, they are difficult to account for when attempting to discover price.

Price Discovery

While the interaction of supply and demand determines price for a particular commodity, marketing agencies and individuals attempt to discover what that price will be. In a very real sense, price discovery is price forecasting. When a product is moving up through the processing sectors, traders, when buying and selling the commodity, are attempting to forecast or discover the price the product will bring at their respective market level.

There are actually two phases of price discovery, (1) evaluating the expected price-determining conditions of supply and demand and then estimating the general level of prices that will result from these conditions, and (2) deciding the value of a specific lot of the commodity in a particular location relative to the general price level.[2] Thus, the general price level is discovered by the combined effect of all the market traders for a particular product. Discounts and premiums are then given to a specific lot of a commodity according to that lot's merits as determined by the traders of that lot. The net result of this process is an attempt by marketing agencies and individuals to discover how a particular price at a specific location will vary from the established price level.

Additional Considerations in Price Discovery

It is important to note that the forces that determine the general price level may have little correlation with variations in price about the general price level. Often, when building a forecasting model, the researcher finds himself in a situation where he has data for several supposed explanatory variables that help to determine the price level, but the model does a poor job of forecasting. The general magnitude of such explanatory variables may be a significant factor in determining the general price level, but their variation, if any, may not be closely related to price variation. Too, it is often observed that lags and leads of factors of demand and supply are more important than the absolute levels of those factors when forecasting price. This is especially true of many agricultural commodities such as pork where supply today may be a function of feed grain prices, or relative changes in those prices, several months ago. The same is true of the demand aspect where, for example, the present demand for the raw product may be a function of the anticipated demand for the finished product in a later time period.

Aggregation

Aggregation of data also affects price variation and must be considered when forecasting price. When the "price" of hogs is an average price over many different lots of hogs, and over days, weeks or months, some of the variability of the actual price series is removed. This results in a "smoother" price series which is easier to predict than a non-aggregated price series. Also, the data for independent variables used in predicting price are often averaged over time periods, thus further reducing the variability inherent in the equation.

FOOTNOTES

[1] Leftwich, Richard H. The Price System and Resource Allocation, Hinsdale, Illinois, 1973.

[2] Thomsen, Frederic L. and Richard J. Foote. Agricultural Prices, McGraw-Hill Book Co., Inc., 1952.

CHAPTER III

PROJECTION OF HOG PRICES

The objective of the price models was to predict the monthly price of slaughter hogs one to six months into the future. To aid in the formulation of the price and supporting models, the computerized Statistical Analysis System (SAS) was employed. This analysis system contains many different methods of data analysis including correlation procedures, least squares regression models and five different methods for developing the "best" least squares regression model based on a highest R^2 criterion. By using SAS, it was possible to test a large number of independent variables including variables lagged different amounts of time. The final selection of variables in the price models was based on economic grounds, statistical significance and contribution to explanatory power.

This chapter discusses (1) the selection of variables for the price models, (2) the projection models for two independent variables, and (3) the results of the hog price models.

Selection of Variables for the Price Models

A necessary step in developing any model was the selection of an appropriate data series for the dependent price variable. The data series must meet several criteria which include good availability, representativeness of most real life situations and continuity.

After viewing the decline of the Chicago livestock markets and the subsequent rise in importance of the Omaha hog market, it was determined that the 220-240 lb. weight class at Omaha would be the best dependent price series available.

Next, attention was turned to identifying the relevant independent variables that help explain slaughter hog prices. The variables for the final price models include two general types: those to which price displays a lagged response and those to which price responds in the current time period. The following variables were hypothesized as helping explain variation in hog prices: total pork storage, pork belly storage, pork production, total personal income, a variable to account for variation in work days per month, beef price, beef production, sow slaughter, hog slaugher, cattle slaughter, hog and pig inventories, monthly dummy variables to account for otherwise unspecified seasonal variation and dummy variables to account for the hog price cycle.

Correlation analysis revealed that pork production data were better than the number of hogs slaughtered for explaining variation in hog prices. Also, beef production explained more variation in hog prices than did cattle slaughter. It was subsequently hypothesized that beef prices, when lagged, would better measure the substitute effect of beef for pork than would beef production in the current time period. This hypothesis was tested and accepted. Given this information and the necessity of forecasting beef production if it was used as an independent variable, beef price was used in place of beef production as the "substitute" variable.

The next variable to be examined was pork storage. It was found that pork storage represented a substantial portion of total pork supply. Therefore, it was tested in the price model and found to be highly significant in explaining variation in hog prices. It was also hypothesized that pork belly storage might be a significant indicator of pork supply. However, high multicollinearity was present with the simultaneous use of total pork storage and belly storage. Also, the use of belly storage as a substitute for pork storage lowered each model's R^2 substantially and increased the standard deviation of each equation. Therefore, total pork storage was used as the storage component of supply.

In addition to the above variables, a set of monthly dummy variables was examined for possible use in representing otherwise unspecified seasonal influences on price, such as seasonal weather. However, the use of this set of variables in the price model increased the R^2 by only .02. This was little more than could be expected with the addition of any eleven variables whether or not they were theoretically related to price. Therefore, the monthly dummy variables were excluded from the price model.

It was also hypothesized that accurate prediction of monthly hog prices, especially for the five and six month models, would be influenced by the stage of the hog price cycle. Thus, a dummy variable representing the hog cycle stages was utilized and found to be effective in measuring hog price variation.

As the selection process continued, it became apparent that the set of variables that best explained monthly variations in hog prices included lagged total pork storage, lagged beef prices, pork production, total personal income, a variable to account for variable workdays in given months, and a dummy variable to account for the hog price cycle. However, to use these variables in the one through six month price forecasting models, it was necessary to also project values for the two non-lagged independent variables, total personal income and pork production. The discussion of these projection models follows.

Total Personal Income and Pork Production Models

Projection of Total Personal Income

The price of live slaughter hogs is basically a derived price. The price of pork at retail is a major determinant of the price that producers receive for their hogs. Therefore, the important demand shifters at retail should be considered.

In the United States, total personal income is traditionally one of the more important of the demand shifters. The specific income variable that was selected for use in the price model was total monthly personal income in the United States. The data were obtained from the Organization for Economic Cooperation and Development monthly report, 1968-1975. This series was selected on the basis of being a continuous monthly series that is readily available.

A graphical analysis of per capita income over time revealed a positive linear relationship between income and time. Thus, a linear regression analysis was employed to quantify the relationship for use as a projection model. The projection model for total personal income is shown in Table I. The positive linear relationship with time explained almost 98 percent of the variation in income.

Projection of Pork Production

Since a slaughter hog price is derived from the wholesale price level, it would seem reasonable that the future supply of pork at the wholesale level would help determine the price of slaughter hogs. This future pork supply can be broken into two components, (1) pork storage and (2) hogs and pigs on farms. Statistics of pork storage are available monthly in several different publications.[1] Previous research and preliminary analysis in this study have revealed a lagged relationship of hog prices to pork storage.[2] Therefore, it was felt unnecessary to project storage into the future for use in the price model. However, price in time period T reacts to pork production in time period T, so it was necessary to project continental U. S. pork production in millions of pounds for each time period a price prediction was desired.

It was hypothesized that the more important determinants of pork production include the number of hogs on farms approaching "normal" market weight during the month, the number of fully utilized slaughter days in a given month, and variables representing information that pork producers use to make placement decisions. The purpose of the following section is to (1) identify the relevant variables, (2) develop the necessary data series, (3) present and interpret the results of the regression analysis in developing the pork production models, and (4) to demonstrate the forecasting ability of the pork production models.

TABLE I

ESTIMATED EQUATION TO PROJECT U. S. TOTAL PERSONAL INCOME, BILLIONS OF DOLLARS

Dependent Variable	Intercept	Time (Months)	R^2
Total Personal Income	626.9572	6.675	.977
	(108.9)[a]	(62.65)	

[a]Values in parentheses are t values.

Factors Associated with Hog Production

Numbers

In attempting to estimate pork production for any particular month it was necessary to first determine the available supply of hogs that would reach market weight in the month in question. The available supply of market weight hogs in any future month is basically determined by the number of hogs and pigs in various weight classes in the present month.[4] The appropriate weight class to use when estimating available supply is determined by the length of the feeding period remaining between the present time and the month for which the supply figure is desired, the average daily rate of gain, and the normal market weight.

The U.S.D.A. divides the hog inventory into five different weight classes.[3] These are class 1 which contains all pigs weighing less than 60 pounds; class 2 which contains all hogs weighing between 60 and 119 pounds; class 3 which contains all hogs weighing between 120 and 179 pounds; class 4 which contains all hogs weighing between 180 and 219 pounds; and class 5 which contains all hogs weighing 220 pounds or greater. These weight classes were used in this study.

In arriving at a figure for rate of gain per day, a problem arose due to the wide diversity in rates of gain caused by differences in hog breeds, feed, sex, weather conditions, etc. Therefore, it was felt that by using a range for rate of gain, most major types of operations could be represented. The range chosen was from a low of one pound of gain per day to a high of two pounds of gain per day.

The determination of a normal market weight was accomplished by taking a weighted average of market weights of hogs at Omaha over the 1968 through 1975 period. This average was computed to be 240 pounds.

The length of the feeding period remaining could not be pinpointed to a specific number of days because there was as much as a 30-day difference in time of marketing during any given month. Therefore, a 30-day range was assumed for each forecast interval. Time period T would begin on the first day of the present month with 30 days being added to obtain successive time periods. For example, T + 4 would consist of exactly 150 days, 30 days for T and 120 more days for the 4 future months. The results of these calculations are shown in Table II. The table shows the length (in days) of each feeding period, total pounds of gain during each time period, the weight range of the hogs in month T through T + 6, and the applicable market weight category for each prediction interval.

Factors Associated with the Production Decisions of Producers

The hog-corn ratio was chosen as one of the variables to measure the production behavior of hog producers. The ratio consists of the price per cwt. of U. S. #1-3 200-220 pound hogs at Omaha, divided by the price per bushel of #2 yellow corn at Omaha. The ratio shows the relative value of hogs to corn. In the long run, as the ratio increases, producers would be expected to increase the feeding of corn to hogs. If the ratio decreased, producers would be expected to sell their corn rather than feed it to the now relatively lower valued hogs. However, in the short run a high hog-corn ratio indicates

TABLE II

ESTIMATION PROCEDURE FOR DETERMINING APPLICABLE MARKET HOGS AND PIGS WEIGHT CATEGORY FOR EACH OF THE PREDICTION INTERVALS T + 1 THROUGH T + 6

Prediction Interval	No. of Days (Range)	Rate of Gain (Range)	Total Pounds of Gain for the Period	Normal Market Weight	Estimated Weight Range in Month T	Applicable Market Hogs and Pigs Weight Category
T + 1	60 30	2.0 1.0	30-120	240	120-210	120-179 180-219
T + 2	90 60	2.0 1.0	60-180	240	60-180	60-119 120-179
T + 3	120 90	2.0 1.0	90-240	240	0-150	< 60 60-119 120-179
T + 4	150 120	2.0 1.0	120-300	240	0-120	< 60 60-119
T + 5	180 150	2.0 1.0	150-360	240	0-90	< 60 60-119
T + 6	210 180	2.0 1.0	210-480	240	0-60	< 60 60-119

relatively high hog prices, possibly resulting from low slaughter hog supply. While the long run tendency is to feed more hogs, fewer hogs will be marketed in the short run as producers try to increase herd size. Therefore, it is possible for the hog-corn ratio to have a negative relationship with pork production over the short run. For these reasons, the hog-corn ratio was selected as an explanatory variable and tested for significance in each production model.

While the hog-corn ratio is useful for determining marketing behavior of the corn-hog producer, the ratio is not as useful a measure of the strictly hog producer's marketing behavior. This producer must purchase all of his corn used for feed. Therefore, it was felt that the price of corn, when properly lagged, would be a useful measure of the strictly hog producer's production decisions.

It was thought that the influence of the hog production cycle should be accounted for in the price and production models. Without some cycle variable it was hypothesized that the "normal" seasonal patterns would be distorted by the influence of the hog production cycle. This influence would vary according to the phase of the cycle. Therefore, a dummy variable was utilized in the model in order to nullify the effects of the cycle.

Other Explanatory Variables

Explanatory variables for pork production also included a variable representing the number of fully utilized slaughter days per month and a monthly dummy series to account for otherwise unspecified seasonal influence on production, such as weather.

The fully utilized slaughter days variable was used to account for monthly variations in the number of days, weekends and holidays. The supply of pork within a month was felt to be responsive to the number of actual work days in a given month. The number of fully utilized slaughter days within a month was calculated by weighting normal weekdays as 1, Saturdays as 1/3, weekday holidays as 1/2, Saturday holidays as 0, and Sunday as 0.[2]

Monthly dummy variables were included to account for seasonally recurring marketing and production patterns. The dummy variable for January was omitted in order to avoid the statistical problem of singularity. The effects of the January dummy were thus included in the intercept terms.

Results of the Pork Production Regressions

The monthly series of pork production was regressed on the previously mentioned explanatory variables. All of the explanatory variables used displayed either a lagged response toward production or were directly measurable, such as workdays. All variables were placed in the model and tested for their impact on pork production. A list of these variables and their abbreviated notation is presented in Table III. Variables were then selected for final use in the models based on economic justification and statistical significance. The results of the testing procedures and regression analysis are presented in Table IV.

In some cases, variables were included in the final models even though their effects were not highly significantly different from zero.

TABLE III

DEFINITION OF VARIABLES IN THE PORK PRODUCTION MODELS

PORDP	=	monthly 48 state pork production (dependent variable)
D_n (n=1 to 12)	=	monthly dummy variables to allow the level of the regression line to shift due to otherwise unspecified seasonal influences. D_2 = February, D_3 = March, D_4 = April, etc. The month of January was denied representation in order to avoid the statistical problem of singularity, so the effect of January will be measured in the intercept.
Weight 1	=	all market hogs and pigs on farms weighing less than 60 pounds.
Weight 2	=	all market hogs and pigs on farms weighing between 60 and 119 pounds.
Weight 3	=	all hogs on farms weighing between 120 and 179 pounds.
Weight 4	=	all hogs on farms weighing between 180 and 219 pounds.
Weight 5	=	all hogs on farms weighing 220 pounds or more.
$CORNP_n$ (n= 1 to 6)	=	price of #2 yellow corn at Omaha lagged 1 through 6 times, according to the time period that a price prediction is desired.
Hog-Corn Ratio (HCR)	=	the price of U. S. #1-3 200-220 pound hogs at Omaha divided by the price of #2 yellow corn at Omaha, and lagged 1 through 6 times.
$Storage_n$ (n= 1 to 6)	=	the amount of frozen and cured pork in cold storage in the 48 states in month T, lagged one to six time periods.
DUP	=	dummy variable included to account for the effects of the cycle on the variation of production. DUP = 1 on the up side of the cycle and 0 on the down side of the cycle.
Workdays	=	the number of fully utilized slaughter days weighted according to the following system: normal weekday=1, Saturday=1/3, weekday holiday=1/2, Saturday holiday=0, Sunday=0.

TABLE IV

THE ESTIMATED REGRESSION EQUATIONS FOR ONE TO SIX MONTH PROJECTIONS OF U. S. PORK PRODUCTION[a]

Dependent Variable	Intercept	Explanatory Variables D_2	D_3	D_4	D_5	D_6
PORDP T + 1	-169.167[a] (-.6707)[a]	21.700 (1.0167)	-5.613) (-.2208)	52.023 (2.4372)	29,584 (1.3570)	-35.812 (-1.6350)
PORDP T + 2	-131.735 (-.5065)	1.817 (0.7341)	-41.920 (-1.4933)	33.364 (1.3879)	91.499 (2.14426)	30.339 (0.7148)
PORDP T + 3	-620.618 (-2.2252)	75.148 (2.3155)	17.807 (.5519)	75.481 (2.3643)	81.251 (1.9754)	28.370 (.6859)
PORDP T + 4	-330.219 (-1.3001)	53.385 (1.8271)	-8.350 (-.2637)	29.279 (1.4147)	134.723 (5.1555)	96.109 (3.6698)
PORDP T + 5	-359.438 (-1.3431)	67.095 (2.2231)	3.402 (0.1123)	55.506 (1.8648)	137.584 (4.8923)	87.013 (3.1556)
PORDP T + 6	-648.743 (-2.3138)	35.041 (1.1341)	17.489 (.4888)	72.043 (2.2011)	160.233 (5.2163)	86.000 (2.8356)

TABLE IV (Continued)

Dependent Variable	Explanatory Variables					
	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}
PORDP T + 1	-105.329 (-4.7928)	-94.567 (-3.2769)	-16.235 (-.5668)	100.017 (3.4757)	2.297 (.0875)	54.622 (2.1195)
PORDP T + 2	-52.512 (-1.2474)	-139.347 (-3.5513)	-73.241 (-1.9097)	58.025 (1.5316)	14.618 (.5855)	61.383 (2.5411)
PORDP T + 3	-53.987 (-1.3071)	-212.261 (-4.5491)	-156.245 (-3.3871)	-19.658 (-0.4335)	23.653 (.9544)	92.150 (3.7016)
PORDP T + 4	26.152 (.9923)	-226.643 (-5.3643)	-192.226 (-4.6526)	-82.528 (1.9893)	9.036 (.3710)	90.822 (3.7597)
PORDP T + 5	27.213 (.9774)	-214.324 (-4.8333)	-171.865 (-3.9874)	-87.185 (-1.9956)	-15.587 (-.5546)	56.668 (2.3565)
PORDP T + 6	13.496 (.4537)	-186.382 (-3.9556)	-135.499 (-2.9481)	-38.052 (-0.8314)	-42.815 (-1.5734)	10.577 (.3804)

TABLE IV (Continued)

Dependent Variable	Explanatory Variables						
	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5	CORNP	Storage
PORDP T + 1			.040 (2.1195)	.0028 (.0658)		.447 (-5.2714)	
PORDP T + 2		.022 (1.4319)	.017 (.8567)			-.454 (-3.8338)	
PORDP T + 3	.025 (2.4688)	-.014 (-.6571)	.042 (2.8398)			-.205 (-1.5576)	.307 (1.8887)
PORDP T + 4	.019 (1.8986)	.019 (1.3435)				-.379 (-3.5350)	.196 (1.1861)
PORDP T + 5	.019 (1.8076)	.020 (1.4188)				-.136 (-2.7249)	.279 (1.575)
PORDP T + 6	.010 (.9220)	.029 (1.9126)				-.203 (-1.6657)	.644 (4.9118)

TABLE IV (Continued)

Dependent Variable	HCR	Workdays	DUP	R^2	Durbin-Watson	Standard Deviation	Mean
PORDP T + 1	-11.751 (-3.9281)	53.135 (5.4596)	34.892 (2.2025)	.832	1.098	56.465	1093.25
PORDP T + 2	-11.180 (-5.3734)	49.885 (5.1300)	41.905 (2.7721)	.828	1.139	56.861	1093.25
PORDP T + 3	- 8.298 (-3.2940)	53.565 (5.7360)	21.184 (1.2693)	.849	1.299	54.228	1093.25
PORDP T + 4	-10.351 (-4.1482)	49.577 (5.2360)	43.105 (2.8057)	.845	1.165	54.500	1093.25
PORDP T + 5	- 8.319 (-3.1510)	46.956 (4.8060)	53.099 (3.3671)	.832	1.229	56.836	1093.25
PORDP T + 6		50.129 (4.8206)	65.230 (3.9004)	.806	1.075	60.635	1093.25

[a]Figures in parentheses are t values.

This is true of the monthly dummy variables in each equation. The inclusion of this set of variables was thought to be necessary because of the traditionally recognized importance of seasonality in pork production. Also, it was often found that a variable displaying a poor statistical significance was highly correlated with another variable. It was felt that the impact of such variables were accounted for in the parameter estimates of the variable with which it was so highly correlated. In the development of prediction models, the precision with which individual parameters are estimated is of minor importance as long as a measure of the impact of each of the economically relevant variables is contained within the equation as a whole.

A model was developed for each time period a projection for pork production was desired. The following sections include discussion of the results of each of the six monthly pork production forecasting models.

One-Month Predictive Equation

The equation designed to predict pork production one month in advance consisted ot two weight class variables (class 3 and class 4), the workdays variable, the hog-cornratio and corn price variables both lagged one month, a dummy variable to account for the cycle and the monthly dummy variables to account for the otherwise unexplained monthly variation. The quantity of pork storage was tested as a variable but was found to contribute very little to the R^2. The storage variable was therefore deleted from the model. The weight 4 variable, while not found to be highly significant, did contribute significantly to R^2 improvement. The low statistical test was thought to be a result of a high degree of correlation bewteen weight class 3 and weight class 4 (r = .951).

To demonstrate the predictive power of the model, backcasts were performed over the entire data range. A graphical representation of these backcasts can be seen in Figure 6. The horizontal axis has time in months and the vertical axis has production in thousands of pounds. Figure 6 shows that with few exceptions, the one month pork production model forecasts the direction of change as well as the magnitude of pork production. The model's "misses" in magnitude were often due to a lead or lag of one month in predicting direction change. The T + 1 model explained approximately 83 percent of the variation in pork production. The average "miss" of the model, as shown by the coefficient of variation, was approximately five percent.

Two-Month Predictive Equation

The two-month model for estimating pork production consisted of weight classes 2 and 3, and workdays variable, the hog-corn ratio and corn price variables (both lagged 2 months), the cycle dummy and monthly seasonal dummy variables to account for otherwise unexplained seasonal variation. As in the one month model the higher weight class (here weight class 3) displays a poor statistical test. All other continuous variables displayed good statistical significance. The pork storage variable was not used in this equation because of a low statistical significance and the lack of economic justification to support the thought that storage could affect pork production in a given 2 month period. The two-month model explained approximately

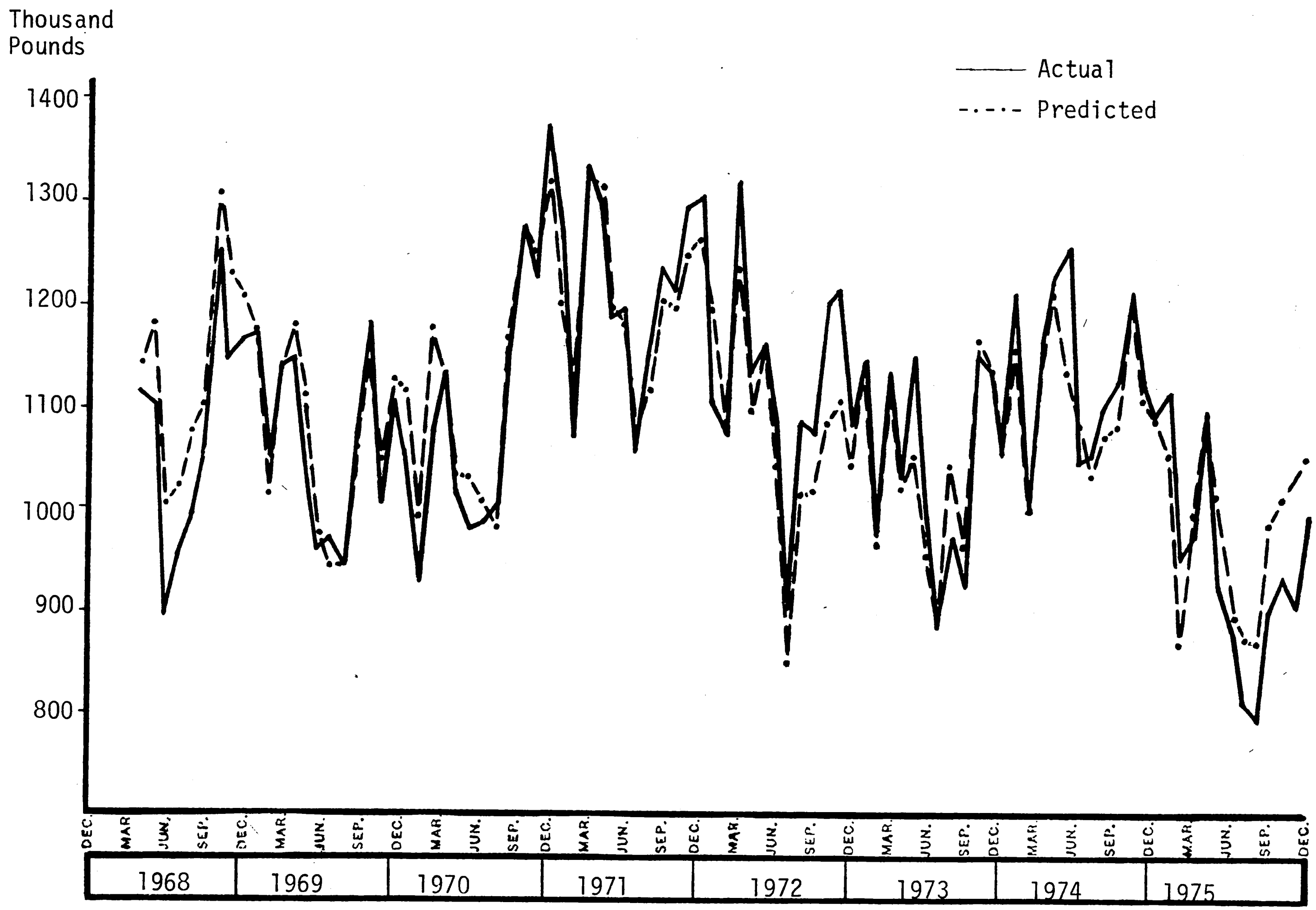

Figure 6. Pork Production, 48 States, 1968-1975, Actual Versus One-Month Forecasts

83 percent of the variation in pork production. A graphical representation of backcasts performed over the entire data range is shown in Figure 7. The horizontal axis shows time in months and the vertical axis shows pork production in thousands of pounds.

As with the T + 1 model, the backcases of the T + 2 model show that the predictive equation does a good job of predicting direction and magnitude of pork production. The average "miss" for the two-month predictive model is 5.2 percent as shown by the coefficient of variation.

Three-Month Predictive Equation

After testing different combinations of variables, it was found that the three-month model which explained a large amount of variation in pork production consisted of the three smallest weight classes (classes 1 to 3), the workday variable, the hog-corn ratio, corn price and pork storage (the latter three lagged 3 months), the dummy for the cycle and the set of monthly dummy variables. In this model, it was found that all continuous variables displayed good statistical significance except for weight class 2. The three-month pork production model is the first in which pork storage shows an effect significantly different from zero. The storage variable had a positive sign, indicating that as storage goes up in month T, pork production increased in month T + 3. All other continuous variables have the *a priori* expected signs except weight class 2. The three-month predictive model explains approximately 85 percent of the variation in pork production. The estimation precision of the three-month model can be seen in the backcase graph of Figure 8.

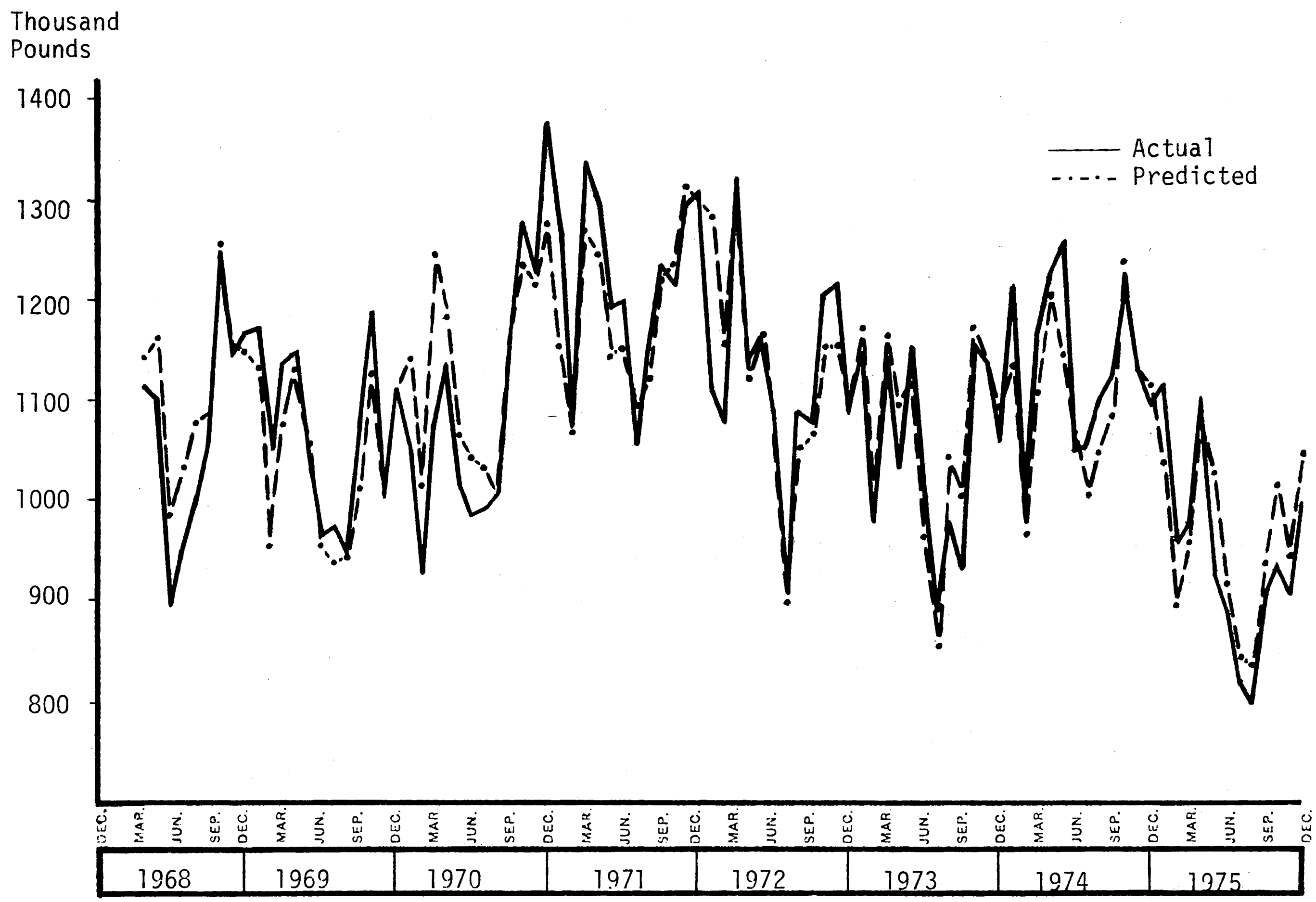

Figure 7. Pork Production, 48 States, 1968-1975, Actual Versus Two-Month Forecasts

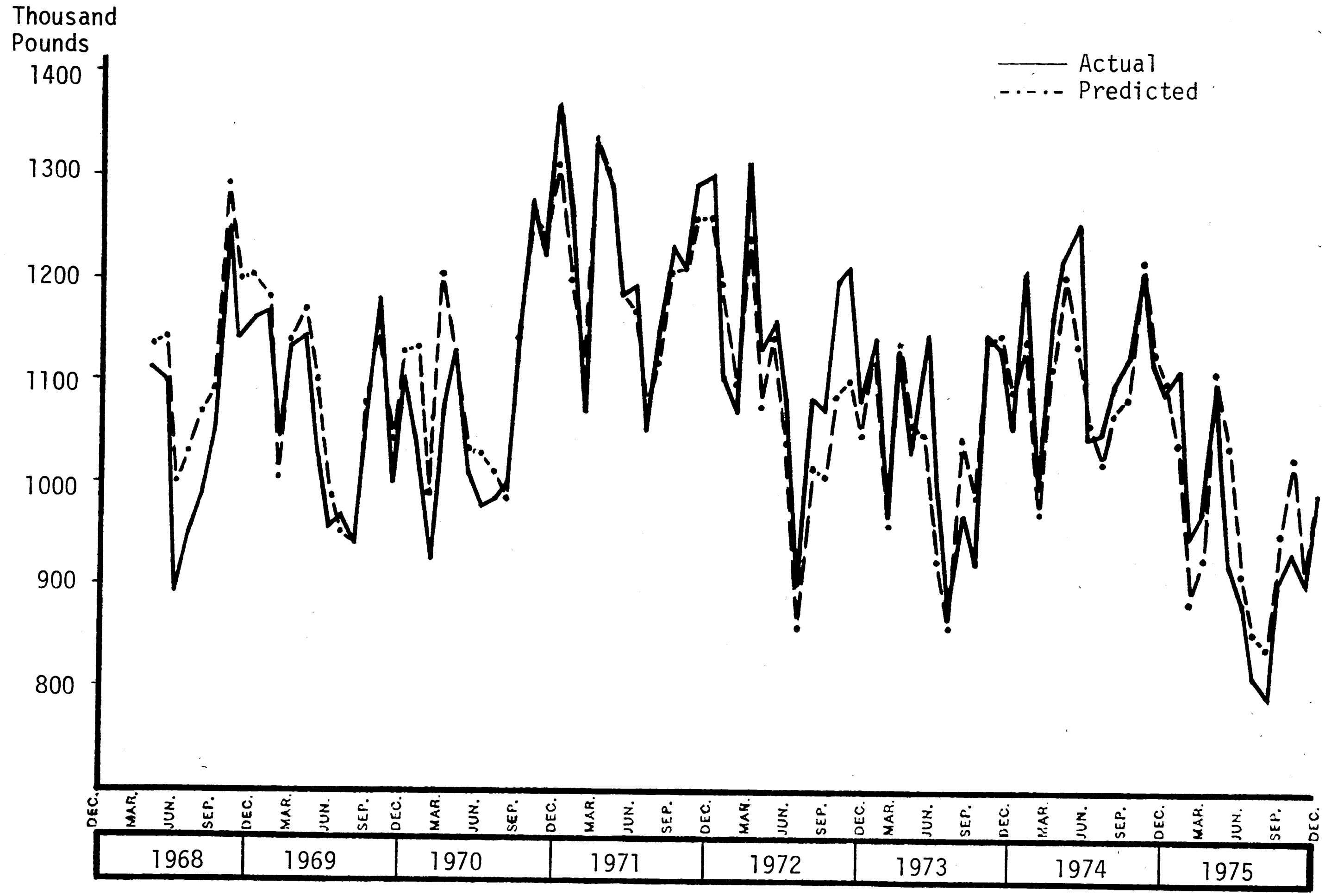

Figure 8. Pork Production, 48 States, 1968-1975, Actual Versus Three-Month Forecasts

The backcasting shows the ability of the model to predict changes in pork production three months in advance. The larger misses in magnitude are often the result of the model predicting a change of direction one month early. However, the model always corrected itself within one month. The average "miss" for the model was 4.96 percent as shown by the coefficient of variation.

Four-Month Predictive Equation

The four-month equation which was selected to explain the variation in pork production contained weight classes 1 and 2, the workdays variable, the hog-corn ratio, corn price and pork storage variables (the latter three lagged 4 months), the cycle dummy and the monthly dummy series. All continuous variables display the signs expected *a priori*. Pork storage displays a relatively poor statistical t-test value, but it was felt that the correlation with both the hog-corn ratio and corn price (r = -.458 and .180, respectively) could account for the low "t" value displayed. The equation explained approximately 85 percent of the variation in pork production. A backcast analysis was performed and is presented in Figure 9. The four-month equation had an average miss in magnitude of 4.98 percent as shown by the coefficient of variation.

Five-Month Predictive Model

The five-month model that best explained pork production variation consisted of weight classes 1 and 2, the workdays variable, the hog-corn ratio, corn price, and pork storage variables (the latter three lagged 5 months), the cycle dummy and the monthly dummy series. All

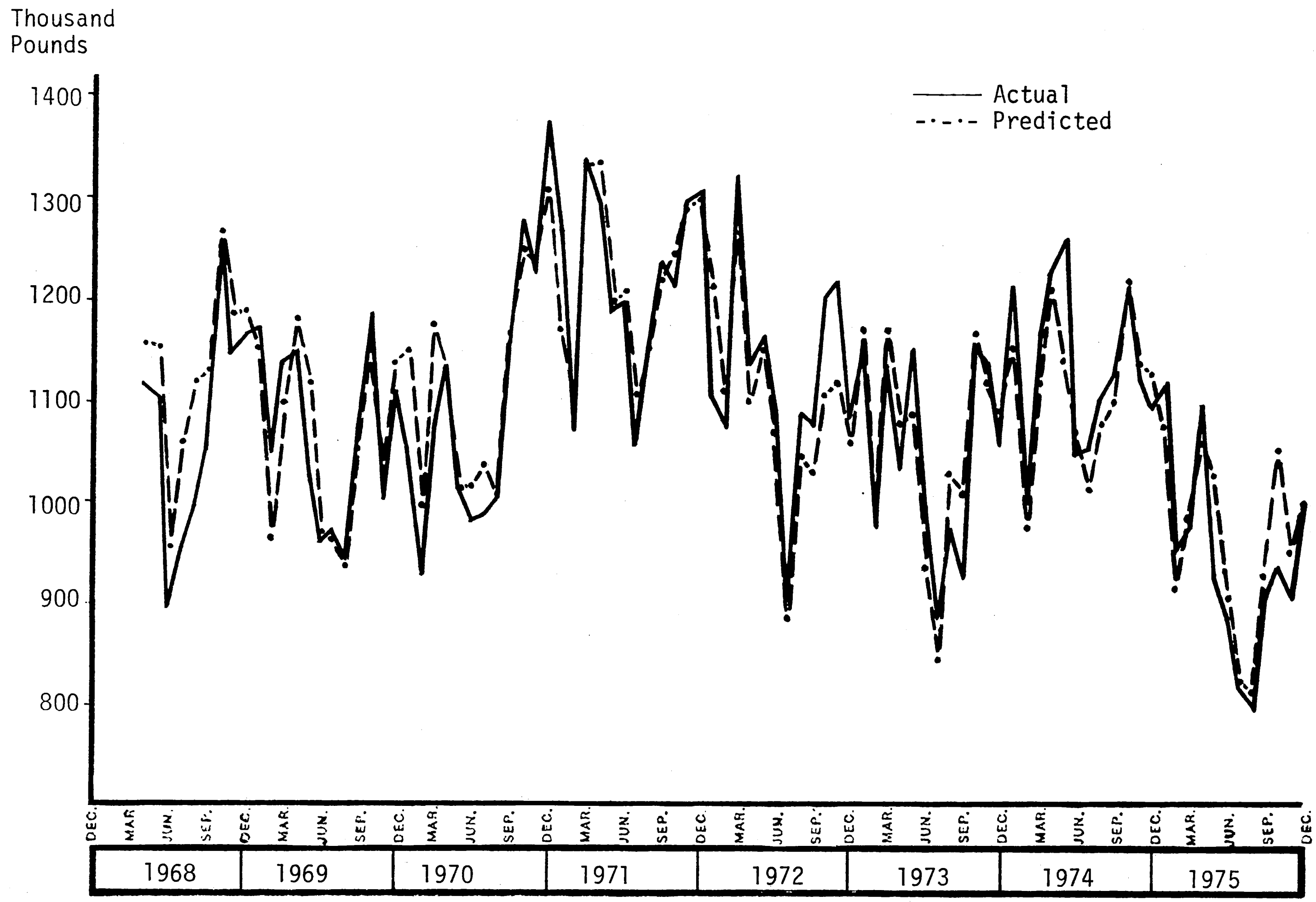

Figure 9. Pork Production, 48 States, 1968-1975, Actual Versus Four-Month Forecasts

regression coefficients for continuous variables were found to be significantly different from zero at the .05 level with the exception of pork storage and weight 2, which were significant at the .12 and .16 levels, respectively. The cycle dummy coefficient was highly significant at the .002 level. Regression coefficients for all continuous variables displayed the expected sign. The model explained approximately 83 percent of the variation in hog prices. A graphical representation of backcases is presented in Figure 10.

The five-month production model had an average "miss" of 5.2 percent as shown by the coefficient of variation. Although the model often fails to predict exactly a change in direction, the model always corrects itself within one month.

Six-Month Predictive Model

The six month model consisted of weight classes 1 and 2, the workdays variable, corn price and pork storage (the latter two lagged six months), the cycle dummy and the monthly dummy series. All continuous variables displayed t tests significant at the .10 level except for weight class 1, which is signficiant at the .35 level. This relatively poor statistical test value is thought to be the result of correlation of weight class 1 with weight class 2 ($r = .458$). The six-month model explained approximately 81 percent of the variation in pork production. The six-month equation does not contain the hog-corn ratio since its effect was not significantly different from zero. It was thought that a time span of five months was of adequate length for producers' reactions to begin to be felt in the market by way of increased marketings. Therefore, the short-run relationship between

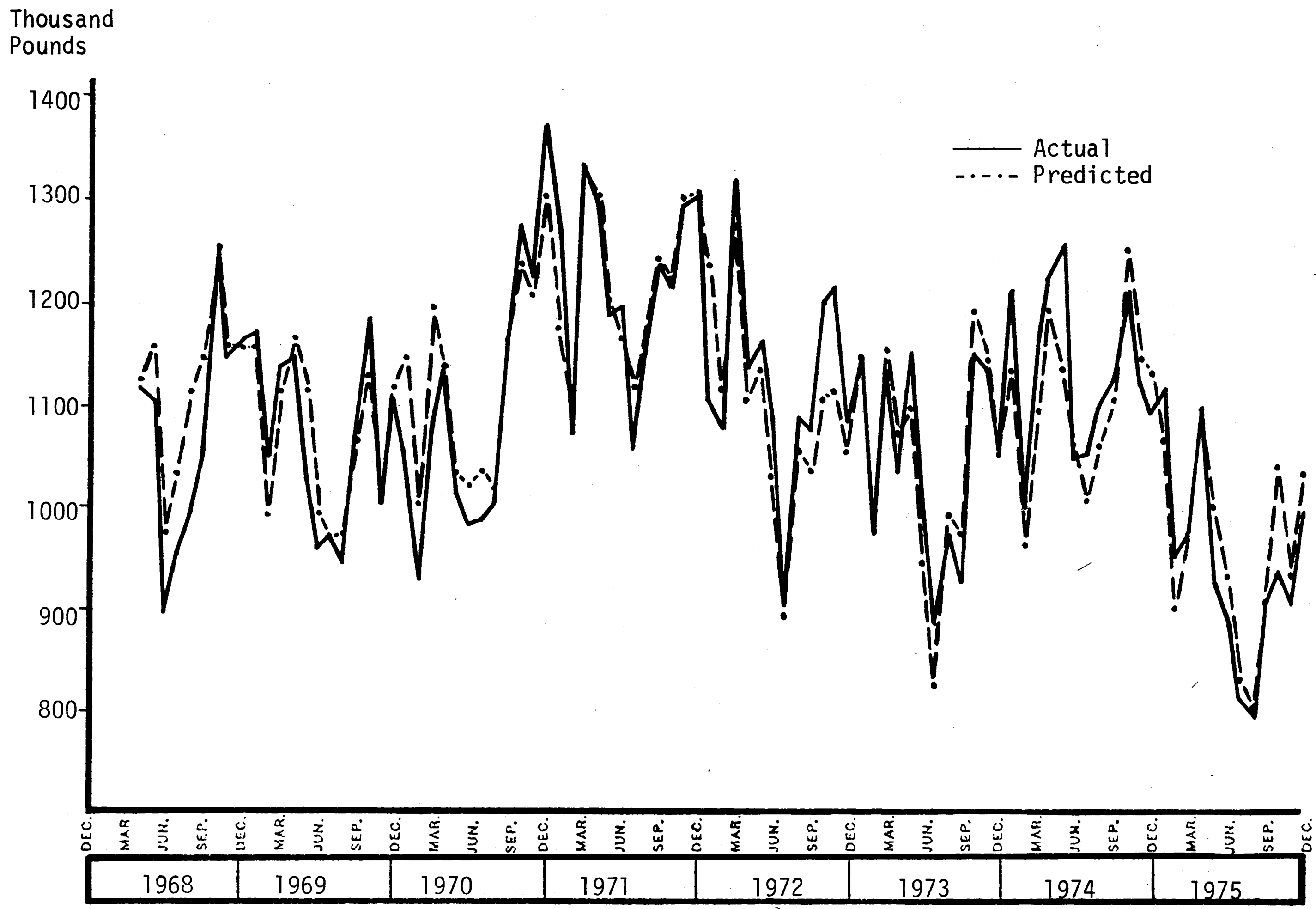

Figure 10. Pork Production, 48 States, 1968-1975, Actual Versus Five-Month Forecasts

the hog-corn ratio and pork production exhibited in the previous pork production models was changing toward a positive relationship as producers increased hog marketings.

A backcast analysis of the six month model, presented in Figure 11, shows the power of the model to predict changes in both direction and magnitude. As in all the other models, when the T + 6 model failed to predict a proper change in direction, it always corrected itself the following month. The six-month model had an R^2 of .806. The average "miss" of the six-month model was 5.54 percent as shown by the coefficient of variation.

Conclusions on Prediction of Pork Production

The analysis of data for forecasting pork production was undertaken with the assumption that pork production is the best supply variable available when attempting to predict slaughter hog prices. Regression analysis was used in an attempt to explain monthly variations in pork production from one to six months into the future.

The equations used were based on data collected in the current time period, so all variables used had to either affect pork production with a lagged response or be variables which were readily measurable into the future (e.g., weekdays). Each of six models developed display good predictive powers, all having an R^2 in excess of .81, with low standard deviations. Graphical comparisons of actual versus predicted pork production showed each of the models "track" changes and magnitude of pork production within an error of one month and with a coefficient of variation around 5 percent.

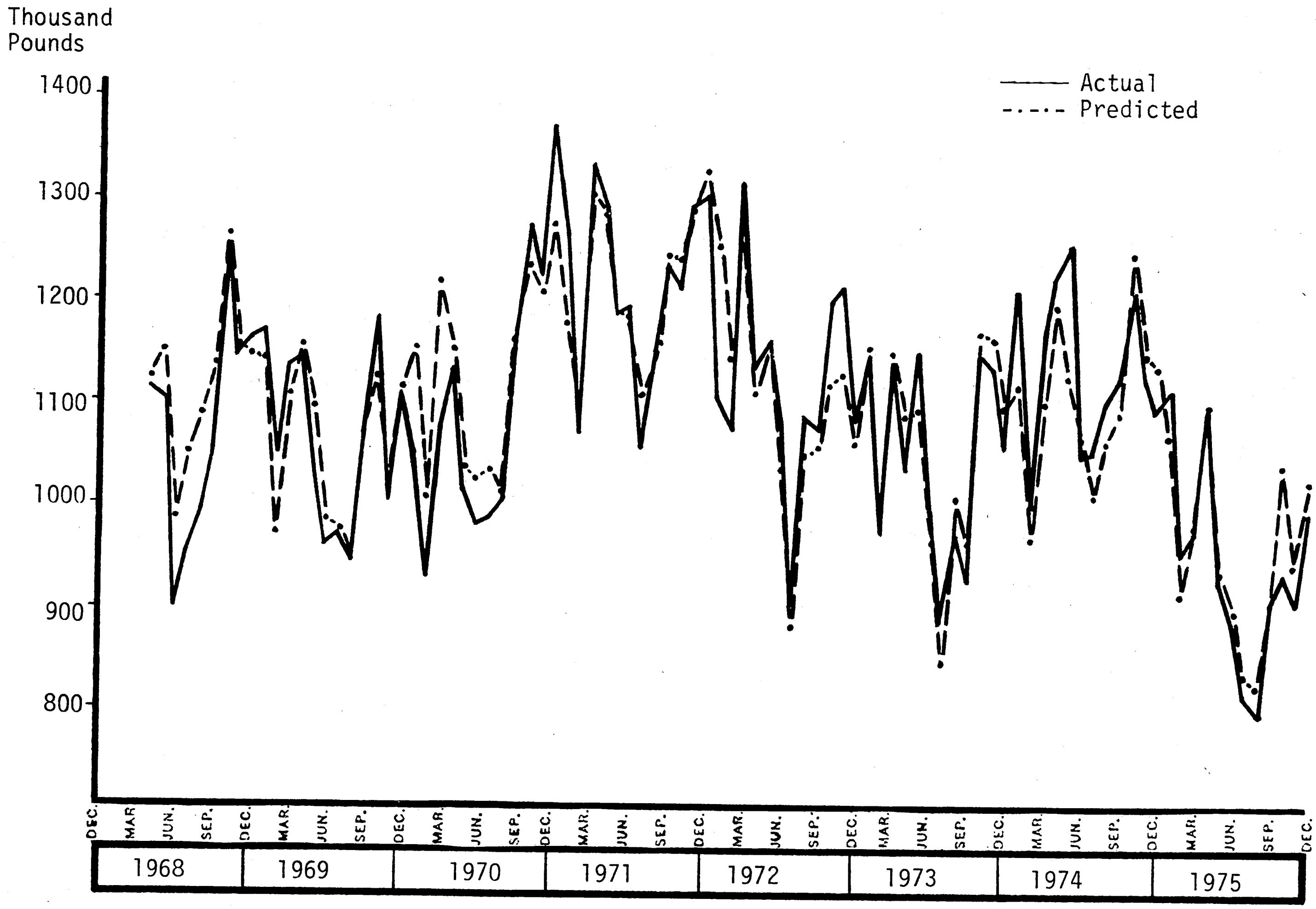

Figure 11. Pork Production, 48 States, 1968-1975, Actual Versus Six-Month Forecasts

The successful forecast of the primary supply variable, pork production, was a necessary prerequisite to accurate forecasting of slaughter hog prices. Any errors in the supply variable prediction would immediately show up in the hog price predictions.

The rest of this chapter is concerned with the development and the results of the price prediction models themselves.

Results of the Hog Price Models

The selected hog price models explained from 95 percent of the price variation in the two-month model to 89 percent in the six-month model. Standard deviations for the equations ranged from 2.77 in the two-month model to 3.86 in the six-month model. These deviations compare with a mean price of $30.53. Table V lists all regression variable names and their respective definitions. Table VI presents the regression coefficients for each variable with accompanying t values as well as other relevant equation statistics. Each monthly hog price model is discussed in more detail in the following sections.

One-Month Predictive Equation

The one-month predictive equation contained pork storage lagged one time period, projected total personal income, projected pork production, a variable to account for variation of workdays bewteen months, beef price lagged one time period and a dummy variable to account for the hog cycle. The regression coefficient for pork storage has a negative sign indicating that as total pork storage increases, price decreases. Total personal income has a positive

TABLE V

DEFINITIONS OF VARIABLES USED IN THE HOG PRICE MODELS

Price	=	Average monthly price, in dollars per cwt., of U. S. # 1-2, 220-240 slaughter hogs at Omaha.
$Storage_n$ (n = 1 to 6)	=	Frozen and cured pork storage in 48 states in a given month, lagged 1 through 6 time periods.
TPI	=	Projected total personal income in United States in month T + i, where i = the number of months into the future that price is predicted.
PORDP	=	Projected pork production in month T + i.
WKDays	=	Number of fully utilized slaughter days in the month for which a price forecast is desired. Days are weighted according to the following code: normal weekday = 1 Saturday = 1/3 Weekday holiday = 1/2 Saturday holiday = 0 Sunday = 0
Bef Pri_n	=	Price per hundredweight of Choice 700-900 pound steers at Omaha, lagged 1 through 6 time periods.
DUP	=	Dummy to account for production cycle; down side of cycle denied explicit representation in order to avoid the statistical problem of singularity.

TABLE VI

ESTIMATED REGRESSION EQUATIONS FOR THE ONE THROUGH SIX MONTH SLAUGHTER HOG PRICE MODELS

Model			Intercept	Explanatory Variables						R^2	Std. Dev.	Mean	Durbin
				Storage	TPI	PORDP	WKDays	Bef Pri	DUP				
T + 1	Price	=	-15.3229	-.0353	+.0349	-.0332	+1.9949	+.3610	-.0575	.9425	2.82	30.53	1.094
			(-1.872)[a]	(-7.072)	(10.436)	(9.1889)	(5.509)	(4.097)	(-.772)				
T + 2	Price	=	-15.2395	-.0371	+.0361	-.0411	+2.4341	+.2936	+.0605	.9445	2.77	30.53	1.25
			(-1.923)	(-7.335)	(10.712)	(-12.677)	(6.665)	(3.416)	(.081)				
T + 3	Price	=	-16.5846	-.03344	+.0363	-.0426	+2.5206	+.2926	-.0817	.9345	3.02	30.53	.994
			(-1.925)	(-6.077)	(9.879)	(-12.476)	(6.435)	(3.229)	(-.102)				
T + 4	Price	=	-22.6085	-.0209	+.0376	-.0387	+2.4684	+.2604	-1.23	.9074	3.58	30.53	.9018
			(-2.215)	(-3.289)	(8.471)	(-9.815)	(5.436)	(2.435)	(-1.37)				
T + 5	Price	=	-24.0020	-.0140	+.0384	-.0370	+2.397	+.2288	-1.95	.8961	3.79	30.53	.7107
			(-2.219)	(-2.004)	(7.921)	(-8.471)	(4.992)	(1.979)	(2.099)				
T + 6	Price	=	-24.8023	-.0120	+.0391	-.0370	+2.4256	+.2063	-2.330	.8924	3.86	30.53	.6454
			(-2.229)	(-1.729)	(7.852)	(-7.965)	(4.888)	(1.716)	(-2.452)				

[a]Numbers in parentheses are t values.

sign indicating that as a person's income increases, that person demands more pork. Pork production exhibits a negative relationship with price as expected. The workdays variable was thought, a priori, to have a negative relationship with price, indicating that as workdays increased so would pork supply, resulting in lower hog prices. However, regression analysis resulted in a positive sign for the workday variable. A possible explanation for this might be that packers, in an effort to comply with a guaranteed work week, bid up the price of hogs in order to better schedule hogs into the packing plants during holidays, weekends, etc. It should be noted that packing plants often continue to operate during holidays, weekends, etc., but the slaughter hog markets are closed. Too, the negative effect of the workdays variable may be accounted for by the pork production variable.

The effect of each variable, except for the dummy variable for the cycle, in the one-month equation is significantly different from zero at the .0001 level. This lack of significance for the dummy variable was thought to be due to the small amount of time elapsed in the cycle during a one month period. The hog cycle was hypothesized to take several months to make itself felt in the pork complex.

The one-month equation explained 94 percent of the variation in slaughter hog prices. The standard deviation of the equation is 2.82 compared to a price mean of $30.53. The best example of the predictive power of the equation can be seen in Figure 12. The figure shows a backcasting of the price equation through the entire data range. The vertical axis shows price in dollars per cwt. and the horizontal axis shows time in months. Figure 12 shows that the price model was

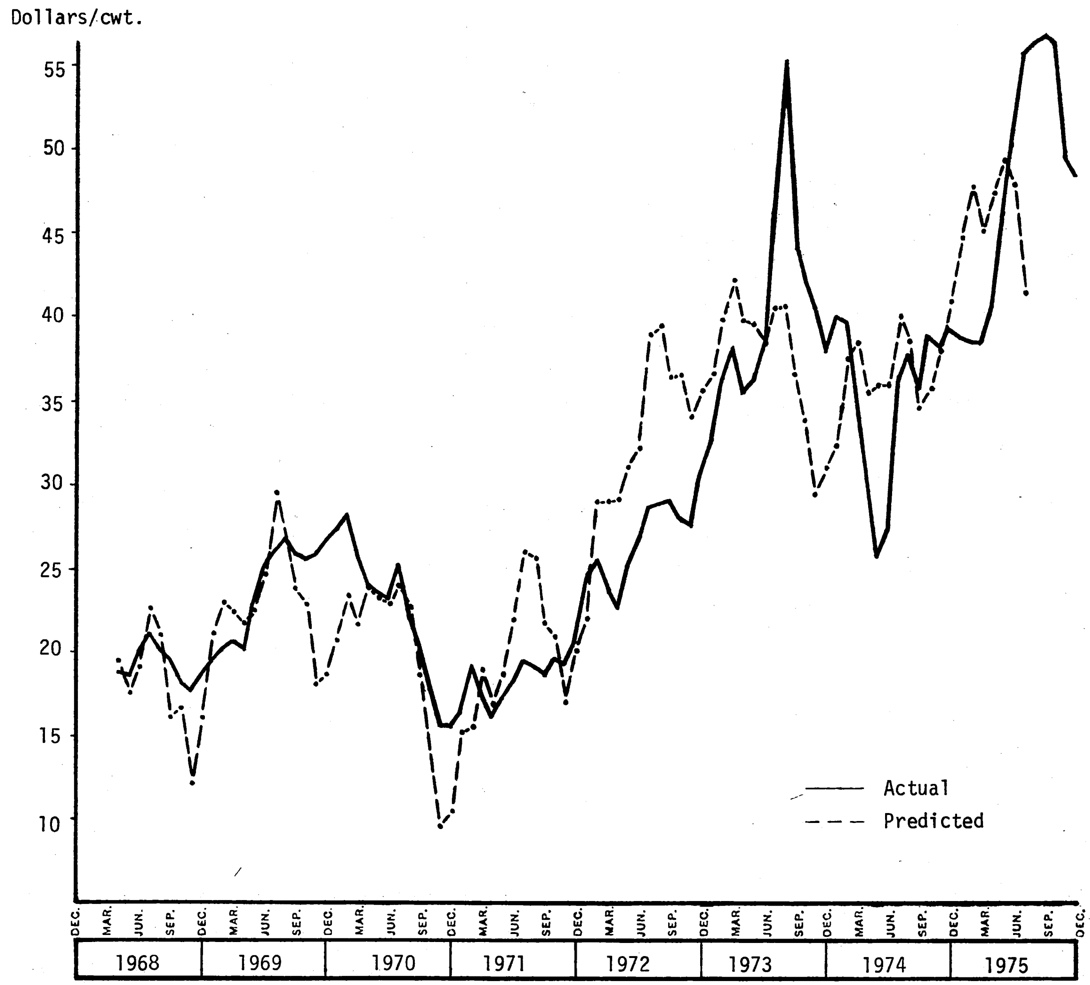

Figure 12. Hog Prices, U. S. #1-3, 220-240 Pounds, at Omaha, 1968-1975, Actual Versus One-Month Forecasts

consistently accurate in predicting direction of change in slaughter hog prices. The larger deviations in magnitude occur in or near the same time period of the price freeze of 1973. It will be noted that when the model failed to predict a change in direction, it always corrected itself within one month. The overall tracking ability of the predictive model is generally good except during a period when an abnormal economic force is imposed on the market (price freeze of 1973).

Two-Month Predictive Equation

The two-month price forecasting equation used the same variables as the one-month equation. All of the continuous variables maintain the same sign as in the one-month model. The sign of the cycle dummy variable changes from that of the one month equation but the level of significance (t = .081) indicates that the sign associated with the variable is unreliable. The regression coefficients for all the continuous variables are significantly different from zero at the .001 level.

The equation itself explains approximately 94.5 percent of the variation in hog prices. The standard deviation of 2.77 compares with the price mean of $30.53. Figure 13 presents a graphical representation of the predictive power of the equation. Deviations ranged from $.07 per cwt. in Februray, 1972 to $15.60 per cwt. in August, 1973. However, this latter large deviaiton can be explained by the abnormal effect of the price freeze in August, 1973. Note that when the model does err in a prediction of a change in direction, the model usually

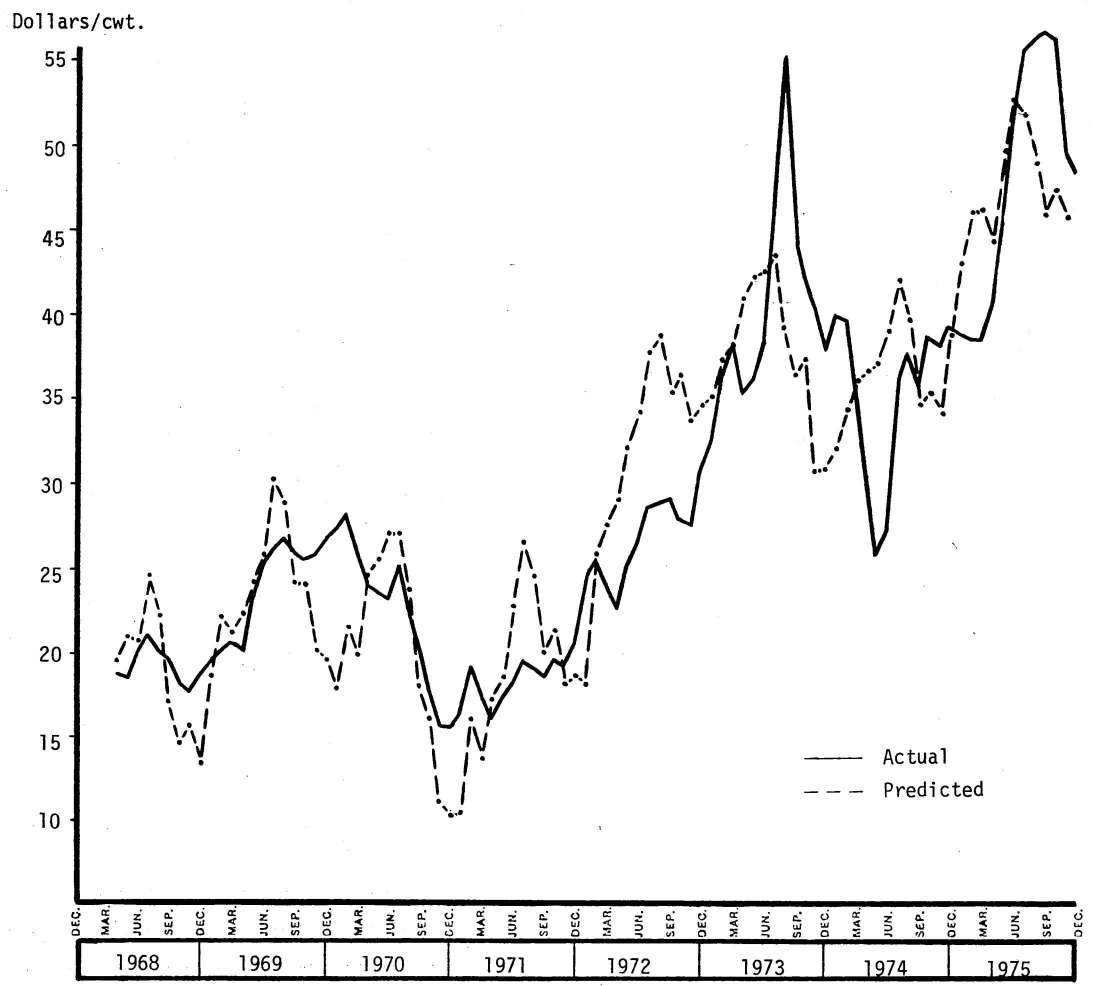

Figure 13. Hog Prices, U. S. #1-3, 220-240 Pounds, at Omaha, 1968-1975, Actual Versus Two-Month Forecasts

corrects itself within one month. Only in late 1969 and early 1970 is there a significant exception to this corrective behavior.

Three-Month Predictive Equation

The three-month predictive equation contained the variables of pork storage lagged three months, projected U. S. total personal income, projected pork production, a variable to account for variation in the number of workdays between months, beef price lagged three months, and the cycle dummy. All continuous variables retain the signs expected *a priori* or as previously discussed. The dummy variable to account for the cycle displayed a negative sign in this model. The significance level of the dummy variable's regression coefficient is quite low indicating little reliability in sign interpretation. It should be noted that as beef price has been lagged over longer time periods the significance level of the regression coefficient for beef price has dropped. This was expected since beef price in month T would have less influence on pork consumption (and so pork price) as the length of time between month T and the prediction month increased.

The three-month equation explained approximately 93.4 percent of the variation in slaughter hog prices. The standard deviation for the three-month equation is 3.02 which compares to the price mean of $30.53 per hundredweight. Figure 14 further reveals the predictive power of the model. As in the other models, the largest deviations occur in or near the time period of the 1973 price freeze. It should be noted that the same self-correcting capabilities that the T + 1 and T + 2 models possessed are exhibited by the T + 3 model.

Figure 14. Hog Prices, U. S. #1-3, 220-240 Pounds, at Omaha, 1968-1975 Actual Versus Three-Month Forecasts

Four-Month Predictive Equation

The four-month equation contained the same variables present in the one, two, and three-month equations. The signs on the regression coefficients remained the same. The regression coefficients for the continuous variables were significantly different from zero at the .02 level or lower. For the first time, the regression coefficient for the cycle dummy is accompanied by a fairly significant t value of -1.367 (significant at the .17 level). The cycle dummy displays a negative sign which indicates that when the up side of the production cycle is in phase, the intercept value for the equation is decreased.

The four-month model explains 90.7 percent of the variation in monthly slaughter hog prices. The standard deviation of the four-month equation is 3.58 which compares to the price mean of $30.53. Figure 15 contains a graphical picture of the backcasts of the model through the data range of April 1968 to December 1975. The ability of the model to depict changes in price four months in advance, taken along with the self-correcting power of the model, allow for excellent tracking. The largest deviation occurs in August 1973, a result of the price freeze.

Five-Month Predictive Equation

The five-month predictive equation contains all of the explanatory variables used in each of the previous equations. All of the signs displayed by the variables are are previously discussed. The regression coefficients for all variables, both dummy and continuous, are significantly different from zero at the .05 level. Beef price

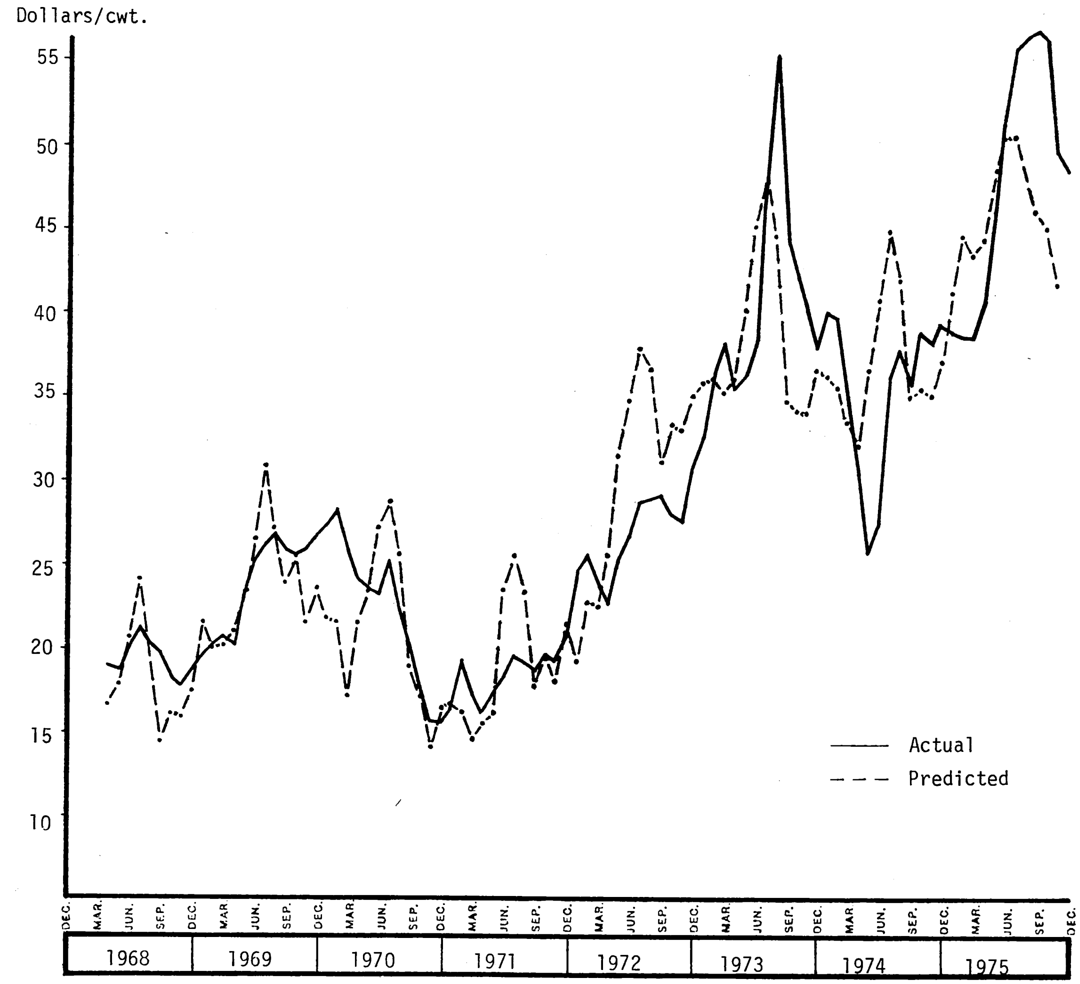

Figure 15. Hog Prices, U. S. #1-3, 220-240 Pounds, at Omaha, 1968-1975, Actual Versus Four-Month Forecasts

displays the lowest t statistic with a value of 1.979. A time lag of five months may be approaching the point that beef price has little effect on hog price. The cycle dummy had a t value of -2.099 which indicates statistical significance at the .03 level.

The five-month equation explained approximately 89.6 percent of the monthly variation in slaughter hog prices. The five month equation displayed a standard deviation of 3.79. Figure 16 presents a graphical representation of the backcasting ability of the five-month price model throughout the entire data range. The model, with few exceptions, predicts the change in direction and the relative magnitude of slaughter hog prices. It should be noted that the model corrects itself within one month. However, several exceptions do occur, mostly due to the price freeze of 1973.

Six-Month Predictive Equation

The model that best predicted slaughter hog price six months in advance was composed of the following variables: pork storage lagged six months, projected total personal income in the U. S., projected pork production, the variable to account for variation in the number of workdays per month, beef price lagged six months and a dummy to account for the hog cycle. The regression coefficients for pork storage and beef price display "t" statistics significant at the .087 and .09 probability levels, respectively. All other continuous variables in the equation have regression coefficients significantly different from zero at the .001 level. The primary reasons for the relatively poor statistical test values displayed by pork storage and beef price were due to the long time span bewteen T and T + 6.

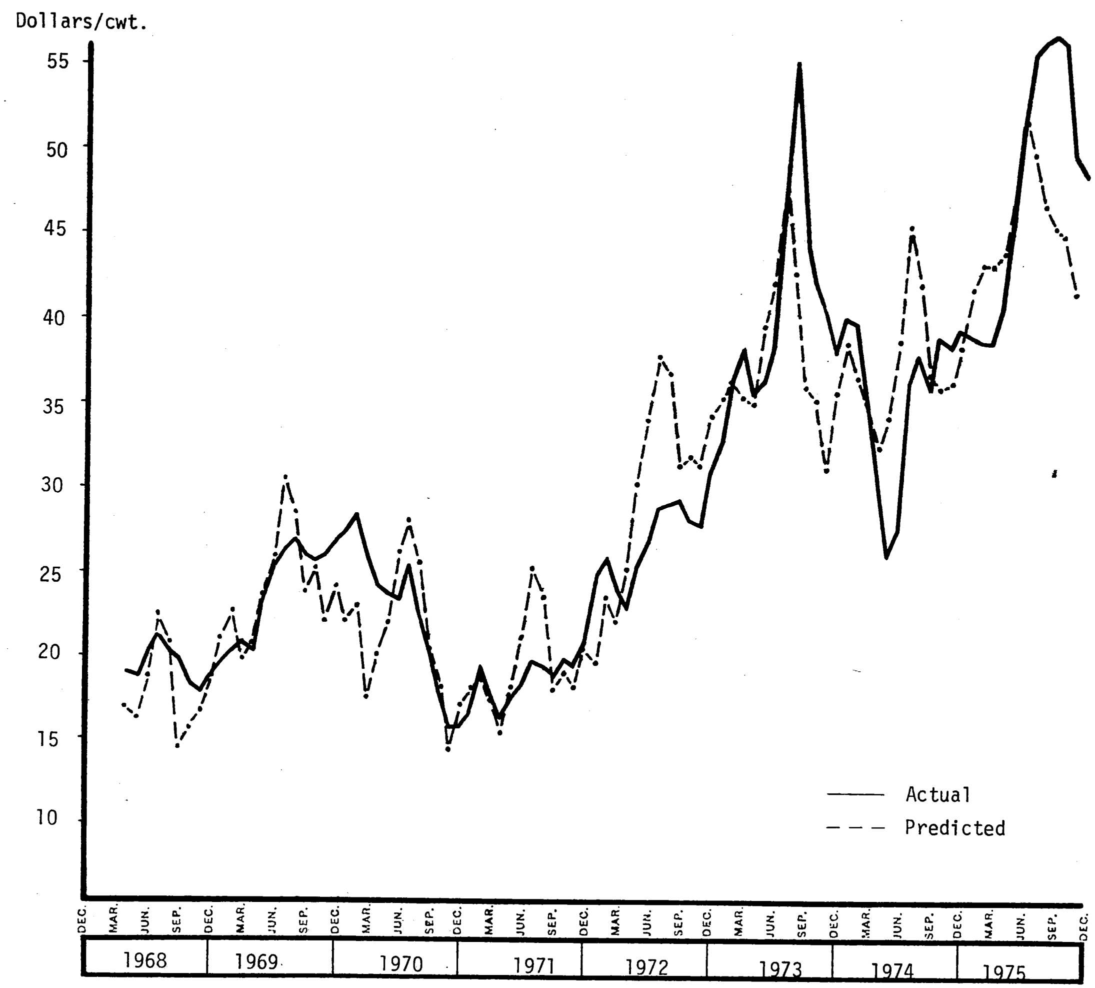

Figure 16. Hog Prices, U. S. #1-3, 220-240 Pounds, at Omaha, 1968-1975, Actual Versus Five-Month Forecasts

Both pork storage or beef price in month T would have already influenced hog price by the sixth month. However, the inclusion of these variables still markedly increased the explanatory power of the model and were therefore included in the model.

The six-month model had an R^2 of .893 and a standard deviation of 3.86. Figure 17 shows the graphical representation of the backcast analysis done over the entire data range. The majority of the large deviations from actual prices occur in or near the time period in which the price freeze was imposed in 1973.

Price Models' Projections Outside the Data Range

In order to further show the ability of the models to predict, prices were projected during the January-June 1976 time period. In order to do this, both TPI and pork production had to be projected during this time period. This was done using the procedures previously specified. These observations were then used in the price models and the projected monthly average price of slaughter hogs at Omaha was obtained. The forecasts for pork production and pork prices for each model for January through June, 1976, along with the actual observed prices, are shown in Table VII.

It should be noted that in the majority of cases the T + 3 and T + 4 models did the best job of predicting slaughter hog prices. This length of time was thought to be the best relationship between price and the independent variables, mainly because three to four months is the usual feeding period for hogs. It can be seen from Table VII that

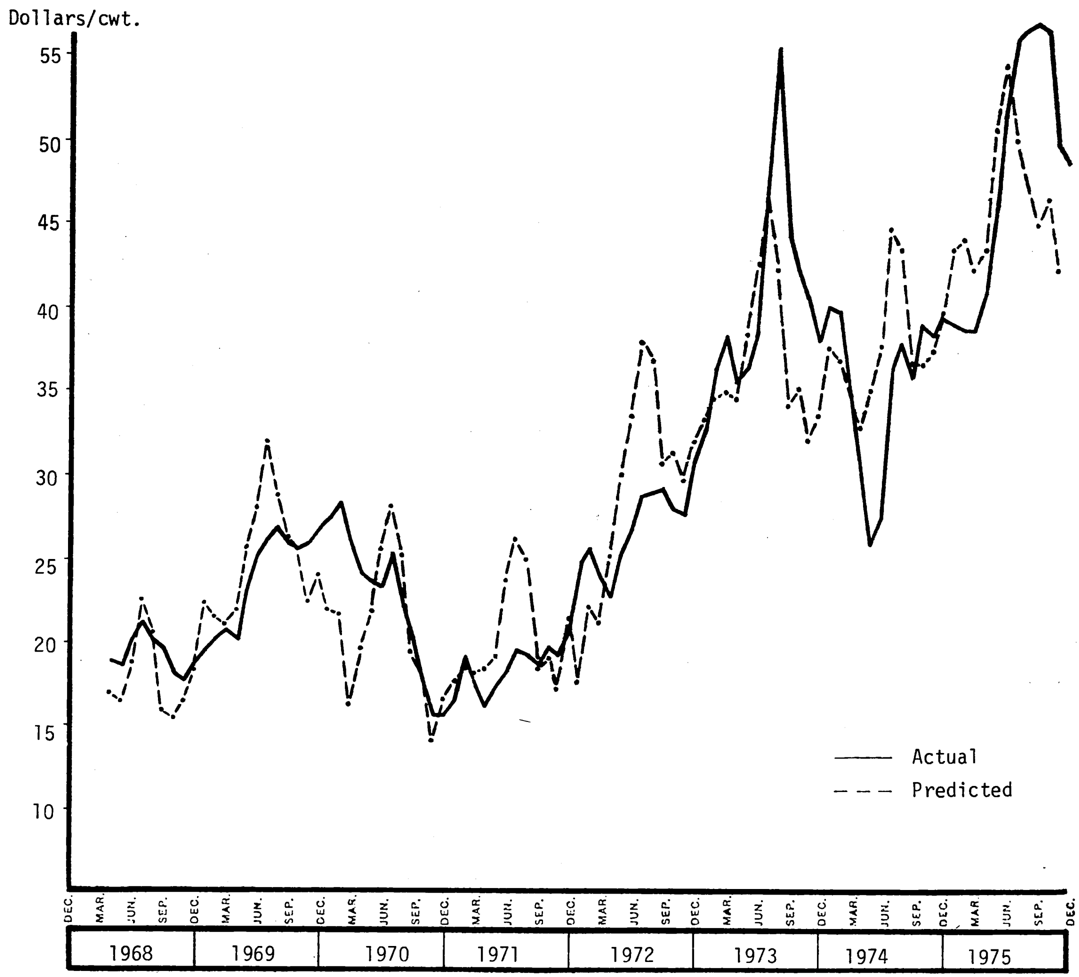

Figure 17. Hog Prices, U. S. #1-3, 220-240 Pounds, at Omaha, 1968-1975, Actual Versus Six-Month Forecasts

TABLE VII

PORK PRODUCTION AND HOG PRICE PREDICTIONS FOR JANUARY THROUGH JUNE, 1976, USING THE RESPECTIVE ONE-MONTH THROUGH SIX-MONTH MODELS

Month	Pork Production Predictions							Price Predictions ($)						
	T + 1	T + 2	T + 3	T + 4	T + 5	T + 6	Actual Production	T + 1	T + 2	T + 3	T + 4	T + 5	T + 6	Actual Price ($)
Jan.	1089.83	1040.84	1021.26	991.95	1021.99	1029.03	953.000	44.09	46.35	48.96	50.63	48.35	47.24	50.24
Feb.	1092.41	1035.50	1111.21	1037.27	1050.18	1073.27	850.000	44.16	46.11	45.65	49.00	47.54	44.77	49.68
Mar.	1118.13	1104.41	1170.69	1060.17	1039.04	1103.55	1092.000	47.09	46.68	44.12	48.68	50.66	48.52	47.23
Apr.	1131.07	1113.50	1167.66	1066.89	1077.57	1130.55	1003.000	43.69	45.35	42.28	46.20	46.92	45.08	48.86
May	1067.66	1073.22	1132.77	1206.52	1009.61	1084.67	897.000	46.04	44.45	42.32	39.23	48.00	45.33	49.78
June	990.32	1040.13	1077.13	1190.67	1187.85	1250.19	899.000	49.67	48.10	46.37	43.00	41.40	38.68	51.91

much of the price forecasting error was due to error in the projection of pork production.

Evaluation of the Price Models

The capacity of the models to accurately predict the price level has been illustrated in Figures 12 through 17 and Table VII. For decision purposes, the ability of the model to accurately predict the direction of price movement may be even more important.

Examination of Figures 12 through 17 reveals the models do, with minor exceptions, correctly depict the direction of price change. The 1973 period in which a price freeze was in effect is an exception, but the models are designed to forecast "normal" economic periods.

FOOTNOTES

[1]U. S. Department of Agriculture. Cold Storage Report, selected issues, 1968-1976, SRS, USDA.

[2]Hayenga, Marvin and Duane Hacklander. Short-run Livestock Price Prediction Models. Michigan Agr. Exp. Sta. Bul. 25, East Lansing, 1970.

[3]U. S. Department of Agriculture. Hogs and Pigs, selected issues, 1968-1975, SRS, USDA.

[4]Moore, W. W. "Quantitative Models to Predict Prices of Choice Steers." Unpublished M. S. thesis, Oklahoma State University, 1975.

[5]Organization for Economic Cooperation and Development. O.E.C.D. Main Economic Indicators. Washington, D. C., published monthly, 1968-1975.

CHAPTER IV

HEDGING STRATEGIES

The large amount of variation present in hog prices during recent years has been discussed in previous chapters. Large price fluctuations can adversely affect producers' profit margins and expose the hog producer to large amounts of price risk.

The live hog futures contract offers one method producers can use to avoid price risk. To date, however, very little hedging has been done by hog producers. This lack of hedging can be attriubted to several factors, some of which are (1) the lack of understanding of the basics of hedging, and (2) a fear of hedging that has developed when poorly informed producers have tried hedging and suffered increased losses. Improved information and decision criteria are essential if the producer is to increase his profit margin and decrease price risk.

The purpose of this chapter is to compare possible hedging strategies, with and without the use of the price forecasting models, which may be incorporated into a hog producer's decision processes. The strategies were kept relatively simple in order to be directly applicable to a individual hog producers' situation. Comparisons were made among the strategies with respect to expected profit and price risk reduction.

Since a hedger is defined as someone in the futures market who has an opposite position in the cash market (e.g., a hog producer), no strategies of a speculative nature (with respect to the futures market) were considered.

Method of Analysis

The January 1972-June 1976 period was divided into 219 consecutive feeding periods of 91 days each. Using a computerized feeding program, the feeding of hogs was simulated by the following steps.

1. Fifty-pound feeder pigs were placed on feed at a cost representing a U. S. #1-2, 40-50 pound feeder pig at the South Missouri markets.
2. The pigs were fed for approximately 90 days using a 2.95 conversion rate of gain for corn (one pound of gain per 2.95 pounds of corn) and a .55 conversion rate for soybean meal. This allowed for a combined feed conversion rate of 3.5. The total gain per head was assumed to be 182 pounds. This allowed for a finished weight of 232 pounds, and a market weight of 220 pounds after a 4.3 percent shrink.[1]
3. The hogs were then sold at a price representing U. S. #1-3, 220-240 pound hogs at Omaha.

The costs of the feeding program were calculated as follows:

(1) Interest on feeder pig investment = cost of pig x .09 x 13/52.

Equation 1 shows that the interest on the feeder pig was calculated by multiplying the cost of the pig times a nine percent interest rate times the fraction of the year the hogs were on feed.

(2) Corn fed per hog = 2.95 x 182 pounds = 536.9 pounds or 9.5875 bushels.

(3) Corn cost = 9.5875 bushels x current price of corn.

Equations 2 and 3 show that the corn costs were calculated by multiplying the conversion rate for corn by the number of pounds of gain to obtain the number of pounds eaten. This was converted to bushels and then multiplied by the current cash corn price at Omaha to obtain the cost of corn.

(4) Soybean meal fed per hog = .55 x 182 lbs. = 100.1 lbs. or .05 tons.

(5) Cost of soybean meal = .05 tons x current pirce of soybean meal.

Equations 4 and 5 show that the soybean meal costs were calculated by multiplying the conversion rate for soybean meal by the pounds gained to give the pounds of meal eaten. This was converted to tons and multiplied by the price of meal to obtain soybean meal cost.

(6) Cost of corn + cost of meal = feed cost

(7) $$\text{Interest on feed cost} = \sum_{n=1}^{13} \frac{\text{feed cost per week} \times .09}{52}$$

(8) Total feed cost = feed cost + interest on feed cost

Equations 6 through 8 show the total feed cost was calculated by adding the corn and soybean meal costs and then adding the interest on the feed cost for the 13 week feeding period.

In addition to these costs, other costs were necessarily calculated in order to develop the hedging strategies. These costs amounted to margin calls and interest on the money necessary to meet these margin calls. These costs were calculated in the following manner. One 220 pound slaughter hog is .00733 of a 30,000 pound live hog contract. It was assumed that one would have to pay nine percent interest on the initial money required when hedging one contract. This initial margin money was assumed to be 900 dollars. Interest on this money was calculated to be the product of 900 dollars times .09 times 91/360 (which is the fraction of the year the hogs are on feed) times .00733. The result is the amount of interest per head paid on the initial 900 dollars.

It was further assumed that additional margin calls of $300 per contract would be made for every one dollar move against the hedge position. It was also assumed that when a margin call was issued, the feeder would pay interest on the additional margin money until the price had moved at least back to its initial position before the adverse price move started. Equations 9 through 11 summarize these calculations. Table VIII gives an example of all the feeding and hedging cost calculations.

(9) 220 pound hog/30,000 pounds per contract = .00733

(10) Initial margin interest = 900 x .09 x 91/360 x .00733

(11) Additional margin calls = $300 for every $1 move against a position in the market.

Criteria for Judging Hedging Strategies

Before the hedging strategies could be analyzed, it was necessary to develop some criteria to judge the performance of each strategy relative to the "feeding only" basis. Two criteria were chosen:

1. The mean (average) net return per head for the alternative strategies.

TABLE VIII

EXAMPLE OF COST CALCULATIONS FOR USE IN COMPARING HEDGING STRATEGIES FOR HOG PRODUCERS

Feeder Pig Cost		=	$9.88
Interest on Feeder Pig	9.88 x .09 x 13/52	=	.22
Corn Cost	2.95 x 182 = 536.9		
	536.9/56 pounds/bushel x $1.34/bushel	=	12.87
Soybean Meal Cost	.55 x 182 = 100.1		
	100.1/2000 pounds/ton x $91 ton	=	4.55
Interest on Feed	$\sum_{n=1}^{13} \frac{17.42 \times .09}{52}$	=	.03
Total Feeding Cost		=	27.55
Interest on Initial Margin	900 x .09 x 91/360 x .00733	=	.01
Interest on Margin Calls			
Strategy A = 300 x .09 x t*		=	.00
Strategy B = 300 c .09 x t*		=	.00
Strategy C = 300 x .09 x t*		=	.00

*t equals the length of time between the margin call and its removal.

2. The variance (a measure of variability) of net return per head for the alternative strategies.

Assuming that all hog producers are profit maximizers, the "best" possible strategy would possess the highest net return and the lowest variance. Therefore, a "good" strategy would either (1) increase the mean return and lower the variance or (2) increase the mean and not markedly increase the variance or (3) decrease the variance and not markedly decrease the mean return. Whether the increase/decrease in mean (expected) return is offset by a respective increase/decrease in the variance of the return will have to be decided by the individual producer as he views his ability to carry price risk.

Seven Selected Hedging Strategies

Strategy I: Unhedged Feeding Operation

The unhedged feeding operation consisted of a typical hog feeding operation where 50 pound feeder pigs were placed on feed, fed 91 days, and sold at a weight of 220 pounds. The results of this strategy provided a basis with which to compare other hedging strategies. The mean net return per head and the variance of the return for this strategy were $43.24 and 242.271 (Table IX).

Strategy II: Completely Hedged Operation

Hedging strategy II assumed all hogs were fully hedged during the entire feeding period. During the week the hogs were placed on feed, an adequate number of the "appropriate futures contract" was sold to fully hedge the operation. The appropriate contract month selected

TABLE IX

RESULTS OF HEDGING STRATEGIES IN DOLLARS PER HUNDREDWEIGHT

Strategy	Mean Net Return	Change in Return from Strategy I	Variance	Change in Variance From Strategy I	Low Return	High Return
I	43.24	----	242.271	----	10.25	86.49
II	39.22	-4.02	226.945	-15.326	6.79	76.53
III	40.29	-2.96	255.515	13.244	12.05	95.47
IV	46.18	2.92	235.374	-6.897	16.53	98.58
V	46.11	2.87	249.276	7.005	10.25	86.49
VI	46.40	3.16	264.488	22.217	10.25	86.49
VII	46.70	3.50	247.577	5.306	10.25	86.49

was either the contract which matured during the week the hogs were sold, or the closest possible contract after the week the hogs were sold. The buy-back trade was completed at the price denoted by Monday's close during the week the hogs were sold. On a per head basis, the net return from the completely-hedged feeding operation was as follows: an expected return of $39.22 with a variance of 226.945 (Table IX).

Strategy III: Hedge When Moving Averages Cross

Under strategy III, the hog producer was assumed to place his hogs on feed but did not hedge the hogs until the five and ten day moving averages (of futures prices) crossed each other.[2] The hedge was then held through the entire feeding period. The logic behind this strategy can be seen in Figure 18. It is evident that the five and ten day moving averages do a good job of depicting a change in direction of price movement. Under this strategy, the five day average must cross the ten day average from above before a hedge is placed. Such a movement in the averages depicts a downturn in price, the situation with which we are concerned. The mean return and the variance for this strategy were calculated to be $40.29 and 255.515, respectively (Table IX).

Strategy IV: Hedge In and Out Using the Moving Average Criteria

Strategy IV is basically the same as strategy III except that the hedge was not necessarily hedl through the entire feeding period. If the five and ten day averages recrossed each other (once a hedge was

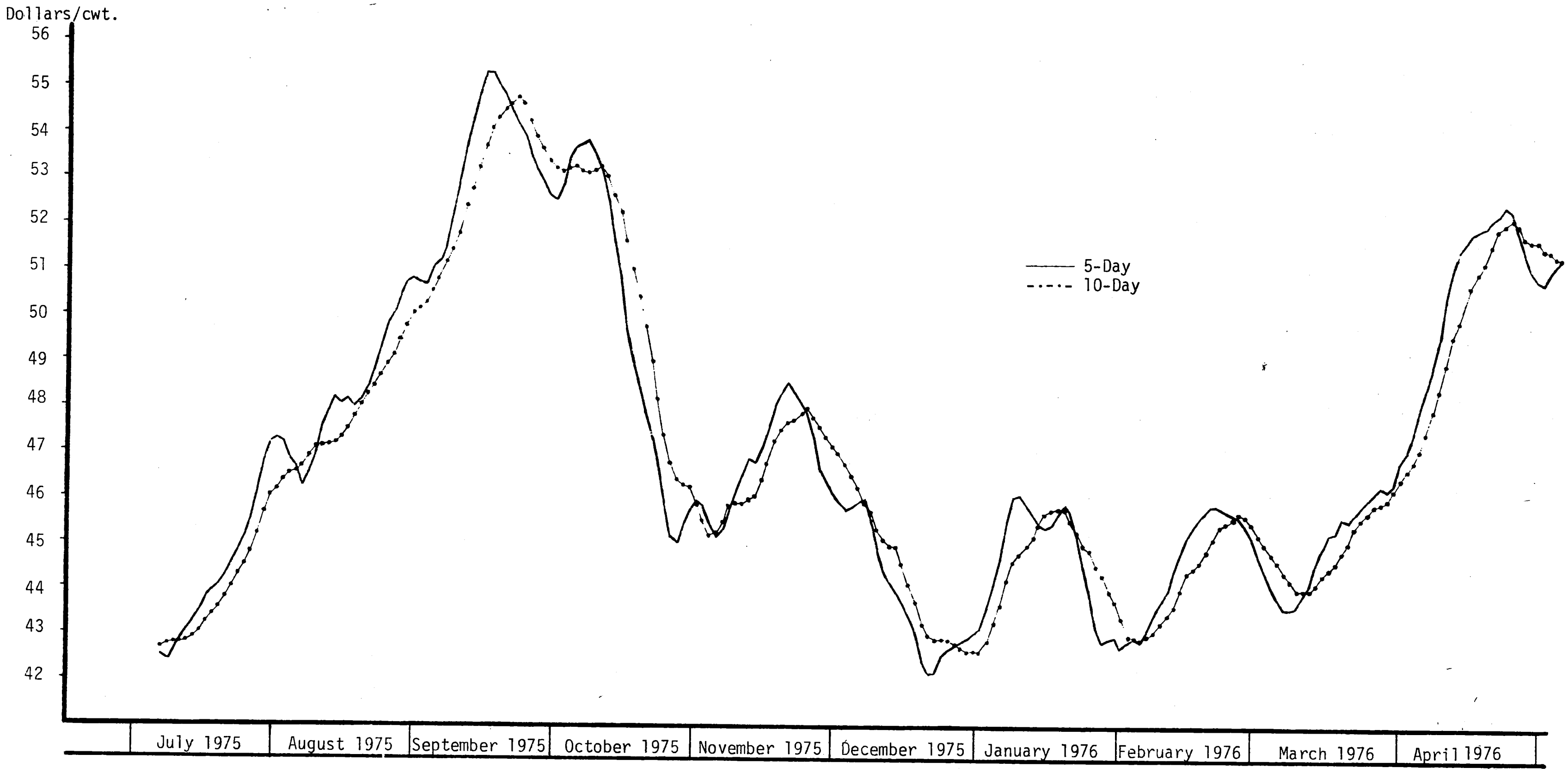

Figure 18. Five and Ten Day Moving Averages of Futures Prices, June Live Hog Contract, Omaha, July 1975-April 1976

placed using Strategy III criteria) an upturn in price is expected. By holding the hedge, losses will occur. Therefore, the hedge is lifted and not replaced unless another intersection of the five and ten day moving averages indicate a downturn in price. The return per head and the variance for this strategy were $46.17 and 235.374, respectively (Table IX).

Strategy V: Hedge If the Projected Price Is Less Than the Futures Quote

Under strategy V, the producer only hedged if the futures quote on live hogs (for the month the hogs are sold) is assumed to be too high. Such a situation was determined using the price projection models and a confidence interval. The procedure was to project price in the month the hogs were to be sold, using the price projection model previously specified. A confidence interval was then calculated by adding/subtracting the equations' standard deviation to/from the price prediction. If the futures quote is above the confidence interval then a hedge is placed and held throughout the feeding period. The expected returns and variance from the strategy were $46.11 and 249.276, respectively (Table IX).

Strategy VI: Using the Price Projection Model to Hedge, if Moving Averages Have Crossed

Strategy VI is basically the same as strategy V except that a hedge was not placed until the moving average criteria had been satisfied. Therefore, when the futures quote (for the month the hogs were to be sold) was above the confidence band computed around the price projection, a hedge was placed only if the five day moving average of futures price crossed the ten day moving average from above, thus signaling a downturn in price. The hedge was then held through the entire feeding period. The net return and variance from this strategy was $46.40 and 264.488, respectively (Table IX).

Strategy VII: A Combination of Strategies IV and V

Strategy VII is similar to strategy VI except the five and ten day average criterion was employed to lift the hedge if the five day crossed the ten day from below, signaling an upturn in price. Therefore, it was possible for the hedge to be placed and lifted several times during the period. This strategy gave the highest net return of all strategies tested, $46.74 with a variance of 274.577 (Table IX).

Comparison of the Hedging Strategies

Table IX contains the results of the seven strategies along with statistics depicting improvements or losses in both mean return per head and the variance per head. Strategy I, the feeding-only operation, provides a basis for comparison. It should be noted that by using the total hedge strategy (Strategy II), a large decrease in mean net return occurred. This illustrates one of the reasons producers who have "tried" hedging are skeptical and prone to avoid hedging as a useful marketing tool. The use of the moving averages improved mean net return when one allowed the moving averages to signal a removal of the hedge when an upturn in price was indicated (Strategy IV). However, if the hedge was held during the entire feeding period (Strategy III), a reduction of $2.96 return per head was incurred. The highest average returns were made when the price model was used to project price and then that price was used to "test" the futures price being quoted for the month the hogs were to be sold (Strategies V, VI, and VII). By using the price projections in conjunction with the moving average criteria, an average increase of $3.50 per head was obtained.

A further comparison can be made between strategies IV and V. Strategy IV used only the moving averages for a decision criterion and strategy V used only the three-month price model for a decision criterion. The average return from the strategies were within .07 of each other. However, strategy V was based on a model that estimated price three months in advance while strategy IV used the moving averages, which are based on a maximum of 10 days. When both the price model and moving average criteria were employed, the return was the highest obtained (strategy VII). The difference in the variances between strategy I and strategy VII was only 2.1 percent while the increase in return was more than seven percent. For the feeder who wishes to increase his mean net return without greatly increasing (if any) his exposure to risk, such strategies as IV through VII may have some merit.

Overall, the results clearly showed that hedging strategies can be developed which are useful for the hog producer when trying to increase revenues or decrease price risk. Strategies wuch as these could readily be incorporated into the hog producer's decision processes.

FOOTNOTES

[1]The Total Feed Ration per 182 pound gain consisted of 9.3 bushels corn and 104 pounds of soybean meal for a total of 624 pounds of feed ration. Pork production systems with Business Analysis, "Feeding Feeder Pigs", Cooperative Extension Service Bulletin #10-133, Purdue University, West Lafayette, Indiana.

[2]Moving averages are one of the technical approaches used in fugures trade today. A number of moving average systems are presented in the following works: C. W. Keltner, "How to Make Money in Commodities", Keltner Statistical Service, Kansas City, Missouri, 1960; Richard J. Teweles, Charles V. Harlow, Hervert L. Stone, "The Commodity Futures Game, Who Wins? Who Loses? Why?" McGraw-Hill Book Co., New York, New York, 1974.

CHAPTER V

SUMMARY AND CONCLUSIONS

Hog producers are subject to large price fluctuations resulting in high degrees of price risk. This price risk makes more difficult the marketing decisions of each hog producer. To reduce the hog producer's price risk and aid him in his marketing decisions, the objectives of this study included (1) the development of six price forecasting models to predict monthly slaughter hog prices from one to six months into the future, and (2) to compare seven strategies for hedging on the live hog futures market.

In order to develop the monthly price models it was necessary to project selected explanatory variables. Simple trend analysis was judged sufficient to project total personal income. Pork production projection models utilized variables such as (1) specified weight classes of hogs that would come to market during the month for which projection was desired, (2) a variable to account for variation in workdays bewteen months, (3) an Omaha-based hog-corn ratio, (4) an Omaha corn price, and (5) a dummy variable to account for the hog cycle. Also, a set of monthly dummy variables were incorporated to allow the intercept of the regression line to shift from month to month in response to otherwise unspecified seasonal influences.

The six (one to six months) pork production models explained from 80 to 85 percent of the variation in pork production. Backcast analyses were performed and showed that the models did an acceptable job in forecasting both direction and magnitude of production changes.

With the pork production and total personal income models developed, the next step was the final development of the slaughter hog price forecasting models. In addition to pork production and personal income, slaughter hog prices were found to be a function of pork storage, beef price and the workdays variable. These variables were found to be positively related to slaughter hog prices, except for pork production and storage. Also, a dummy variable to account for the influenue of the hog cycle on slaughter hog prices was included. The six price forecasting models explained from 89 to 95 percent of the variation in slaughter hog prices. Large "misses" were recorded during the middle of 1973. However, these errors can be attributed to the price freeze instituted in March, 1973. The freeze was removed in September, 1973, but several months were required for the abnormal marketing patterns to move through the system. The model regained its accuracy within several months after the removal of the price freeze. Due to this ability to regain predicting accuracy after an abnormal market shock, it is expected that the price models will continue to be useful and accurate predictors of price, as long as the primary relationships between price and the price determining forces do not change markedly.

With the price models developed, seven hedging strategies were developed which the hog producer might use to lessen his price risk. Cash results for these strategies were calculated by buying 40-50 pound feeder pigs at a price representing the South Missouri markets. The hogs were then fed ninety days using a 3.5 feed conversion rate. Total gain was 182 pounds with a market weight os 220 pounds after a

4.3 percent shrink. The hogs were then sold at a price representing U. S. #1-3, 220-240 pound hogs at Omaha.

The first hedging strategy (I) consisted of a feeding only operation. Under this strategy the feeder was not involved in the futures market at any time. Strategy I was used as a basis for comparison and yielded an average return of $43.24 per head.

Strategy II consisted of a complete hedging operation where all hogs were hedged at all times. Such a strategy revealed that users of the futures market will drastically reduce their average returns by hedging all hogs regardless of price outlook. This strategy yielded an average return of $39.22 per head.

The next 2 strategies incorporated a decision criterion by which a hedge is placed. The criterion consisted of calculating 5 and 10 day moving averages of price. When a downturn in price was signaled (five day average crosses ten day average from above) the hedge was placed. Strategy III held the hedge, once placed, throughout the entire feeding period, while strategy IV removed the hedge if the moving averages signaled an upturn in price. The hedge was then replaced if a downturn in price was signaled. Strategy III gave a return of $40.28 per head and strategy IV yielded a return of $46.16 per head.

Strategy V used the three-month cash price outlook model previously developed. The model was used to predict cash price when the hogs were expected to be sold. A confidence interval was then computed about this price and the maximum value for this interval was compared with the current futures quote for the month the hogs would be sold. If the futures quote was above the top limit of the confidence interval, a hedge was placed and held throughout the entire feeding period. Strategy V yielded a return of $46.11 per head.

Strategy VI was a variation of the previous strategy. The same procedure was followed except the additional criteria of the moving averages was added. If the futures quote was above the confidence band calculated around the price prediction, a hedge was placed only after the 5 and 10 day moving averages had signaled a downturn in price. The hedge was then held throughout the feeding period. Strategy VI gave an average return of $46.39 per head.

The last strategy (VII) tested was basically the same as strategy VI except the hedge was lifted if the moving averages later signaled an upturn in price. The hedge was replaced if the averages again signaled a downturn in price, etc. This strategy gave a return of $46.74 per head.

The strategies were evaluated against the feeding only operation using mean net return and variance criteria. It should be noted that the strategies which incorporated the use of the price outlook model in combination with the moving average criteria produced the largest average return per head adding as much as an additional 3.50 per head over the feeding only operation. This increase in return was accomplished without substantially increasing the amount of price risk as measured by the variance.

Conclusions and Implications

The hog producer today is faced with large amounts of price risk resulting from rapid price fluctuations. Such risk compounds the difficulty the producer encounters when making his marketing decisions.

The producer is forced to plan over a shorter time horizon and allow the large variations in returns. By using the price projection models developed in this study, the producer is provided with more information on which to base his decision. The models exhibit several strong points and one such point is to allow the producer to plan his marketings more effectively as far as six months in advance. This time span will allow the producer to vary such things as placements, rates of gain, etc.

Another advantage inherent in the models is the relative simplicity of the models and their adaptability to many different producer situations. Given these advantages and the predictive accuracy of the price models, the models should prove to be an acceptable and useful tool for the Oklahoma hog producer.

The producer can reduce his price risk even more by using selected hedging strategies developed herein. By being able to plan for and lock-in particular margins, the producer should be able to stabilize the flow of returns and possibly increase his long-run net return.

Additional Study Needed

This study suggests several areas that merit further research. Additional analysis to improve the projection accuracy of those exogenous variables to which price reacts in the current time period could improve price predictions. Price predictions that are useful over longer time horizons should also be developed to aid in longer run production decisions. More sophisticated and accurate criteria to use in making hedging decisions need to be developed and tested. And the values of alternative tools (such as closer vertical coordination) for avoiding marketing risks need to be determined.

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