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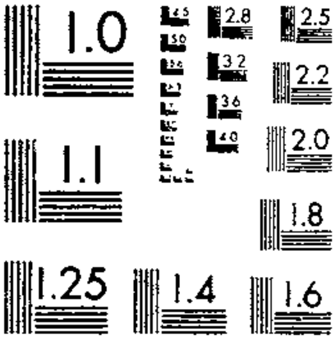

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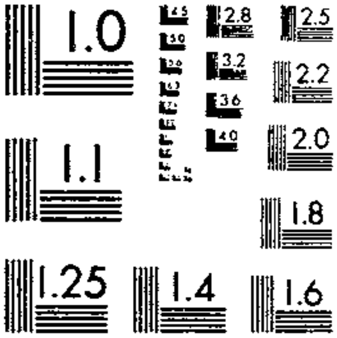

MICROCOPY RESOLUTION TEST CHART
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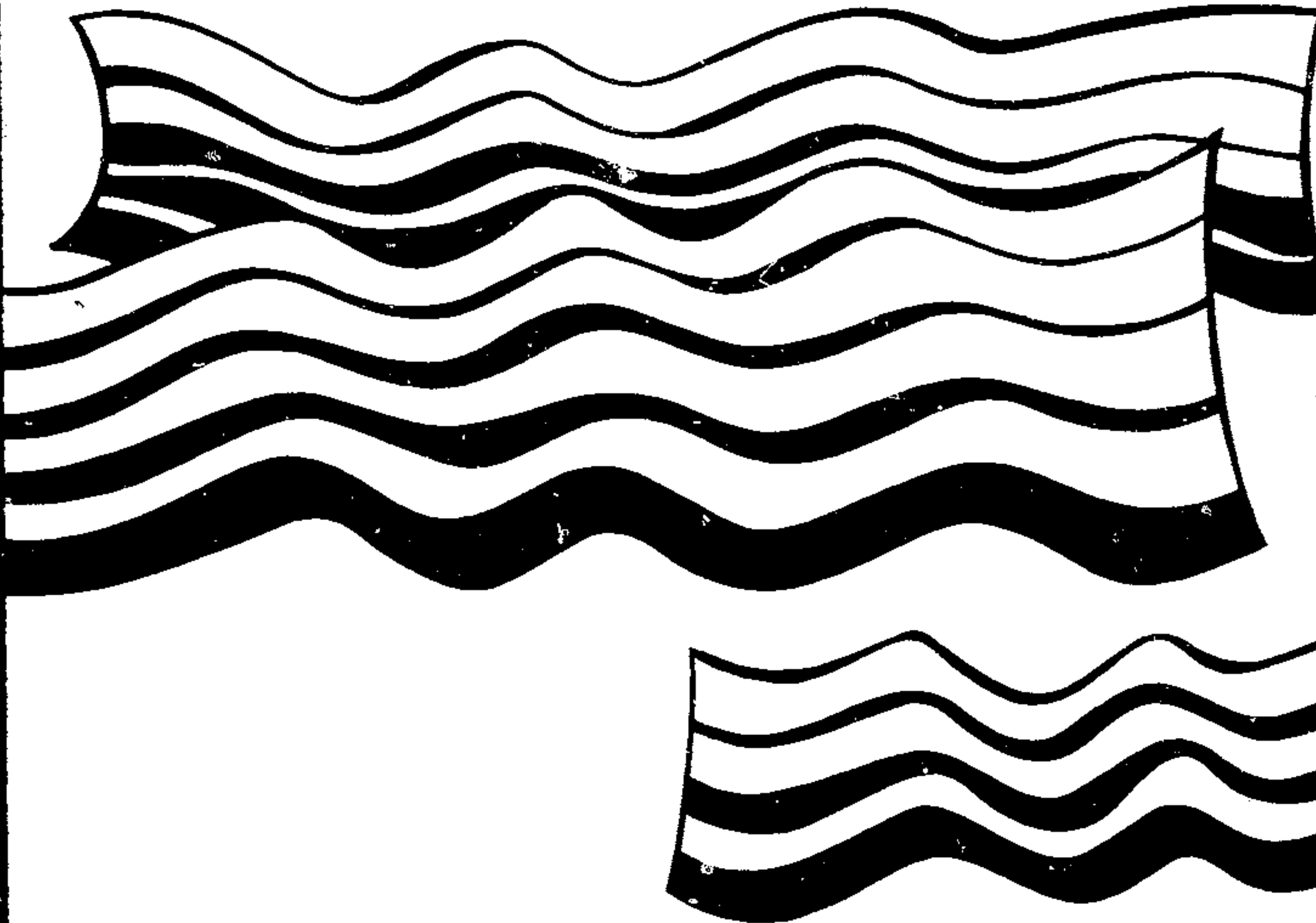
TECHNICAL BULLETIN NO. 148[illegible]

QUARTERLY AND SHORTER-TERM PRICE FORECASTING MODELS RELATING TO CASH AND FUTURES QUOTATIONS FOR PORK BELLIES



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ABSTRACT

Quarterly and monthly three-equation models designed to predict (a) wholesale cash prices for fresh pork bellies at Chicago, (b) quarterly consumption, and (c) end-of-quarter stocks were developed and fitted, based on data for 1957-71. The major methodological contribution was a demand-for-storage equation that combined a statistical technique developed by Nerlove to measure price expectations with a formula of supply expectations based on data published in the U.S. Department of Agriculture quarterly *Hogs and Pigs* report. The models appeared to give reliable forecasts of the endogenous variables for the first half of 1972, which represents a period beyond the period of fit. Least squares regression equations for predicting pork belly production up to two quarters ahead and models for predicting weekly changes in pork belly prices are also presented.
Keywords: Pork bellies, quarterly models, cash prices, futures trading, econometric models, price forecasting.

PREFACE

This bulletin describes the principal economic variables that influence prices, consumption, and end-of-period stocks for pork bellies (the part of the hog from which bacon is obtained). Statistical analyses are summarized and presented so as to be used for analytical purposes or as a guide in studying trends within and between marketing years. Major economic implications are also discussed in detail. No similar comprehensive description of the forces that affect the pork belly economy is available.

This report was prepared under a research contract No. 12-19-01-5-9 by Texas Tech University for the Commodity Exchange Authority (CEA), U.S. Department of Agriculture (USDA). The Authority has responsibility for supervising and regulating trading in futures contracts for pork bellies on the Chicago Merchantile Exchange. Allen B. Paul, Chief, Competition and Pricing Branch, Economic Research Service (ERS), USDA, served as contracting officer.

The material presented should be of interest primarily to persons who seek a wider understanding of the factors influencing the pork belly economy and of relations between cash and futures quotations for the commodity. Economists, statisticians, and other research workers probably will be interested in the simultaneous equation techniques that were applied and tested. The economic forces involved are ranked as to relative importance, and methods are provided for determining price levels of cash and futures quotations that are consistent with current and future economic factors.

Information came from many sources. Special acknowledgement is made to the Chicago Merchantile Exchange for the loan of file copies of its annual yearbook; Leonard J. Havercamp, Vice President, Wilson and Company, Inc. for price data; the Livestock Section, Statistical Reporting Service, USDA, for photostats of certain pages from the *Pig Crop* and *Hogs and Pigs;* and staff members of the Animal Science Department, Texas Tech University.

Washington, D.C. 20250 July 1973

CONTENTS

HIGHLIGHTS

A set of quarterly three-equation models was formulated and fitted statistically to represent the economic forces which determine prices for cash pork bellies at Chicago, movement into consumption for the 48 States, and end-of-period U.S. stocks. These models were designed to permit estimates of price levels for cash and futures quotations. Fitted to data for 1957 through the first quarter of 1971, the models appeared to explain current prices and utilization satisfactorily for most periods from the second quarter of 1971 forward.

Disposable personal income and pork belly prices accounted for most of the variability in consumption over the years studied. Availability of eggs for consumption was examined for any effects on pork belly (bacon) consumption. When quantitative variables in the consumption relation were expressed in per capita terms, a complementary relation between eggs and pork bellies was found in all quarters. Prices of pork bellies tended to be higher when egg supplies were large than when they were small, other things being equal.

Based on the best models, pig crops that will be marketed beyond the current quarter seemed to affect quarterly storage policy in all but the April-June quarter. Demand for storage was assumed to depend on the trade's expectations about both prospective demand and supply of pork bellies for one or two quarters ahead. Expectations with respect to demand were measured in part through use of a statistical technique developed by Nerlove that involved current prices and current and prospective consumer income. Expectations about supply were based on data on pig crops that would be marketed in the respective quarters, published in USDA's quarterly report *Hogs and Pigs*. Storage stocks of pork bellies normally increased from October to May or June and decreased during the remainder of the October-September hog marketing year. During periods in which stocks were being reduced, movement out of storage represented about 10-15 percent of estimated total consumption. Stocks usually reached an annual low around September 30; they are seldom carried from one marketing year to the next.

A set of monthly three-equation models was developed. However, calculated prices from the models at times varied greatly from actual prices. Apparently, a month was too short a time for the basic economic forces to interact in a measurable way. Single-equation analyses from the first round of the three-stage least squares fits for these models were useful for some months.

As published data were available either for production or consumption of pork bellies, alternative ways of estimating were considered. Based chiefly on trade recommendations and on cutout percentages for hogs over a wide weight range, production was assumed to equal 11.5 percent of liveweight commercial slaughter of hogs. Consumption was estimated from production adjusted for changes in stocks.

Methods were developed to estimate pork belly production two quarters ahead from data in *Hogs and Pigs*. Equations were estimated for predicting (a) average live weight per head for barrows and gilts slaughtered, (b) average live weight per head for sows slaughtered, (c) total number of barrows and gilts slaughtered, and (d) total number of sows slaughtered. For the near quarter, estimates were computed in two ways—directly for the quarter and indirectly by estimating for each month and adding these estimates. A set of "best" equations were developed for 1964-71, some of them based on the sum of the months and some, on a direct quarterly approach. A slight adjustment was required to go from data used in these analyses to equivalent liveweight commercial hog slaughter for the 48 States. After the adjustment was made, liveweight slaughter of hogs, and hence, production of pork bellies, was forecast for both the near and far quarter from data in each *Hogs and Pigs*; the error, on the average, did not exceed 2 percent.

Relations between cash quotations in the models and futures quotations near the close of trading in the delivery month apparently stabilized from 1968 on. Such prices for pork belly futures tended to be above cash quotations for fresh or frozen bellies in February-May, suggesting higher quality standards for bellies that are deliverable on the contract than for those normally sold in cash markets. Futures were usually below the cash market for fresh bellies in July and August. From midsummer through September, cash frozen bellies usually sold below fresh bellies. Normal spreads between the futures quotation in the delivery month and cash prices per pound were estimated for pork bellies weighing 12-14 pounds at Chicago. For February, the futures premium was 3.45 cents; for March and May, 2.7 cents, and for July and August, 3 5 cents.

Likely expectations by the trade regarding pork belly production were estimated for the following 6 months from September 1967 through March 1972, based on data for this period from *Hogs and Pigs*. This and related information was used in connection with the quarterly models to predict cash prices for two quarters ahead and, after adjustment for normal basis, to predict the level of futures quotations for specified contracts beginning with February 1968 and ending with May 1972. Net errors from all sources for futures quotations averaged between 2 and 5 cents per pound for near-quarter predictions and between 3 and 7 cents per pound for far-quarter predictions. The most important error sources for the near-quarter predictions were the models and equations (when all predetermined variables were known), differences in cash prices between the period predicted and that at the close of the contract, and differences in basis from the assumed normal. For the far quarter, errors caused by differences between initial estimates of sows farrowing and the pig crops and later official figures, particularly from the reports giving data only for 10 states, and those caused by faulty estimates of beginning stocks were equally important.

Regression analyses were based on data in the monthly USDA *Cold Storage* report and on data relating to daily hog slaughter and weekly bacon slicings in federally inspected plants and storage stocks at Chicago from the *Daily Information Bulletin* issued by the Chicago Merchantile Exchange. These analyses were run to determine the extent to which slaughter and slicings affected short-term movements in futures prices. Certain variables came in with signs that were consistent with economic expectations. These variables explained an average 20-40 percent of the deviations in highs or lows occurring shortly after the data became available from the level that prevailed just before the reports were released.

QUARTERLY AND SHORTER-TERM PRICE FORECASTING MODELS RELATING TO CASH AND FUTURES QUOTATIONS FOR PORK BELLIES

by Richard J. Foote, Robert R. Williams, Jr., and John A. Craven[1]

INTRODUCTION

Trading in pork belly futures on the Chicago Merchantile Exchange began in September 1961 but the initial volume was small. Major changes in contract provisions were made by 1963 (21).[2] Volume picked up sharply beginning with the July 1964 contract and has remained relatively large ever since. In the year beginning on July 1, 1972, for example, the average value of open commitments was about $220 million dollars. This amount was exceeded only by that for silver, soybeans, corn, cotton, cattle, and copper out of the approximately 30 commodities actively traded in the United States during the year. In 1969, transactions for pork belly futures numbered 2,175,775 contracts, the largest for any commodity traded that year. In its first 10 years, the pork belly contract accounted for 9,300,000 transactions, more than was generated by any other commodity futures contract during its first decade.

Currently, contracts call for the delivery of 36,000 pounds of frozen bellies in the 12-14 pound weight range from approved warehouses. Deliveries made from approved warehouses outside Chicago are subject to an allowance representing transportation costs from the warehouse to Chicago. For the 1971 and 1972 contracts, bellies in the 10-12 pound weight range were deliverable at par and those in the 14-17 pound range, at a 3-cent discount. Beginning with the 1973 contracts, discounts will be applied of 1 cent per pound for 10-12 pound bellies, 2 cents for 14-16 pound weights, and 4 cents for 16-18 pound weights. Grade standards are listed in detail in the contract. To be eligible for delivery during February through August, bellies must not have been in storage prior to December 1 of the previous year. All must have been fresh or FFA (fresh freezer accumulation) at time of shipment from the packing plant to the approved warehouse. FFA means that bellies have been accumulating for a period not exceeding 15 days from date of slaughter.

Chicago is the major cash market for fresh and frozen pork bellies. Cash quotations are given for several weight ranges, the most important being 10-12, 12-14, 14-16, 16-18, and 18-20 pounds. Highest prices normally are paid for bellies weighing 12-14 pounds each, because they tend to have the highest proportion of lean meat relative to fat. Frozen bellies during much of the year sell for about the same price as fresh bellies but usually begin to be discounted in summer and early fall as storage stocks seldom are carried beyond September. The discount normally disappears from October on. Frozen bellies not needed for bacon at the end of the October-September hog-marketing year frequently are used for sausage, which has a considerably lower value per pound. Many bellies do not move through the cash market but instead are held by meatpackers for use in their branded lines of bacon.

Bellies normally are sliced just before the bacon is sold through retail channels. Slicing may take place in meatpacking plants or in warehouses or packaging plants operated by grocery chains or other stores. Small quantities are sliced directly in retail stores. Data on weekly slicings in meatpacking plants under Federal inspection are published by USDA. The series is used by many people interested in the movement of pork bellies into consumption. However, research done for this bulletin demonstrates that the series is not a reliable indicator. Only part of total slicings are covered and the proportion which is covered apparently varies from time to time.

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[1] Approved as Texas Tech University College of Agricultural Sciences Manuscript No. T-1-110.

During the time in which this research was being done, Richard J. Foote was professor of agricultural economics and statistics and Robert R. Williams and John A. Craven were graduate research assistants at Texas Tech University. Mr. Foote now is with the U.S. Agency for International Development in Saigon, Vietnam, Mr. Williams is with the Federal Land Bank in Houston, and Mr. Craven is a graduate research assistant at the University of Illinois.

[2] Underscored numbers in parentheses refer to items in Literature Cited.

Storage stocks of bellies normally increase from the seasonal low on September 30 to a seasonal peak around the end of May. The importance of storage relative to estimated production and consumption is shown in table 1 for 1970-71, the most recent complete marketing year at the time this bulletin was written. Although the proportions vary from year to year, the following basic implication would be true for any year: Storage tends to even out the disparity between production and consumption, but in no quarter is the storage movement large in relation to either production or consumption. The greater consumption in July-September is believed to reflect the heavy summer demand for bacon-lettuce-and-tomato sandwiches.

Table 1—Pork bellies: Production, consumption and movement in or out of storage by quarter, (year beginning October 1) 1970-71

Quarter	Production[1]	Consumption[1]	Storage movement[2]
		mil. lb.	
Oct.-Dec.	700	633	67
Jan.-Mar.	658	621	37
Apr.-June	654	629	25
July-Sept.	608	695	−87

[1] Estimated by methods described in this bulletin.
[2] Positive numbers reflect movement into storage.

No data on foreign trade in bellies are published by USDA. Such trade is believed to be small; some canned bacon enters from Denmark and possibly other countries.

ALTERNATIVE WAYS OF ESTIMATING PORK BELLY PRODUCTION AND CONSUMPTION

No published data are available for production or consumption of pork bellies but with data on stocks, one can be estimated from the other based on the formula:

$$Q_t + S_t = C_t + S_{t+1} \tag{1}$$

where:

Q_t = production for some given period
C_t = consumption for same period
S_t = stocks at start of period
S_{t+1} = stocks at end of period.

The options were to estimate C and derive Q or estimate Q and derive C. Actually, as discussed in the next section, plans called for approximating C first and deriving Q, then getting a better estimation of Q and deriving a better estimation of C. But the plans did not work, as will be explained. Thus, the method finally adopted was to estimate Q and derive C.

Consumption Measured by Bacon Slicings

Reported weekly bacon slicings in meatpacking plants under Federal inspection are used by market analysts to measure current movement of pork bellies into consumption. These figures are published currently in the *Daily Information Bulletin* of the Chicago Mercantile Exchange (2). Weekly data were available back to October 1958 from the Exchange year books (3). Less satisfactory data for earlier periods based on 4- or 5-week totals applying to individual months were published in the *National Provisioner* (18). Weekly data were converted into a monthly series. Slicings in weeks that began in 1 month and ended in the next month were allocated into the appropriate month based on the number of packinghouse workdays in each month. Workday data came from a table developed by Hayenga and Hacklander (13, p. 34). A comparable procedure was used for data from the *National Provisioner*. Estimates were carried back to February 1957 to match the earliest figures on stocks.

Over the years, the proportion of meat produced under Federal inspection has increased. For all pork, monthly data are available on total commercial slaughter and slaughter from federally inspected plants. These figures are published in USDA's monthly report *Livestock Slaughter* (41). Estimated monthly bacon slicings in federally inspected plants were multiplied by the ratio of total commercial to federally inspected slaughter for all pork for the month. The resultant series was assumed to approximate C_t in equation (1) from which an estimate of Q_t for each month was derived.

Data on numbers of (a) barrows and gilts and (b) sows slaughtered monthly in federally inspected plants and on total commercial slaughter are published in *Livestock Slaughter*.

The same proportion by classes was assumed to apply both to total commercial and federally inspected slaughter. Based on these percentages, monthly estimates were obtained of numbers of each class slaughtered commercially. If the estimated Q_t (production of pork bellies) were regressed on the two series, the respective regression coefficients should indicate the average weight of bellies obtained from each class. These weights were known to be around 20-28 pounds for barrows and gilts; that is, two 10-14 pound belly cuts per animal. A moderately smaller weight would have been acceptable because some whole-hog sausage is made. Also, some bellies are used for pork and beans and other canned products and hence may be omitted from data on slicings. The weight would be larger for sows. A time trend, expected to be negative, was included to allow for shifts over time toward leaner hogs. Allowance also was made for economic variables, such as hog prices, corn prices, or a hog-corn price ratio which might affect the average weight per animal. These analyses are shown in (46, pp. 36-43).

Results of these regressions were not consistent with expectations. First, the time trend for all analyses was positive. Second, regression coefficients for sows in some months were negative. However, sales of sows at times are known to be small, so this discrepancy did not cause too much concern. Examination of the magnitude of the coefficients for barrows and gilts did cause concern. These ranged from 3 to 25 pounds per animal, compared with the expected level of 20-28 pounds. All but four of the coefficients for the monthly analyses and all but one for the quarterly studies were less than 20 pounds. The average for all equations was 16 pounds. Positive coefficients for sows ranged from 14 to 182 pounds per animal; the average was 60 pounds. Because of these findings, we wrote a large meatpacker for advice. In reply, plant personnel pointed out that once the hogs have passed inspection, the bellies need not be sliced in a federally inspected plant. In fact, many are known to be sliced elsewhere. Thus, slicings in federally inspected plants do not necessarily indicate total slicings, and no valid procedures are available to reach a total.

If the regressions had yielded reasonable coefficients, plans would have called for estimating Q_t from the regression equations, data on slaughter numbers, and other variables involved—for each month. A new and presumably improved C_t would have been derived from equation (1), the new Q_t, and data on stocks. Since the regressions were not satisfactory, these plans were abandoned, and estimates of Q_t and C_t were obtained differently.

Production Estimated from Liveweight Hog Slaughter

Three sources of information were used to derive factors to estimate production of bellies directly from liveweight hog slaughter: (1) A large meatpacker indicated that its firm used a figure of 11 to 11-1/2 percent, (2) staff members of the Texas Tech University Animal Science Department believed a uniform percentage figure could be used for all marketable weights for both barrows and gilts and sows, and (3) cutout percentages given in (48, p. 71) also indicated a fairly uniform level of 11.8 to 12.3 percent for hogs in a 200-300 pound weight range. Based on this information, production was assumed to equal 11-1/2 percent of liveweight hog slaughter. Consumption was estimated based on equation (1).

Trading-day Variation for "Consumption" Estimated by Alternative Procedures

A further check was made of the relative reliability of the consumption data series derived from estimated total bacon slicings versus the series derived from production taken as 11-1/2 percent of commercial liveweight slaughter. Census Method II for Seasonal Adjustment (23) was used to compare the two series. This computer program provides a "trading-day" measurement which indicates days of increased or decreased activity within each week. Based on known working patterns for the meatpacking industry, activity should be fairly uniform for the normal 5-day workweek and reduced on weekends. This pattern was found for the consumption series derived from production. For the series based on estimated slicings, however, Wednesday equaled 90 percent of the weekly average; Friday, 40 percent; Saturday, 100 percent; Sunday, 50 percent; and Monday, Tuesday and Thursday each equaled an offsetting above-average amount. This finding does not seem reasonable. The general level for the consumption series derived from production in million pounds also was much higher than for estimated slicings, suggesting that the estimating factor based on the ratio of commercial to federally inspected production for all pork was too low. The factor would be too low if, as believed, a substantial part of the slicing is done in plants that are not part of the meatpacking industry.

QUARTERLY THREE-EQUATION MODELS

A major part of this research project was concerned with measuring factors that influence the pork belly economy and with deriving systems of equations that could be used to estimate price levels for cash and futures quotations that would be consistent with basic economic factors.

Stoken (24) gave a general discussion of factors that affect pork belly prices. His is the only published study in this area, except for short-term reviews by various commodity brokerage houses.

Many statistical analyses have been published that consider relations between price and consumption of pork. Most of these allow for the effects of one or more competing items, such as beef, poultry, or fish, or all three. Because the demand function for bacon probably differs materially from that for all pork, no reference will be made here to these price-consumption relations. Factors that affect the demand for storage for all pork, however, may be similar to those that affect such demand for bellies. Hence, studies that include an actual or implied equation relating to storage are discussed in the section on demand for storage.

Many of the previous models were designed to predict data by quarter-years or by months. Most of these make use of dummy (or 0-1) variables to distinguish between the several time periods within a given year. In these models, a given partial regression or comparable coefficient is specified for each pair of variables over all quarters or months but the intercept can vary based on the activity of the dummy variable. Particularly when storage is an integral part of the model, this practice seems unsound because certain factors may affect storage in a different way when stocks are increasing than when they are decreasing. Thus, separate sets of equations have been used in this study for each quarter and month.

The Price-Consumption Relation

Consumer surveys or interviews would be needed to determine how people decide whether to eat bacon for breakfast, which is presumed to be the major use for bacon. Some is used for bacon-lettuce-and-tomato sandwiches and some for other purposes, such as wrap for fillet mignon or frankfurters. For the last-named uses, cost of the bacon is a small part of the total expense. Thus, most of the price elasticity of demand must be associated with use or lack of use at breakfast.

Detailed scientific knowledge of how different foods enter into breakfast choices is lacking. But it was hypothesized that eggs and bacon are complementary goods. Thus, when eggs are low-priced not only will more eggs be eaten, but also bacon would be added. Thus, the price or supply of eggs may affect the consumption of bacon.

Based on the line of reasoning developed in (9), consumption of many farm products can be considered predetermined, in the economic sense, because economic factors that affect current production exerted their influence in an earlier time period and most production moves directly into consumption. This theory may be true for eggs when a time period of less than 6 months is involved. Birds hatched as replacement layers require 6 months to enter the laying flock. Further, foreign trade and changes in stocks are negligible in relation to the quantity of eggs moving directly from production into consumption. Some eggs are used for processing, but a good part of the variation in this use reflects the growth in demand for convenience-type foods.[3] Prices of eggs, on the other hand, probably are affected to some extent by current prices of bacon, as well as by many other factors not included in a model of the pork belly economy. It was assumed that the influence of eggs on the price and consumption of bacon could be examined by bringing in a single predetermined new variable, namely shell egg consumption in the current quarter. Using egg prices as a causal variable, however, might require adding one or more entire equations to the model because egg prices might need to be treated as at least partially endogenous.

When their incomes are large, consumers are more willing to pay a relatively high price for meat to have with eggs and initially may be more likely to choose eggs over other less expensive breakfast foods. Thus, changes in income

[3] Recent research (22) suggests that such use is in part price determined. To the extent that this hypothesis is true, consumption of shell eggs cannot be treated as predetermined.

should have a positive effect on consumption of bacon, after allowing for the effect of other factors.[4] Disposable personal income, which essentially reflects take-home pay, is a series that is commonly used when studying the demand for food and other nondurable goods. This series normally is published on an annual rate basis that is seasonally adjusted. Seasonal factors that affect income chiefly reflect such items as summer employment of students and bonuses paid prior to Christmas. Changes in income of this type probably do not affect eating habits significantly. But a rise or fall in seasonally adjusted income might well alter consumer attitudes toward bacon and egg consumption. For this reason, seasonally adjusted income was used in the models.

In models designed primarily to measure elasticity of demand, all price and income series may be deflated by dividing by a measure of the general price level, such as the U. S. Bureau of Labor Statistics Cost of Living Index. Also, all quantitative variables generally are expressed in per capita terms. Experience has shown that if interest centers on the development price-forecasting models, equally good results normally are obtained using nondeflated total data. Because these models were designed mainly as tools of price analysis rather than as measures of structural relations, equations were run initially based on nonadjusted data. Results suggested that measuring the effect of eggs on the pork belly economy might be enhanced by using per capita data. Hence, a second set of analyses was run with per capita data in the price-consumption equation. Both sets are discussed later on.

Retail prices of bacon probably should have been used in the demand equation if major interest had been centered on this equation. An additional equation would have been required to show factors that affect the relation between retail bacon prices for the United States, say, and wholesale prices at Chicago for pork bellies. Instead, the price of pork bellies at Chicago was used directly in all equations. Chicago is the single most important cash market for pork bellies, and its cash quotations are probably the most closely related to futures quotations.

The Demand-for-Storage Relation

The carrying-charge structure of the futures market may be the most important factor in determining the demand for storage of any given commodity if such a market exists in adequate volume. If the more distant futures are above nearby futures or the cash market enough to more than cover storage cost, storers can buy the cash commodity, sell a corresponding quantity of futures, and thereby lock-in a storage profit regardless of what later happens to the price level. Thus, carrying-charge markets encourage storage, while partially or fully inverted markets discourage storage. This relation is behavioristic; it can account for the amount of storage, given the structure. But this relation cannot be used to measure the influence of storage demand on the overall price level as, in a sense, the relation is independent of the price level.

Attempts to measure the influence of storage demand on prices for agricultural commodities have not been particularly successful. Such equations for all pork have been included in a number of models; the relevant studies are discussed briefly here. Harlow (11) expressed end-of-quarter storage as a function of four lagged variables: (1) pork production, (2) beginning stocks, (3) deflated retail price, and (4) mean temperature for the preceding quarter in relation to that for the year. All except temperature had a positive effect on storage. The fact that high prices tended to increase storage suggests that Harlow's function may have reflected the effect of price on consumption. If consumption is reduced, storage would increase for any given beginning supply. Although these variables explained 91 percent of the variation in stocks over the period of fit, poor forecasts of storage were given by the model over the eight quarters that followed this period. Fuller and Ladd (10) used a Nerlove-type expectational equation for production of both beef and pork. The four lagged variables plus the difference between spring and fall hog farrowing represented factors that affect the storage of all pork. Fall farrowings were used only in the first and fourth quarters. Price variables were not considered. Including expectational variables alone with respect to production does not appear sound because the trade has access to likely hog production from *Hogs and Pigs* as well as similar data bearing on fed-beef production. Fuller and Ladd did not show forecasts for their model. Maki (16) included an equation to predict year-to-year changes in end-of-quarter storage holdings of pork. Causal variables were year-to-year changes in the following variables: (1) Ending stocks for the preceding quarter, (2) commercial production of pork for the current quarter, (3) average wholesale prices of pork during the preceding quarter, (4) a time trend, and (5) a dummy variable to designate the quarter. These variables

[4] A counter argument is that well-to-do consumers are more concerned with balanced caloric consumption and hence may eat less bacon. To test this theory explicitly, analyses should have been run with all price and income variables on a deflated basis. As handled in this bulletin, income entered all price-consumption relations with a positive coefficient that was highly significant statistically. Thus, it seemed reasonable to require that income variables also enter with positive coefficients in the first round and storage relations.

explained 82 percent of the variation in stocks over the period of fit. Price forecasts from the models were made for eight quarters ahead. Maki (16, p. 632) commented: "Live hog and wholesale pork prices were predicted with less accuracy than beef and cattle prices, partly as a result of pork storage operations that were not adequately explained by changes in the quantities of beef and pork". Crom (5) expressed ending stocks of pork as a function of price of pork, prices for two alternative grades of beef, supply available for consumption of pork, a time trend, and a set of 0-1 variables relating to the quarter involved. Both pork price and consumption had positive coefficients. Hayenga and Hacklander (12) considered that changes in stocks of pork during each month are associated with the current price of hogs, commercial slaughter of hogs to be handled per workday during the month, and the beginning level of stocks. Dummy variables were used to specify the month. The equation was estimated by two-stage least squares. Pork price and beginning stocks each had a negative regression coefficient in affecting the in-movement. Coefficients for the dummy variables were negative from June through December; the largest negatives were in August and September. Myers, Havlicek, and Henderson (17) treated beginning stocks for each month as part of the supply of pork but do not include a prediction equation for stock as such. Instead, they estimated supply and consumption of pork by two different equations and treated end-of-month stocks as a residual. None of these approaches to the measurement of storage demand appeared entirely satisfactory. Hence, a different procedure was used in the models in this report.

In our initial formulation, desired end-of-quarter stocks were assumed to depend chiefly on the difference between expected production and expected consumption for each of two quarters ahead. Stocks were assumed to accumulate mainly because storage profits were expected. As stocks normally are not carried from one marketing year to the next, storers would look less far ahead at some point within the marketing year. It was decided to let results of the statistical fit determine the storers' time horizon rather than to attempt to determine what this horizon would be. Expectations for production were assumed to reflect knowledge about the share of the pig crop that would be marketed in each quarter based on published information in the quarterly *Pig Crop* or *Hogs and Pigs.* Expectations for consumption were assumed to depend on expectations concerning consumer income based on a projection of recent trends and prices. Price adjustments were assumed to be based on a Nerlove-type formulation discussed subsequently. This formulation makes no assumption about how expectations are derived initially.

The Supply-Demand Identity

A complete structural model for supply and demand requires as many equations as endogenous variables. Price, consumption, and end-of-quarter stocks are predicted. Hence, three equations are necessary. One equation used is the identity labeled earlier as equation (1). Price must be held at a level that maintains this identity.

Variables and Initial Equations

The initial equations are shown below. In these and subsequent equations, t relates to the current quarter, t−1 to the preceding quarter, and t+1 to the following quarter.

$$C_t + S_{t+1} = Q_t + S_t \qquad (1)$$

$$C_t = f(P_t, I_t, E_t) \qquad (2)$$

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

Variables with an asterisk represent expectations by persons in the trade who determine storage policy. S_{t+1} equals storage at the end of the current quarter.

In the equations:

Q_t – Estimated production (million pounds) of pork bellies during the quarter.
S_t – Cold-storage stocks (million pounds) of bellies, first of quarter.
C_t – Derived consumption (million pounds) of bellies during the quarter.
P_t – Average wholesale price (cents per pound) at Chicago for 12-14 pound fresh or FFA bellies for the quarter.
I_t – Disposable personal income (billion dollars) for the quarter at seasonally adjusted annual rates.
E_t – Civilian consumption (billion) of shell eggs for the quarter.

Derivation of the Storage Equation

Data required for equation (3) do not exist because they relate to expectations, in this case, by persons who determine storage policy. Thus, the figures must be estimated or derived.

As discussed in previous sections, $\overset{*}{Q}_{t+1}$ and $\overset{*}{Q}_{t+2}$ are assumed to depend chiefly on actual or expected pig crops that will be marketed in the respective quarters based on information in the latest *Hogs and Pigs.* The relation can be expressed as follows:

$$\overset{*}{Q}_{t+1} = f(F_{t-1} \times L_{t-1}) \tag{4}$$

F_t = Million head of sows farrowed during the quarter.

L_t = Estimated number of pigs saved per litter during the quarter.

Approximately 6 months are required from the time when pigs are born (farrowed) until they reach a marketable weight of 200-240 pounds.

A later section of this report discusses a set of five equations for each quarter that together predict Q for up to two quarters ahead from information in quarterly issues of *Hogs and Pigs.* This set was used to estimate Q_t in equation (1) when the models were used to predict expected levels for cash and futures prices. For equation (3), however, the relations implied by equation (4) are considered adequate in measuring basic factors that affect storage policy. Variation in the size of the pig crops is the major factor affecting total hog slaughter in any given quarter.

Each *Hogs and Pigs* gives data on previous pig crops that relate to Q_t and Q_{t+1} and on F_t, which affects Q_{t+2}. These variables essentially are known, since sows that are to farrow in the current quarter must have been bred before that quarter. The number of pigs saved per litter for the current quarter, however, depends partly on weather conditions at the time of farrowing. Each quarterly issue shows a projected L_t for the current 6-month period for the United States, based on trend projections for each State weighted by sows that are to farrow. In the data set for this study, the projected L_t was adjusted to a quarterly basis and designated as $\overset{*}{L}_t$. This variable was used with F_t in equation (4) to obtain $\overset{*}{Q}_{t+2}$. Certain complications exist in using data from *Hogs and Pigs* because farrowings in the March and September issues relate only to the 10 major Corn Belt States, whereas U.S. totals are needed. These problems and their solutions are discussed in the Appendix.

Concerning $\overset{*}{C}_{t+1}$ and $\overset{*}{C}_{t+2}$, persons who made storage policy would probably allow for expected consumer incomes and prices of bacon or pork bellies in these future periods. The assumption was made that persons storing bellies probably would not consider future egg supplies or prices. The equation for expected consumption is:

$$\overset{*}{C}_{t+1} = f(\overset{*}{P}_{t+1}, \overset{*}{I}_{t+1}). \tag{5}$$

Forecasts of consumer income are available from various sources, such as the Wharton School of Finance and Commerce at the University of Pennsylvania (see 5), based on large-scale econometric models of the general economy. However, the Wharton forecasts have been available only since 1963. For the pork belly model, we assumed that storers would know the likely level of disposable personal income for the current quarter and would project based on the most recent quarter-to-quarter change. This relation can be expressed as:

$$\overset{*}{I}_{t+1} = I_t + \Delta I_t \tag{6}$$

where:

$$\Delta I_t = I_t - I_{t-1}.$$

Over the period of fit, ΔI_t was negative in one quarter and the amount was negligible. Thus, projecting an upward trend based on the most recent slope would be fairly reasonable, unless a better method could be devised.

Equation (3a) allows for the substitutions discussed up to this point in relation to equation (3):

$$\begin{aligned} S_{t+1} = f(&\overset{*}{P}_{t+1}, \overset{*}{I}_{t+1}, F_{t-1} \times L_{t-1}, \\ &\overset{*}{P}_{t+2}, \overset{*}{I}_{t+2}, F_t \times \overset{*}{L}_t). \end{aligned} \tag{3a}$$

$\overset{*}{I}_{t+1}$ and $\overset{*}{I}_{t+2}$ would be highly correlated over the period of fit. For this reason, $\overset{*}{I}_{t+1}$ and ΔI_t were used instead. (Actually these also were highly correlated; in many analyses, only one came into the model with signs that were consistent with economic expectations.) As discussed below, $\overset{*}{P}_{t+1}$ and $\overset{*}{P}_{t+2}$ each reflected the basic bullishness or bearishness of the current price level, based on a Nerlove-type estimation procedure. For this reason, $\overset{*}{P}_{t+2}$ was omitted. Equation (3a) thus became:

$$S_{t+1} = f(\overset{*}{P}_{t+1}, \overset{*}{I}_{t+1}, \Delta I_t, F_{t-1} \times L_{t-1}, F_t \times \overset{*}{L}_t). \tag{3b}$$

All variables except $\overset{*}{P}_{t+1}$ could be derived from existing data.

The Nerlove approach was developed initially to study changes in crop acreage (20). Producers were assumed to base planting decisions on expectations of prices at time of harvest. Obviously, no data were available for these expectations. However, Nerlove's method provides for estimating supply relationships from existing data on prices and previous acreage response (see also 19).

The following equation represents the heart of the Nerlove approach when applied to price expectations:

$$\overset{*}{P}_t - \overset{*}{P}_{t-1} = \beta(P_{t-1} - \overset{*}{P}_{t-1}). \tag{7}$$

According to the equation, decisionmakers adjust their expectations in proportion to the error that they made in the most recent period. Confirmation of this behavior can be found in observations of farmers' reactions to price-support programs for grains when prices for some unforeseen reason, such as the 1970 corn blight, deviate widely from previous levels. Persons who make decisions about meat storage policy probably *adjust* their expectations in a similar way. Assumptions are not needed about how expectations were obtained initially since the models are concerned with changes in expectations.

The following algebraic derivation was needed to use equation (7) with equation (3b):

1. Equation (3b) was rewritten in the linear form

$$\begin{aligned} S_{t+1} &= a + b_1\overset{*}{P}_{t+1} + b_2\overset{*}{I}_{t+1} \\ &+ b_3\Delta I_t + b_4(F_{t-1} \times L_{t-1}) + b_5(F_t \times \overset{*}{L}_t) \\ &= b_1\overset{*}{P}_{t+1} + \Pi_{t+1} \end{aligned} \tag{3c}$$

where:

$$\Pi_{t+1} = a + b_2\overset{*}{I}_{t+1} + b_3\Delta I_t + b_4(F_{t-1} \times L_{t-1}) + b_5(F_t \times \overset{*}{L}_t).$$

2. Equation (3c) was lagged by one time period to get

$$S_t = b_1\overset{*}{P}_t + \Pi_t$$

and was rewritten as

$$\overset{*}{P}_t = \frac{1}{b_1}(S_t - \Pi_t)$$

so that

$$\overset{*}{P}_{t-1} = \frac{1}{b_1}(S_{t-1} - \Pi_{t-1}). \tag{8}$$

3. Equation (7) was rewritten as

$$\overset{*}{P}_t = \beta P_{t-1} + (1-\beta)\overset{*}{P}_{t-1}$$

and equation (8) was substituted for $\overset{*}{P}_{t-1}$ to get

$$\overset{*}{P}_t = \beta P_{t-1} + (1-\beta)\frac{1}{b_1}(S_{t-1} - \Pi_{t-1}).$$

4. Equation (8) was moved ahead one time period and rewritten to simplify the coefficients, giving

$$\overset{*}{P}_{t+1} = B_1P_t + B_2S_t + B_3\Pi_t. \tag{9}$$

5. Equation (9) was substituted in equation (3c), giving

$$S_{t+1} = b_1(B_1P_t + B_2S_t + B_3\Pi_t) + \Pi_{t+1}.$$

This result can be rewritten as an implied linear function:

$$S_{t+1} = f(P_t, S_t, \overset{*}{I}_t, \Delta I_{t-1}, F_{t-2} \times L_{t-2}, F_{t-1} \times \overset{*}{L}_{t-1}, \overset{*}{I}_{t+1}, \Delta I_t, F_{t-1} \times L_{t-1}, F_t \times \overset{*}{L}_t).$$

Some of the variables on the right of the prevoius equation would be highly correlated. $\overset{*}{I}_{t+1}$ and ΔI_t were chosen to represent all of the income variables. $F_{t-1} \times L_{t-1}$ was assumed to represent itself and $F_{t-1} \times \overset{*}{L}_{t-1}$ adequately. Hence, the initial formulation chosen for the statistical fit was:

$$S_{t+1} = f(P_t, S_t, \overset{*}{I}_{t+1}, \Delta I_t, F_{t-2} \times L_{t-2}, F_{t-1} \times L_{t-1}, F_t \times \overset{*}{L}_t). \tag{3d}$$

This equation plus equations (1) and (2) constituted the basic model in this bulletin. All were written in linear form.

In the past, the Nerlove formulation has been used chiefly with models based on annual data. Or it has been used for quarterly models that assumed one regression coefficient for all quarters and an intercept that shifted based on use of dummy variables. For the equations developed in this bulletin, the b's involved in equation (3c) were presumed to be different in each quarter. Thus, the b_1 involved when equation (3c) is lagged by one time period, as in step 2 of the algebraic derivation, might be different than when the equation is not lagged. Theoretically, either of two effects might be involved: (1) The Nerlove approach might be unusable; or (2) the approach might be usable for forecasting but nor for deriving the structural coefficients, such as the β in equation (7). Because major emphasis here was placed on a model that would give good forecasts, we adopted a trial-and-error method, starting with the Nerlove approach. Signs for many of the coefficients, including all but one for variables known to be important in the models based on total data, were consistent with economic expectations. Also, the models gave good forecasts both in and outside the period of fit. Thus, the chief effect was assumed to be of the second type. In the models based partly on per capita data, signs of coefficients for all dominant variables are consistent with economic expectations.

Methods Used in Fitting Equations

Alternative Methods of Fit

Many of the previously discussed models that involve simultaneous relations for the beef and pork economies were formulated so that they could be fitted statistically by a recursive approach involving multiple regression analysis based on ordinary least squares (OLS). Essentially all electronic computers in research have programs for such analysis. Also, the work can be done on desk calculators through well-known procedures. Two problems exist with the recursive approach: (1) Some models cannot be formulated in this way and (2) Recursive models normally are not efficient statistically.

In 1954, Theil (25) published a procedure referred to as "two-rounds estimates." In 1957, Basmann (1) proposed methods which now are called two-stage least squares (2-SLS). Wallace and Judge (45) in 1958 showed that these two methods are mathematically equivalent. The 2-SLS approach described by Basmann is the one chiefly used now for systems of equations because it can be handled on a computer by two successive runs based on OLS. The method is as follows: In equations with more than one endogenous or simultaneously determined variable, (2) and (3d), for example, each of these variables on the right of the equality sign is treated as a function of all or selected predetermined variables from the entire model. These equations are fitted by OLS. Calculated values (purged of their endogeneity) are substituted in the initial structural equation for these endogenous variables and the equations are fitted statistically by OLS. Coefficients obtained from the second round are statistically consistent and as efficient for large samples as any others based on the same amount of information. Some of the previously discussed livestock models were fitted by 2-SLS.

In 1962, Zellner and Theil (47) published a procedure known as three-stage least squares (3-SLS). In this method, the residuals from equations fitted by 2-SLS are used to estimate the joint covariance matrix of the disturbances of the several simultaneously determined equations in the model. The equations are refitted using this information. Coeficients obtained are statistically consistent and, at least for large samples, are more efficient than for 2-SLS because more information is used in obtaining them. A computer program based on this approach was prepared by Stroud, Zellner, and Chau in 1963 and revised by Thornber and Zellner in 1965 (28). USDA modified the program for use on an IBM 360/50 and tapes of the program are available.

In 1967, Cragg (4) published results of a comprehensive study which used the Monte Carlo approach to appraise the relative merits of various fitting procedures when small samples were used and various types of specification errors existed. Although no method was found uniformly best, he concluded that the 3-SLS and full-information, maximum-likelihood approaches were best, on the average, followed closely by the 2-SLS and limited-information, maximum-likelihood methods. OLS usually came out poorly when simultaneous relations were involved. Full-information procedures are exceedingly difficult on the computer; only large-scale machines can be used (see Foote and Eisenpress, 7).

Given a computer program for 3-SLS, we believe that this procedure should be used initially for most models. Time required to fit a model of the type used in this study was only about 5 seconds for one period within the central processing unit of the IBM 360/50 at Texas Tech University. The printout showed results for the first-round equations and also those for 2-SLS and 3-SLS. However, the method has been rarely used in applied published research to date.

First-Round Equations for 3-SLS as a Forecasting Tool

The first-round equations in 2-SLS and 3-SLS are estimated as an intermediate step in obtaining consistent and efficient estimates of the coefficients on the structural equations. However, models of the sort developed here frequently allocate supply into alternative uses (in this case, $Q_t + S_t$ into C_t and S_{t+1}) with reasonable accuracy, but are poor as price indicators. Thus, it appeared desirable to compare price estimates and predictions from the first-round equations with those from the model because the first-round equations treated price as a dependent variable. If sufficient observations are available, the first-round equations normally contain all predetermined variables in the model; no attention is paid as to whether these variables come in with signs that are consistent with economic expectations. If the first-round equations are to be used as a potential forecasting tool, however, variables whose coefficients carry signs that are not consistent with economic theory should be dropped, particularly if their inclusion in the model is questionable. (See the next section.) Dropping such variables should not interfere with the subsequent use of calculated values from these equations in 2-SLS and 3-SLS because the sole purpose of the first round is to provide reasonably good substitutes for certain endogenous variables that are purged of their endogeneity. In fact, given problems of multicollinearity in small samples, this procedure may well improve the accuracy of the succeeding two rounds.

For both the quarterly and monthly models, price predictions from the best of the first-found equations over the period of fit were somewhat better than from the best of the reduced-form equations derived from the models (see tables 4, 5, and 13). Reduced-form equations from the quarterly models did better over the most recent price cycle (table 6).

Myers, Havlicek, and Henderson (17) also used first-round equations as a prediction tool. Their results were compared with those from models fitted by 2-SLS. However, these economists essentially employed a recursive approach rather than a matrix solution of the full system of equations as was done in the models we used. They concluded: "For five of the endogenous variables the structural equations predicted a greater number of correct changes than the first stage equations, while for pork supply and pork demand both sets of equations predicted the same number of correct changes" (17, p. 2). These predictions covered an 18-month period outside the period of fit.

Dropping Variables with Coefficients Having Signs Contrary to Economic Expectations

In most economic analyses, some variables are known to be important and others are of questionable value. In equation (2), for example, economic theory said that the coefficient on P_t should be negative and the coefficient on I_t should probably be positive. If E_t were important, the coefficient should be positive, but advance knowledge did not verify E_t's importance. A rule of thumb has developed that if a questionable variable like E_t comes in with a sign consistent with economic expectations, it is kept in the analysis; if the sign is contrary, the variable is dropped.[5] A similar situation prevailed for the equation on storage but it was more complex because more variables were involved, some of which were highly correlated. Within the correlated groups, chances were good that only one or two would come in with correct signs. Also knowledge was not available as to how far storers look ahead. Again, the rule was adopted that if variables not known to be important came in with signs that were expected, they were kept; otherwise, they were dropped.

The following rules were used in succession to derive the final equations. The comments relate to the initial formulation of the model based on equations (1), (2), and (3d).

1. E_t and the income variables, except in equation (2), were considered first. Any with negative signs were dropped. In the analyses based on total data, E_t was positive only for equations relating to the July-September quarter. In most parts of the year, egg supplies are ample. Hot weather at times results in low production and high prices for eggs in July-September. Apparently, only when egg prices are extremely high do they exert a significant effect on consumption of bacon. However, when egg consumption was included as a variable in July-September, all income variables came in with negative signs in the first-round equation and the equation for S_{t+1}. I_t had the expected positive sign in equation (2) and hence entered the reduced-form equation for price. As income was believed to be the more important variable, eggs were dropped from equation (3). When E_t was omitted from the model for the July-September quarter, I_{t+1} and ΔI_t both came into equation (3d) with positive coefficients, and I_t and ΔI_t both came into the first-round equation. However, calculated prices from the first-round equations were considerably more accurate for the July-September

[5] Another possibility would be to include the variable with a coefficient consistent with economic theory but of a magnitude that makes its effect small over the period of fit.

For some models, it is impossible to determine the signs in the reduced-form equations that would be consistent with specified signs in the structural equations. Had this fact been true for the models presented here, the procedure of specifying in advance the signs in the first-round equations could not be justified.

quarter when E_t was retained and the income variables were dropped. Hence, equations and results for this quarter are shown from both sets of analyses. In all other quarters, E_t was dropped because of a negative sign and I^*_{t+1} or ΔI_t came into equation (3d) with positive signs. I_t or ΔI_t, or both, came into the first-round equation with the expected sign. For all quarters and formulations, I_t entered equation (2) with a positive sign. Had the sign I_t been negative, reformulation of the models probably would have been required.

When quantitative variables in equation (2) were expressed in per capita terms, both E_t and one or more income variables came into the first round and equation (2) with the expected positive signs, and income variables also entered equation (3d) with positive signs. However, the coefficient on E_t in equation (2) differed significantly from zero only in the July-September quarter.

2. $(F_{t-1} \times L_{t-1})$ and $(F_t \times L^*_t)$ in equation (3d) and the first round were considered next. When coefficients were positive, these variables were dropped. Their retention implied that storage policymakers or persons determining price, or both, consider the number of hogs that will be marketed beyond the current quarter. For models based on total data, $(F_{t-1} \times L_{t-1})$, which relates to marketable supplies of hogs one quarter ahead, was retained in the first-round equations for the first, third, and fourth quarters of the calendar year. $(F_t \times L^*_t)$, relating to marketable supplies of hogs two quarters ahead, was retained in the first round for the third and fourth quarters. In equation (3d), however, these variables were retained only in the first quarter. Such results imply that these factors had a measurable effect in determining prices, but that the storage equation was not sensitive enough to isolate their effect, if any, on the quantity stored. Different results were obtained when equation (2) was run in per capita terms. These results are discussed later.

3. $(F_{t-2} \times L_{t-2})$, which relates to marketable supplies of hogs for the current quarter, and S_t were required to have negative coefficients in the first-round equations. They did for all final formulations. Had they not, with the possible exception of S_t in the October-December quarter, reformulation would have been required. When variables for the first-round equations were chosen initially, a decision was made to let $(F_{t-2} \times L_{t-2})$ represent itself and Q_t. To the extent that weights per head, retention of gilts for breeding, or slaughter of sows depend on current price, Q_t is partially endogenous, whereas $(F_{t-2} \times L_{t-2})$ is fully predetermined. As discussed in (7), the endogenous influences appear to be minor. However, since $(F_{t-2} \times L_{t-2})$ and Q_t could not both be included in the first-round equations because of problems of multicollinearity, $(F_{t-2} \times L_{t-2})$ appeared to be the better choice.

4. P_t (or really $\hat{P}_t$) was required to have a negative coefficient in equations (2) and (3d) for the 3-SLS fits. The coefficient was negative for all final equations but not for some intermediate steps. Actually, P_t was never dropped. Major reformulation of a model would have been required had price come into either of these equations with a positive sign in the final stages of the fitting process.

5. No sign was specified for $(F_{t-2} \times L_{t-2})$ or for S_t in the 3-SLS fits. S_t came into the algebraically derived reduced-form equations for price (see next section) in two ways: as a part of equation (1) and as a part of equation (3d). The net effect on price was negative in all but the fourth quarter for models based on total data and in all quarters for models based on per capita data. Beginning stocks were negligible in relation to total supply in the fourth quarter. Q_t, which was measured in pounds and came into the reduced-form equation for price through equation (1), was approximately 25 times its counterpart $(F_{t-2} \times L_{t-2})$, which was measured in numbers of animals and came in through equation (3d). Each barrow or gilt marketed contained two bellies, typically weighing 10-14 pounds apiece. Opposite signs were given for these variables in the reduced-form equations for price in some quarters. There, the larger effect was given by the uniformly negative coefficient on Q_t after the relative size of the variables was allowed for.

This set of procedures resulted in retaining some variables in the first-round equations that were not in the final structural equations. In other words, the direct effect of these variables on price was measurable, but their effect on other endogenous variables was not. Except for eggs, discrepancies chiefly involved the storage relation. This relation probably is the weakest in the model, and many potential variables (hence, few degrees of freedom) were involved. Monte Carlo studies or other types of experimentation would be highly desirable methods to use in handling 3-SLS equations for forecasting, when working with small samples and many highly correlated predetermined variables.

It should be noted that the several runs through the computer all were made before testing how close calculated values were to actual values for the three variables simultaneously determined by the model. Only after each model had been finalized were computed values obtained. Also, the models were tested for years both in and following those included in the data set used for fitting. In assessing relative merits of the alternative models, largest weight should be placed on indicated forecasting accuracy for quarters outside the period of fit. For these models and equations, such information was limited, and stock data for some such periods were more than double any included in the model. Hence, chief reliance was placed on forecasts within the period of fit.

Equations to Obtain Calculated Values for the Simultaneously Determined Variables From the Structural Models

After the structural equations, such as equations (2) and (3d), have been fitted by appropriate statistical means (in this report by 3-SLS), the so-called reduced-form equations can be derived by matrix or ordinary algebra. These latter equations can be used to obtain calculated values of the simultaneously determined variables that meet all specifications of the model. Because a complete model has as many equations as simultaneously determined variables, a unique calculated data set is obtained for each period for which basic data are available.

We can consider the structural equations as initially formulated based on total data. As shown below these are rewritten with the simultaneously determined variables grouped in separate columns on the left and all equations expressed in linear form:

$$C_t + S_{t+1} = Q_t + S_t = A_1 \quad (1)$$

$$C_t - b_{21} P_t = a_2 + b_{22} I_t + b_{23} \overset{*}{E}_t = A_2 \quad (2)$$

$$S_{t+1} - b_{31} P_t = a_3 + b_{32} S_t + b_{33} \overset{*}{I}_{t+1} + b_{34} \Delta I_t + b_{35} (F_{t-2} \times L_{t-2}) + b_{36}(F_{t-1} \times L_{t-1}) + b_{37}(F_t \times \overset{*}{L}_t) = A_3 . \quad (3d)$$

If desired, this system of equations can be rewritten in the following matrix form:

$$\begin{pmatrix} 1 & 1 & 0 \\ 1 & 0 & -b_{21} \\ 0 & 1 & -b_{31} \end{pmatrix} \begin{pmatrix} C_t \\ S_{t+1} \\ P_t \end{pmatrix} = \begin{pmatrix} A_1 \\ A_2 \\ A_3 \end{pmatrix} \quad (10)$$

or

$$CX = A. \quad (10a)$$

The matrix solution

$$X = C^{-1} A \quad (10b)$$

provides the desired vector of calculated values for any given period if actual values for the variables determined outside the model are substituted as required to obtain specific values for the elements of the A vector for that period.

At times, a direct algebraic solution is preferred. When equations (2) and (3d) are subtracted from equation (1), the following equation for P_t is obtained:

$$P_t = \frac{A_1 - A_2 - A_3}{b_{21} + b_{31}} . \quad (11)$$

When the calculated value of P_t from equation (11) is substituted for P_t in equations (2) and (3d) for each period and specific values for the A's for each period also are entered, calculated values for C_t and S_{t+1} result that are consistent with equation (1). Equation (11) for $\hat{P}_t$, as derived from the structural models, is called the reduced-form equation for P_t in the remainder of this report.

Estimated Equations

Consumption Expressed in Total Terms

As discussed previously, the models were first fitted based on the consumption-price relation shown in equation (2). A later fit involved expressing all of the quantitative variables in that relation in per capita terms. In theory, analyses run in per capita terms have certain advantages. Also, it was found that when based on total data, the separate effects of income and egg consumption on consumption of pork bellies were difficult to isolate because of correlated trends. Expressing both series in per capita terms was done to reduce the correlation and this reduction did occur.

The estimated structural equations based on total data obtained from the 3-SLS computer printouts are shown below. Also shown are the reduced form and first-round equations for price. Multiple coefficients of determination (R^2) are included for the first-round equations as these were fitted by OLS. Theil's U_2 inequality coefficient, somewhat comparable with $(1-R^2)$, is discussed in a subsequent section. This coefficient was calculated for values both from the first-round equations and from the models. The number shown in parentheses below each coefficient is its standard error. These errors are not available for the reduced-form equations relating to P_t. Coefficients for the Durbin-Watson test of serial correlation in the residuals are not given because this test would apply only to the first-round equations and only approximately as lagged values of endogenous variables are involved.

Estimated Structural Equations for January-March

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for C_t and S_{t+1}

$$\underset{(14.2)}{\hat{C}_t = 510.1} + \underset{(.0243)}{.3225\, I_t} - \underset{(.412)}{4.504\, \hat{P}_t}.$$

$$\hat{S}_{t+1} = \underset{(93.0)}{285.4} + \underset{(.27760)}{.04359\, S_t} + \underset{(1.147)}{2.802\, \Delta I_t} + \underset{(4.489)}{6.908(F_{t-2} \times L_{t-2})}$$

$$- \underset{(4.01)}{10.94(F_{t-1} \times L_{t-1})} - \underset{(1.537)}{3.035(F_t \times \overset{*}{L}_t)} - \underset{(.852)}{2.922\, \hat{P}_t}$$

Estimated Structural Equations for April-June

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for C_t and S_{t+1}

$$\hat{C}_t = \underset{(4.7)}{560.9} + \underset{(.0081)}{.2378\, I_t} - \underset{(.158)}{4.203\, \hat{P}_t}$$

$$\hat{S}_{t+1} = \underset{(2912)}{3318} - \underset{(2.377)}{2.123\, S_t} + \underset{(1.329)}{1.561\, \overset{*}{I}_{t+1}} - \underset{(114.0)}{127.3(F_{t-2} \times L_{t-2})} - \underset{(31.67)}{37.37\, \hat{P}_t}$$

Estimated Structural Equations for July-September

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for C_t and S_{t+1} with E_t excluded

$$\hat{C}_t = \underset{(10.8)}{585.2} + \underset{(.0168)}{.3363\, I_t} - \underset{(.292)}{4.967\, \hat{P}_t}$$

$$\hat{S}_{t+1} = \underset{(8.10)}{.51} + \underset{(.2364)}{.1522\, S_t} + \underset{(.61680)}{.02082\, \Delta I_t} + \underset{(.0104900)}{.0005007\, \overset{*}{I}_{t+1}} + \underset{(1.7320)}{.4800(F_{t-2} \times L_{t-2})} - \underset{(1.0770)}{.2435\, \hat{P}_t}$$

3-SLS for C_t and S_{t+1} with E_t included in first round and tested in the consumption equation

$$\hat{C}_t = \underset{(10.7)}{582.4} + \underset{(.0171)}{.3442\, I_t} - \underset{(.293)}{4.991\, \hat{P}_t}$$

$$S_{t+1} = \underset{(28.07)}{-11.17} + \underset{(.0797)}{.1864\, S_t} + \underset{(.8058)}{.7252(F_{t-2} \times L_{t-2})} - \underset{(.2850)}{.1055\, P_t}$$

Estimated Structural Equations for October-December

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for C_t and S_{t+1}

$$\hat{C}_t = \underset{(11.3)}{562.5} + \underset{(.0192)}{.2899}\, I_t - \underset{(.365)}{4.733}\, \hat{P}_t$$

$$\hat{S}_{t+1} = \underset{(106.50)}{-25.33} + \underset{(.595)}{1.115}\, S_t + \underset{(.855)}{2.011}\, \Delta I_t + \underset{(2.463)}{2.438}(F_{t-2} \times L_{t-2}) - \underset{(.9516)}{.9459}\, \hat{P}_{t\text{-}}$$

Reduced-Form Equations for Price Derived from 3-SLS Equations

January-March

$$\hat{P}_t = 107.12 - .1288\, S_t + .04343\, I_t + .3773\, \Delta I_t + .9302(F_{t-2} \times L_{t-2}) - 1.473(F_{t-1} \times L_{t-1}) - .4087(F_t \times \overset{*}{L}_t) - .1347\, Q_t$$

April-June

$$\hat{P}_t = 93.31 - .07513\, S_t + .005720\, I_t + .03755\, \overset{*}{I}_{t+1} - 3.062(F_{t-2} \times L_{t-2}) - .02406\, Q_t$$

July-September with E_t excluded

$$\hat{P}_t = 112.40 - .1627\, S_t + .06454\, I_t + .000096\, \overset{*}{I}_{t+1} + .005412\, \Delta I_t + .09211(F_{t-2} \times L_{t-2}) - .1919\, Q_t$$

July-September with E_t permitted to enter

$$\hat{P}_t = 112.07 - .1596\, S_t + .06753\, I_t + .1423(F_{t-2} \times L_{t-2}) - .1962\, Q_t$$

October-December

$$\hat{P}_t = 94.60 + .02025\, S_t + .05105\, I_t + .3541\, \Delta I_t + .4293(F_{t-2} \times L_{t-2}) - .1761\, Q_t$$

First-Round Equations for Price

January-March

$$\hat{P}_t = \underset{(3.60)}{95.49} - \underset{(.0212)}{.1910}\, S_t + \underset{(.00415)}{.04467}\, I_t + \underset{(.1110)}{.2461}\, \Delta I_t - \underset{(.438)}{1.253}(F_{t-2} \times L_{t-2}) - \underset{(.467)}{2.504}(F_{t-1} \times L_{t-1})$$

$R^2 = .986$

April-June

$$\hat{P}_t = \underset{(5.21)}{91.47} - \underset{(.01972)}{.07129}\, S_t + \underset{(.00454}{.04355}\, I_t - \underset{(.347)}{3.610}(F_{t-2} \times L_{t-2})$$

$R^2 = .954$

July-September with E_t excluded

$$\hat{P}_t = \underset{(16.93)}{92.48} - \underset{(.0326)}{.2423}\, S_t + \underset{(.01089)}{.01205}\, I_t + \underset{(.3153)}{.1676}\, \Delta I_t$$

$$\underset{(.8991)}{.4256}(F_{t-2} \times L_{t-2}) - \underset{(.5154)}{.4644}(F_{t-1} \times L_{t-1}) - \underset{(.829)}{1.012}(F_t \times \overset{*}{L}_t)$$

$R^2 = .923$

July-September with E_t included

$$P_t = 32.66 - .2328\,S_t - .9694(F_{t-2} \times L_{t-2}) - .8101(F_{t-1} \times L_{t-1})$$
$$(21.43)\ (.0217)\quad (.6608)\qquad\qquad (.2777)$$

$$- .7129(F_t \times \overset{*}{L}_t) + 5.920\,E_t$$
$$(.4193)\qquad (1.520)\qquad\qquad R^2 = .949$$

October-December

$$\hat{P}_t = 111.5 - .4213\,S_t + .03025\,I_t - 1.316(F_{t-2} \times L_{t-2})$$
$$(9.2)\ (.0890)\quad (.00931)\quad (.346)$$

$$- .2759(F_{t-1} \times L_{t-1}) - 2.169(F_t \times \overset{*}{L}_t)$$
$$(1.1080)\qquad (1.196)\qquad\qquad R^2 = 929$$

Results for the July-September quarter with and without E_t are shown. When E_t was permitted to enter, it came into the first-round equation with an acceptable positive sign and hence was initially retained. However, all variables relating to income came in with negative signs in the first round and also the storage relation and were dropped. As income was considered an important variable, analyses were rerun omitting E_t from the model. When E_t was included, the sign in equation (2) was negative. Thus, E_t was dropped from this equation in all formulations. For other quarters, E_t entered in all equations only with a negative sign and was dropped. When all quantitative data in equation (2) were expressed in per capita terms, both income and egg consumption entered all equations with the expected positive signs. These equations are presented later.

Estimates by 2-SLS are not shown. In all cases, the 2-SLS and 3-SLS coefficients for equation (2) were almost identical. Magnitudes of the coefficients differed substantially for equation (3d), but usually the signs were the same.

The structural coefficients have been discussed in considerable detail already, and relative accuracy of forecasts from the alternative equations are taken up later on. The only sign that was contrary to economic expectations for the final models was that for S_t in the reduced-form equation for P_t in the October-December quarter. Stocks normally are at their marketing-year minimum at the beginning of this quarter and the magnitude of the coefficient is small. These analyses were not designed to measure price and income elasticity; hence, related calculations are not shown.

Consumption and Related Variables Expressed in Per Capita Terms

When most demand studies were based on single-equation analyses, data for consumption and personal income commonly were expressed in per capita terms. In the type of model we used, with an identity like equation (1) expressed in terms of totals, use of per capita data complicates the fitting process. Thus, the tendency exists to run the study initially in total terms. When we used totals, results of the first run suggested the desirability of an additional run in per capita terms.

The complication involved in using per capita data arises because of the difficulty of handling a nonlinear endogenous variable, like per capita consumption, in the algebraic derivation of the reduced-form equations. Also, in deriving the statistical theory that underlies such models, an assumption is made that all simultaneously determined variables come into the equations in linear form. Klein (15, pp. 120-121) suggested the following linear approximations for nonlinear variables:

$$XY \cong \bar{Y}X + \bar{X}Y - \bar{X}\bar{Y} \tag{12}$$

$$\frac{X}{Y} \cong \frac{\bar{X}}{\bar{Y}} + \frac{X}{\bar{Y}} - \left(\frac{\bar{X}}{\bar{Y}^2}\right) Y. \tag{13}$$

In relation to equation (2), I_t and E_t are predetermined. They can be expressed in per capita terms directly with no problem because they are a part of the A-terms in the algebraically derived reduced-form equations. If N represents total population (millions) for the 48 States, the new desired dependent variable in equation (2) equals C_t/N_t. This variable was converted to a linear approximation by use of equation (13):

$$\frac{C_t}{N_t} \cong \frac{\bar{C}_t}{\bar{N}_t} + \frac{C_t}{\bar{N}_t} - \left(\frac{\bar{C}_t}{\bar{N}_t^2}\right) N_t .$$

In the fitting process for 3-SLS, equation (2) becomes:

$$\frac{C_t}{N_t} = a_2 + b_{21} P_t + b_{22} \frac{I_t}{N_t} + b_{23} \frac{E_t}{N'_t} . \tag{2a}$$

(The distinction between N and N′ is discussed later in this section.) The linear equivalent of C_t/N_t is substituted for C_t/N_t in the 3-SLS fit of this equation. In the first-round equation, I_t/N_t is substituted for I_t, E_t/N'_t is substituted for E_t, and N_t normally would be used as an additional variable. The variable N_t should come into the first-round equation with a positive sign. However, N_t is so highly correlated with I_t over the period of fit that problems arise in measuring the positive effect of income on price in this equation. Hence, N_t was dropped. Quantitative predetermined variables from equations (1) and (3d) enter the first-round equation in total terms.

In the algebraic solution for the reduced-form equation relating to P_t, the initial equation (2) becomes:

$$\frac{C_t}{\bar{N}_t} - b_{21} P_t = \left(a_2 - \frac{\bar{C}_t}{\bar{N}_t}\right) + b_{22} \frac{I_t}{N_t} + b_{23} \frac{E_t}{N'_t} + \left(\frac{\bar{C}_t}{\bar{N}_t^2}\right) N_t$$

or

$$C_t - \bar{N}_t b_{21} P_t = (\bar{N}_t a_2 - \bar{C}_t) + \bar{N}_t b_{22} \frac{I_t}{N_t} + \bar{N}_t b_{23} \frac{E_t}{N'_t} + \left(\frac{\bar{C}_t}{\bar{N}_t}\right) N_t = A'_2 . \tag{2b}$$

The reduced-form equation for $\hat{P}_t$ becomes:

$$\hat{P}_t = \frac{A_1 - A'_2 - A_3}{\bar{N}_t b_{21} + b_{31}} . \tag{11a}$$

In solving for C_t and S_{t+1}, the computed P_t can be substituted into the following to obtain C_t:

$$C_t = \bar{N}_t b_{21} \hat{P}_t + A'_2 .$$

The resulting C_t, together with S_{t+1} obtained from equation (3d), will satisfy equation (1).

E_t and I_t are shown in per capita terms in the original source material for these variables. E_t relates to civilian consumption and was divided by the population consuming civilian supplies to place it on a per capita basis. Notationally, this process is shown by using N'_t rather than N_t. C_t is based on production and stocks in the 48 States and includes military consumption. Thus, N_t was the appropriate denominator. I_t relates to 50 States and hence should have been divided by total population for the 50 States. However, by error, it was computed as I_t/N_t. As this series would be almost perfectly correlated with the correct series, per capita income in the models was used in this form. The error, however, required computation of I_t/N_t for future use in the models and prevented direct use of personal disposable income per capita as published in various official sources. Historic data on N_t and N'_t for July 1 and January 1 are given in (36, p. 3). Interpolations were made to obtain midquarter (and for later analyses, midmonth) estimates. Current monthly data relating to total population are shown in the *Survey of Current Business* (44, p. S-13).

The sensitivity of 3-SLS estimates to seemingly minor changes in the data is illustrated by the following example. Three variables in equation (2) and two variables in the first-round equation were expressed in per capita rather than total terms. As a result, significant changes in variables that came in with signs that were consistent with economic expectations were found, not only in these equations, but also in equation (3d) and hence in the reduced-form equation for price.

As noted previously, E_t/N'_t and I_t/N_t entered equation (2) with the expected positive signs in all quarters. E_t/N'_t and one or more variables relating to income also entered the first-round equations with positive signs, and one or more variables relating to income entered equation (3d) with positive signs in all quarters except April-June. The variable relating to current marketable supplies $(F_{t-2} \times L_{t-2})$ shows in these first-round analyses the expected negative sign. Marketable supplies for both one and two quarters ahead, $(F_{t-1} \times L_{t-1})$ and $(F_t \times L_t)$, show an effect for the January-March and October-December periods, with $(F_{t-1} \times L_{t-1})$ only coming in for the other two periods. In terms of storage policy, the marketable supplies for one quarter ahead have a measurable effect in January-March. For July-September and October-December, a measurable effect is shown for supplies projected to the distant quarter, but not for the nearby one.

As before, the equations obtained from the 3-SLS computer printouts or derived by algebra from these are shown below. A number in parenthese below a coefficient is its standard error. These errors were available only for the fitted equations. The fitted equation treating the linearized value of C_t/N_t as dependent and the algebraic equivalent for which C_t is written on the left of the equality sign are both shown.

Estimated Structural Equations for January-March

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for $\frac{C_t}{N_t}$ and S_{t+1}

$$\underset{}{\frac{\hat{C}_t}{N_t}} = \underset{(.462)}{3.045} + \underset{(.0000383)}{.0001399}\frac{Y_t}{N_t} - \underset{(.00223)}{.02349}\hat{P}_t + \underset{(.005086)}{.001133}\frac{E_t}{N_t'}$$

$$\hat{S}_{t+1} = \underset{(1836)}{1379} - \underset{(3.557)}{1.939}S_t + \underset{(.8790)}{.4943}I^*_{t+1} + \underset{(3.106)}{4.766}\Delta I_t - \underset{(27.42)}{11.05}(F_{t-2} \times L_{t-2})$$

$$- \underset{(47.79)}{38.91}(F_{t-1} \times L_{t-1}) - \underset{(19.14)}{14.12}\hat{P}_t$$

Derived for C_t

$$\hat{C}_t = 54.0 + .02662\frac{I_t}{N_t} - 4.770\hat{P}_t + .2156\frac{E_t}{N_t'} + 2.761 N_t$$

Estimated Structural Equations for April-June

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for $\frac{C_t}{N_t}$ and S_{t+1}

$$\frac{\hat{C}_t}{N_t} = \underset{(.237)}{2.368} + \underset{(.00002560)}{.00007728}\frac{I_t}{N_t} - \underset{(.00153)}{.02187}\hat{P}_t + \underset{(.00289)}{.01352}\frac{E_t}{N_t'}$$

$$\hat{S}_{t+1} = -\underset{(58.6)}{102.4} + \underset{(.1559)}{.6683}S_t + \underset{(1.820)}{6.614}(F_{t-2} \times L_{t-2}) - \underset{(.6453)}{.1570}\hat{P}_t$$

Derived for C_t

$$\hat{C}_t = -83.5 + .01456\frac{I_t}{N_t} - 4.120\hat{P}_t + 2.547\frac{E_t}{N_t'} + 2.811 N_t$$

Estimated Structural Equations for July-September

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for $\frac{C_t}{N_t}$ and S_{t+1}

$$\frac{\hat{C}_t}{N_t} = 2.116 + .0001980 \frac{I_t}{N_t} - .02605 \hat{P}_t + .01805 \frac{E_t}{N'_t}$$

(.400) (.0000331) (.00176) (.00489)

$$\hat{S}_{t+1} = 8.91 + .1345 S_t + .004783 I^*_{t+1} + .8115(F_{t-2} \times L_{t-2})$$

(44.44) (.1233) (.013760) (1.0300)

$$.5537(F_t \times L^*_t) - .3200 \hat{P}_t$$

(1.2010) (.4843)

Derived for C_t

$$\hat{C}_t = -168.3 + .03742 \frac{I_t}{N_t} - 4.923 \hat{P}_t + 3.411 \frac{E_t}{N'_t} + 3.006 N_t$$

Estimated Structural Equations for October-December

Identity

$$\hat{C}_t = Q_t + S_t - \hat{S}_{t+1}$$

3-SLS for $\frac{C_t}{N_t}$ and S_{t+1}

$$\frac{\hat{C}_t}{N_t} = 3.170 + .00007841 \frac{I_t}{N_t} - .02518 \hat{P}_t + .004189 \frac{E_t}{N'_t}$$

(.393) (00003570) (.00191) (.004211)

$$\hat{S}_{t+1} = 34.5 + .6453 S_t + .1249 I^*_{t+1} + 2.712(F_{t-2} \times L_{t-2})$$

(152.7) (.6093) (.0470) (2.239)

$$-4.206(F_t \times L^*_t) - 1.733 \hat{P}$$

(3.477) (1.312)

Derived for C_t

$$\hat{C}_t = 38.8 + .01487 \frac{I_t}{N_t} - 4.777 \hat{P}_t + .7947 \frac{E_t}{N'_t} + 2.965 N_t$$

Reduced-Form Equations for Price Derived from 3-SLS Equations

January-March

$$\hat{P}_t = 75.86 - .1556 S_t + .001409 \frac{I_t}{N_t} + .02617 I^*_{t+1} + .2523 \Delta I_t$$

$$- .5850(F_{t-2} \times L_{t-2}) - 2.060(F_{t-1} \times L_{t-1}) - .05294 Q_t + .01141 \frac{E_t}{N'_t} + .1462 N_t$$

April-June

$$\hat{P}_t = -43.46 - .07755 S_t + .003404 \frac{I_t}{N_t} + 1.546(F_{t-2} \times L_{t-2}) - .2338 Q_t$$

$$+ .5955 \frac{E_t}{N'_t} + .6572 N_t$$

July-September

$$\hat{P}_t = -30.39 - .1651 S_t + .007136 \frac{I_t}{N_t} + .0009121 I^*_{t+1} + .1548(F_{t-2} \times L_{t-2})$$

$$- .1056(F_t \times L^*_t) - .1907 Q_t + .6505 \frac{E_t}{N'_t} + .5732 N_t$$

October-December

$$\hat{P}_t = 11.26 - .05448\, S_t + .002284\, \frac{I_t}{N_t} + .01918\, I^*_{t+1} + .4166(F_{t-2} \times L_{t-2})$$

$$- .6460(F_t \times L^*_t) - .1536\, Q_t + .1221\, \frac{E_t}{N'_t} + .4554\, N_t$$

First-Round Equations for Price

January-March

$$\underset{(15.92)}{\hat{P}_t = 84.41} - \underset{(.0306)}{.1942\, S_t} + \underset{(.00154)}{.01127\, \frac{I_t}{N_t}} + \underset{(.1349)}{.1871\, \Delta I_t} - \underset{(.510)}{1.415(F_{t-2} \times L_{t-2})}$$

$$- \underset{(.562)}{2.276(F_{t-1} \times L_{t-1})} - \underset{(.4487)}{.1917(F_t \times L^*_t)} + \underset{(.21570)}{.09953\, \frac{E_t}{N'_t}} \qquad R^2 = .984$$

April-June

$$\underset{(12.56)}{\hat{P}_t = 60.72} - \underset{(.01671)}{.7384\, S_t} + \underset{(.00101)}{.01138\, \frac{I_t}{N_t}} - \underset{(.348)}{3.190(F_{t-2} \times L_{t-2})}$$

$$-\underset{(.2715)}{.3510(F_{t-1} = L_{t-1})} + \underset{(.1359)}{.2972\, \frac{E_t}{N'_t}} \qquad R^2 = 969$$

July-September

$$\underset{(11.91)}{\hat{P}_t = 29.80} - \underset{(.0170)}{.2045\, S_t} + \underset{(.001230)}{.004933\, \frac{I_t}{N_t}} + \underset{(.1393)}{.1724\, \Delta I_t} - \underset{(.336)}{1.601(F_{t-2} \times L_{t-2})}$$

$$-\underset{(.299)}{1.020(F_{t-1} \times L_{t-1})} + \underset{(.1624)}{.9574\, \frac{E_t}{N'_t}} \qquad R^2 = .976$$

October-December

$$\underset{(14.00)}{\hat{P}_t = 63.36} - \underset{(.0673)}{.2957\, S_t} + \underset{(.001823)}{.007147\, I_t\, N_t} + \underset{(.1758)}{.1716\, \Delta I_t} - \underset{(.291)}{2.002(F_{t-2} \times L_{t-2})}$$

$$-\underset{(.901)}{1.004(F_{t-1} \times L_{t-1})} - \underset{(1.0280)}{.8975(F_t \times L^*_t)} + \underset{(.1762}{.6959\, \frac{E_t}{N'_t}} \qquad R^2 = .969$$

Computed Values and Forecasts From the Alternative Equations

Calculated Values Over the Most Recent Price Cycle

Prices of pork bellies historically have fluctuated widely. Dramatic moves occurred during January 1970-June 1972. In monthly averages, cash prices at Chicago declined from 45.0 cents per pound in January 1970 to a low of 22.0 cents in January 1971. They remained low through most of 1971 but by January 1972 had reached 35.3 cents. The monthly averages reached their high of 35.8 cents in June, but prices went up to the 38-cent level by the end of June. Data used in fitting the equations ran through the first quarter of 1971. Thus, part of the latest cycle was within the period of fit and part was outside. Calculated and actual values from the quarterly models are shown in tables 2 and 3 for the first quarter in 1970 through the second quarter in 1972. Data from published sources issued through May 1972 were used in the calculations. Thus, calculations for April-June 1972 partly represent a near-quarter prediction from the March 1972 *Hogs and Pigs.*

Table 2 contains actual and calculated quarterly average prices from first-round and reduced-form equations and from the two sets of analyses based on consumption in total and per capita terms. As discussed previously, for the analyses based on total data, E_t entered with the expected positive sign only in July-September and, when it did, variables relating to income entered with negative signs in all equations other than (2). As income was considered the more important variable, equations based on total data for this quarter were rerun with E_t arbitrarily excluded. Equations for both analyses are shown on page 3. Calculated values and related coefficients for both are given later in the report.

Table 3 shows actual and calculated values for consumption and end-of-quarter stocks from the algebraic solution for the models fitted by 3-SLS for the same quarters as in table 2. Results from first-round equations are not presented. These equations were not computed because they were not needed for the 3-SLS fits. The calculated consumption and stock data satisfied equation (1) except for rounding errors of no more than 2 million pounds (about 1/4 of 1 percent, or less).

Table 2—Pork bellies: Average cash prices for fresh or FFA, 12-14 pounds, at Chicago, actual and calculated by quarter, 1970-72

Year and quarter	Actual P_t	Calculated P_t when C_t was based on—			
		Total data		Per capita data	
		First-round equation	Reduced-form equation	First-round equation	Reduced-form equation
		Cents per pound			
When E_t was permitted to enter:					
1970:					
I	43.5	42.9	44.1	42.6	42.4
II	41.0	43.0	42.9	42.8	39.5
III	37.6	37.0	39.8	36.8	38.9
IV	24.0	24.5	23.2	24.0	24.2
1971:					
I	23.1	25.3	26.2	24.8	24.3
II	23.3	27.1	26.7	28.7	22.5
III	24.0	24.3	25.6	23.9	23.1
IV	25.7	16.5	31.5	20.6	29.7
1972:					
I	34.4	29.8	31.9	30.3	29.4
II[1]	35.0	36.1	34.9	37.4	24.6
When E_t was arbitrarily excluded:					
Third quarter:					
1970	37.6	36.7	39.9	—	—
1971	24.0	22.1	23.5	—	—

Note: — = not estimated.

[1] Calculated values based on data in (40, March 1972) and (37, May 1972).

Table 3—Pork bellies: Consumption and end-of-quarter stocks, actual and calculated, by quarter, 1970-72

Year and quarter	Consumption (C_t)			Stocks (S_{t+1})		
	Actual	Calculated when C_t was based on —		Actual	Calculated when C_t was based on —	
		Total	Per capita		Total	Per capita
	Million pounds					
When E_t was permitted to enter:						
1970:						
I	524	527	515	61	58	69
II	553	544	552	67	76	68
III	622	621	622	10	12	11
IV	633	656	639	76	54	70
1971:						
I	621	625	614	114	110	120
II	629	625	636	139	143	132
III	695	719	719	52	28	28
IV	638	632	623	86	91	101
1972:						
I	582	613	600	108	79	91
II[1]	594	599	632	106	148	115
	Million pounds					
When E_t was arbitrarily excluded:						
Third quarter:						
1970	622	621	—	10	11	—
1971	695	720	—	52	27	—

Note: — = not estimated.

[1] Calculated values based on data in (40, March 1972) and (37, May 1972).

For the first three quarters of 1971, all models and equations predicted continued relatively low prices, and the simultaneous equation models predicted large consumption and stocks. Stocks resulting at the end of the third quarter were the largest on record for that date (prior to 1971), although they were much smaller than actual stocks. The structure of the futures market in the fall of 1971 permitted locking-in storage profits far above storage costs for those firms that could use these stocks in the spring of 1972. (Bellies placed in storage prior to December 1 are not deliverable on futures contracts for the following year.)

First-round equations predicted prices for the last quarter of 1971 that were too low; the models predicted prices that were too high. However, the models were correct with respect to the direction of price change in the cash market. Monthly average prices for the last half of 1971 reached a low of 23.7 cents in September and advanced to 28.0 cents by December. They averaged 35.3 cents in January. For the first quarter of 1972, all equations were accurate for the cash market; all predictions for the quarter were below the average price for cash in January. Cash prices declined during the quarter, reaching a monthly average low of 33.4 cents in March. All equations except the reduced form based on per capita data predicted correctly for the second quarter of 1972. All were above the level of cash prices in March and April; the high for the quarter was 38 cents in mid-June. Examination of Theil inequality coefficients (discussed in the next two sections) suggested that the model based on per capita data for the April-June quarter should not be used for forecasts because the price coefficients were nearly double those for the model based on total data. In all other quarters, the models based on per capita data appeared to be preferable over those based on total data for use beyond the period of fit. Or, at least, they were nearly as reliable as models based on total data. Some first-round equations also appeared to be useful.

Measures of Predictive Accuracy

Theil discussed in detail statistical and economic criteria for the appraisal of forecasts (26, pp. 22-48). As he pointed out, in connection with the analysis of business cycles and similar phenomena, major interest may center on accurate prediction of turning points because trends, once started, usually continue for some time in the same direction. In connection with commodity prices, on the other hand, we believe that major interest is centered on accurately predicting the magnitude of change from one period to another. For example, monthly average pork belly prices declined steadily from 42.6 cents per pound in July 1970 to 22.0 cents in January 1971. Given the developing supply situation for hogs, a decline was generally expected. The important consideration in July 1970 was the depth to which prices would fall. The key measurement appeared to be what part of the total change was predicted by the model.

With respect to using the correlation coefficient to measure predictive accuracy, Theil said: "Its disadvantage is that perfect (positive) correlation does not imply perfect forecasting, but only the existence of an exact linear relation with positive slope between the individual predictions (P_i) and the actual values (A_i),

$$P_i = \alpha + \beta A_i, \beta > 0,$$

whereas perfect forecasting requires, in addition to this, $\alpha = 0$ and $\beta = 1$" (26, pp. 31-32). He proposed instead an inequality coefficient:

$$U_1 = \frac{\sqrt{\frac{1}{N}\Sigma(P_i - A_i)^2}}{\sqrt{\frac{1}{N}\Sigma P_i^{\,2}} + \sqrt{\frac{1}{N}\Sigma A_i^2}} \qquad (14)$$

in which the positive root is used. In this formula, P_i relates to predicted changes and A_i to actual changes. The maximum value that U_1 can assume is unity and perfect forecasts give a value of zero.

To avoid using P_i in the denominator, Theil proposed the following modification, again based on the positive root (27, p. 28):

$$U_2 = \sqrt{\frac{\Sigma(P_i - A_i)^2}{\Sigma A_i^2}} \,. \qquad (15)$$

Perfect forecasts again give a value of zero. A value of unity indicates the same root mean square error as a naive no-change prediction. If $U_2 > 1$, the forecasting procedure is performing less accurately than a naive no-change prediction. No upper limit exists for the value of U_2.

As pointed out by Myers, Havlicek, and Henderson, if P_j is the predicted *level* and A_j is the actual *level*, equation (15) converts to (17, pp. 25-26):

$$U_2 = \sqrt{\frac{\Sigma(P_j - A_j)^2}{\Sigma(A_j - A_{j-1})^2}} \,. \qquad (15a)$$

Thus, the coefficient depends on the error of prediction in relation to the magnitude of the actual change. If the average square of the errors exceeds the average square of the actual changes, the coefficient is greater than unity.

U_2 appeared to be an ideal coefficient to measure the type of errors that are of interest in connection with commodity forecasts. However, because the change in actual values is used in the denominator, we had to decide what change to consider. For monthly or quarterly models, month-to-month or quarter-to-quarter changes are of greatest interest. However, if strong seasonal movements are involved, as for stocks, a low U_2 might occur merely because of the normal seasonal change. Also, at times, interest may center in a longer term prediction. For these reasons, the U_2 coefficients were computed in terms of period-to-period and year-to-year changes for each quarter or month. The numerator for equation (15a) was the same for both sets of changes, but the respective denominators differed.

Comparison of Results Based on Theil's U_2 Coefficients

Table 4 shows U_2 coefficients for all quarterly models considered, based on year-to-year comparisons. Quarter-to-quarter data appear in table 5. These results, insofar as possible, cover the period of fit. Some forecasts for the earliest periods had to be ignored because t−1 values did not exist. Table 6 contains similar coefficients for each set of equations based on data for the 10 quarters within the most recent price cycle. Comparisons were quarter to quarter.

In every case, the U_2 coefficients were less than unity, indicating that calculated values from the model were better than a no-change forecast. When data for the price-consumption equation were on a total basis, price predictions from the structural equations over the period of fit averaged better than those from the first-round equations in three out of the four quarters. When consumption was expressed in per capita terms, price predictions from the structural equations were better in two quarters. Inclusion or exclusion of egg consumption in the third quarter for equations based on total data had little effect on the U_2 coefficients based on the model. However, the arbitrary exclusion raised considerably the coefficient on price based on the first-round equation. In six out of the eight price comparisons, U_2 coefficients were better when consumption was expressed in per capita rather than total terms. In these price comparisons, first round were compared with first-round, and reduced form with reduced form, quarter by quarter.

For the most recent price cycle, best results on price were given by the reduced-form equation for the model based on per capita data; next best came from the reduced-form equation for the model based on total data. In both models, first-round equations were poorer by a considerable margin. Consumption and stocks over the last price cycle were estimated more accurately from the models based on per capita data.

MONTHLY MODELS THAT ARE COMPARABLE WITH QUARTERLY MODELS

Variables Used in Initial Fits

Variables used in initial monthly models were nearly equivalent to those in initial quarterly models based on to-

Table 4—Pork bellies: Theil U_2 coefficients based on year-to-year comparisons over the period of fit[1]

Quarter	Variable			
	Price based on —			
	First-round equation	Reduced-form equation	Consumption	Ending stocks
Consumption on total basis:				
I	0.089	0.122	0.176	0.283
II	.186	.178	.236	.192
III				
a	.161	.158	.063	.360
b	.196	.156	.063	.343
IV	.194	.164	.198	.381
Consumption on per capita basis:				
I	.097	.095	.224	.338
II	.154	.306	.321	.269
III a	.114	.157	.065	.347
IV	.130	.105	.140	.282

[1] Data relating to consumption and stocks begin with April-June 1957. Computations began with the earliest t−1 comparison. III-a covers analyses for which E_t was permitted to enter; III-b covers those for which E_t was arbitrarily excluded.

tal data. However, E_t, ΔI_t, and $\hat{I}_{t+1}$ were included or excluded initially in the models for each month in the quarter depending on whether they had entered with correct signs in the final equations for the quarter. All of the variables relating to farrowing times pigs per litter were retained in the initial runs. Monthly data were used for P_t, Q_t, C_t, S_t, and S_{t+1}. All other variables were based on quarterly data; the quarterly figure was used for each of the 3 months within each specified quarter.

Variables whose coefficients had signs that were contrary to economic expectations were dropped, based on the same rules that were applied to the quarterly models. Reduced-form equations for price were derived by algebra from the final structural equations, using the same procedures that were applied to quarterly models.

First-Round Equations for Price Based on Per Capita Data

In the quarterly models, first-round equations for price with per capita data gave better results in most periods than did those using only total data. Criteria listed in tables 4, 5, and 6 were used. In the monthly models, first-round equations for price with total data did better on the average than reduced-form equations for price (table 13). Given these two sets of results, a decision was made to run first-round monthly equations for price a second time based on the following additions and substitutions:

(1) I_t was dropped and replaced by I_t/N_t; I_t previously had been included in all months; (2) E_t/N'_t was substituted for E_t or added as a variable. E_t had previously entered with a positive sign only for the months of July, August, and September.

After the first run with these changes in the initial variables, variables whose coefficients had signs that went against economic expectations were dropped, based on the same rules applied previously.

Models based on total data were poor predictors of price. Hence, no attempt was made to rerun these models with per capita data.

Table 5—Pork bellies: Theil U_2 coefficients based on quarter-to-quarter comparisons over the period of fit[1]

Quarter	Variable: Price based on — First-round equation	Reduced-form equation	Consumption	Ending stocks
Consumption on total basis:				
I	0.279	0.380	0.221	0.205
II	.381	.362	.252	.399
III				
a	.371	.360	.060	.040
b	.448	.359	.061	.037
IV	.248	.210	.411	.228
Consumption on per capita basis:				
I	.301	.295	.261	.245
II	.312	.619	.344	.525
III a	.262	.359	.062	.038
IV	.165	.133	.291	.169

[1] Data relating to consumption and stocks begin with April-June 1957. Computations began with the earliest t−1 comparison. III-a covers analyses for which E_t was permitted to enter; III-b covers those for which E_t was arbitrarily excluded.

Table 6--Pork bellies: Theil U_2 coefficients based on quarter-to-quarter comparisons over the most recent price cycle[1]

Analysis	Variable			
	Price based on –		Consumption	Ending stocks
	First-round equation	Reduced-form equation		
All quarters:	0.682	0.497	0.346	0.325
Total basis[2]				
Per capita basis	.532	.412	.274	.258
Omitting IV of 1971[3]:	.418	.366	.377	.334
Total basis[2]				
Per capita basis	.443	.341	.276	.243

[1] January-March 1970 through April-June 1972.

[2] The model used for the July-September quarter was that for which E_t was arbitrarily excluded.

[3] For this quarter, beginning stocks (S_t) were more than double any over the period of fit. Large price errors occurred in all methods.

Results

To save space, results from the monthly models are presented in tabular form.

Table 7 shows the regression coefficients (b's) and their standard errors (S.E's) from the first-round equations based on total data with price dependent. Variation explained over the period of fit ranged from 89.8 to 98.3 percent. This figure was obtained by taking 100 times the R^2 shown in the table. In the quarterly models, when egg consumption entered with a positive sign in the third quarter, the income variables carried negative signs in the first round and hence were dropped from these equations.

Table 8 presents similar information for the first-round equations for price that initially included the egg consumption and income variables expressed in per capita terms. I_t/N_t came in with a positive sign every month. ΔI_t entered with a positive sign in 5 months. E_t/N'_t entered with a positive sign in all months except January and February. Variation in price explained by these analyses over the period of fit ranged from 91.5 to 98.3 percent. For each month, the R^2 was about the same or somewhat larger for the analyses based on per capita data compared with those based on total data.

Results from the 3-SLS equations relating to consumption (C_t) and end-of-month stocks (S_{t+1}), are in tables 9 and 10, respectively. Eggs were permitted to enter the consumption equation during the third quarter and had a positive sign only in July. Income entered with a positive sign, and price with a negative sign, in all months. Price entered the storage equation with the expected negative sign in all months except April, September, and October. Price was dropped if it had a positive sign. Income variables entered with negative signs in all but 4 months; thus, they were dropped for those months. Variables relating to pig crops that would be marketed beyond the current period entered with the expected negative sign in 7 of the 12 months.

Table 11 shows the algebraically derived reduced-form equations for price. Beginning stocks carried a sign contrary to economic expectations from October through December in both the per capita and total quarterly models.

In table 12 are calculated and actual values for each of the three simultaneously determined variables by month from January 1970 through June 1972, based on data published through May 1972. Calculated prices are given from the reduced-form and both of the first-round equations. Calculated values for C_t and S_{t+1} are from the models. Large price errors existed for some months, particularly in 1971 when stocks were by far the largest on record. The models tended to underestimate stocks and overestimate consumption in the latter part of that year. Stocks were accumulating because hog production was supposed to drop sharply in 1972. Further, an unusually wide carrying charge for futures

Table 7–Analyses based on total data: First-round equations to estimate $\hat{P}_t$ from selected predetermined variables

Variable and coefficient	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
I_t:												
b	0.03781	0.03771	0.04371	0.03858	0.04984	0.03980	–	–	–	0.02552	0.04106	0.04761
S.E.	.00511	.00585	.00761	.00622	.00674	.00763	–	–	–	.00692	.01145	.01134
ΔI_t:												
b	.5070	.4581	.1208	–	–	–	–	–	–	–	–	–
S.E.	.1387	.1561	.1805	–	–	–	–	–	–	–	–	–
E_t:												
b	–	–	–	–	–	–	7.682	4.865	2.119	–	–	–
S.E.	–	–	–	–	–	–	2.033	1.944	1.710	–	–	–
S_t:												
b	–.2510	–.2032	–.09532	–.08457	–.05342	–.1121	–.2402	–.3113	–.4801	–.4754	–.3034	–.2601
S.E.	.0281	.0285	.02323	.02699	.02884	.0309	.0292	.0361	.0492	.0737	.0810	.0634
$F_{t-2} \times L_{t-2}$:												
b	–1.663	–.2769	–	–2.961	–3.607	–3.221	–2.241	–.6375	–.03900	–1.079	–.9434	–.9849
S.E.	.572	.5612	–	.474	.573	.611	.629	.8215	.71830	.277	.4119	.4224
$F_{t-1} \times L_{t-1}$:												
b	–2.385	–3.488	–3.185	–	–	–.4205	–.2132	–.8161	–1.153	–	–.3616	–.6619
S.E.	.578	.610	.338	–	–	.6656	.3697	.3439	.297	–	1.2680	1.2910
$F_t \times L^*_t$:												
b	–.05125	–.2723	–	–	–	–.08267	–	–.8081	–.9194	–1.749	–2.130	–2.770
S.E.	.21240	.2705	–	–	–	.44640	–	.5215	.4541	.405	1.389	1.392
Constant:												
a	107.6	102.6	80.7	80.8	87.6	101.9	–.2	39.8	74.3	92.4	95.0	117.0
S.E.	4.6	6.1	6.1	7.1	8.3	12.0	2.9	27.1	23.6	7.8	10.9	11.7
R^2	.983	.976	.946	.904	.898	.920	.918	.925	.939	.930	.897	.936

Note: – = variable that does not enter the equation.

Table 8—Analyses based in part on per capita data: First-round equations to estimate $\hat{P}_t$ from selected predetermined variables

Variable and coefficient	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
I_t/N_t:												
b	0.008830	0.009076	0.01215	0.01067	0.01249	0.01061	0.007360	0.004844	0.001873	0.005791	0.01055	0.01016
S.E.	.001611	.001966	.00190	.00174	.00229	.00237	.002348	.002454	.001531	.001842	.00212	.00373
ΔI_t:												
b	.5001	.4370	.1183	–	–	–	–	–	–	.2461	–	.2527
S.E.	.1841	.2184	.1764	–	–	–	–	–	–	.1734	–	.3300
E_t/N'_t:												
b	–	–	.2405	.3244	.3269	.3886	1.009	.8559	.8320	.6892	.7890	.6467
S.E.	–	–	.1113	.1950	.3031	.2998	.366	.4736	.2277	.1857	.2163	.3505
S_t:												
b	–.2464	–.1875	–.09583	–.08037	–.05630	–.1168	–.2289	–.2877	–.4472	–.3550	–.2268	–.2030
S.E.	.0351	.0336	.02283	.02817	.03610	.0381	.0363	.0503	.0471	.0704	.0677	.0800
$F_{t-2} \times L_{t-2}$:												
b	–1.810	–.5634	–	–2.704	–3.199	–2.669	–2.128	–1.253	–.7263	–1.675	–1.952	–1.667
S.E.	.721	.6968	–	.511	.781	.835	.792	1.205	.4972	.308	.421	.658
$F_{t-1} \times L_{t-1}$:												
b	–2.254	–3.250	–2.971	–	–	–.7889	–.5800	–1.186	–1.821	–.8778	–.5178	–1.560
S.E.	.766	.842	.338	–	–	.8545	.5711	.628	.350	.9298	1.0157	1.779
$F_t \times \overset{*}{L}_t$:												
b	–	–	–	–	–.2657	–.1894	–	–.1159	–	–.2914	–1.310	–1.278
S.E.	–	–	–	–	.4196	.5735	–	.9948	–	1.0578	1.122	2.010
Constant:												
a^1	103.2	93.8	49.1	43.8	57.2	66.0	20.8	38.8	50.2	42.2	44.7	72.0
R^2	.983	.972	.970	.933	.915	.939	.931	.938	.970	.980	.967	.961

Note: – = variable that does not enter the equation.

[1] A least-squares program was used for these calculations and it did not compute the standard error of the constant term.

Table 9—Equation (2) based on $\hat{P}_t$ with C_t (consumption) as dependent variable (3-SLS)

Variable and coefficient	Jan.	Feb.	Mar.	Apr.	May	June	July[1]	Aug.	Sept.	Oct.	Nov.	Dec.
P_t:												
b	−1.688	−1.660	−1.027	−1.460	−1.911	−.9360	−2.116	−1.709	−1.409	−1.993	−1.209	−1.332
S.E.	.217	.213	.473	.301	.330	.2135	.259	.291	.233	.350	.317	.222
I_t:												
b	.1103	.1190	.09779	.1021	.08150	.05815	.08252	.1082	.1251	.1069	.08466	.09027
S.E.	.0145	.0142	.02457	.0143	.01734	.01197	.02280	.0172	.0131	.0165	.01576	.01493
Constant:												
a	190.7	152.9	160.8	171.7	202.5	187.9	18.9	198.1	180.2	205.2	177.6	177.4
S.E.	8.3	6.2	11.8	8.3	9.5	7.3	99.2	10.7	8.1	9.9	9.2	8.1

[1] E_t also entered with a b of 15.69 and an S.E. of 8.10.

Table 10–Equation (3d) based on $\hat{P}_t$ with S_{t+1} (end-of-month stocks) as dependent variable (3-SLS)

Variable and coefficient	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
$\hat{P}_t$:												
b	-1.280	-1.529	-0.6476	–	-118.4	-0.1826	-0.5689	0.2106	–	–	-0.8391	-0.2135
S.E.	.439	.618	.3390	–	102.6	.3073	.4162	.2615	–	–	.3250	.3410
$\overset{*}{I}_{t+1}$:												
b	–	–	–	–	5.790	–	–	–	–	–	–	–
S.E.	–	–	–	–	4.940	–	–	–	–	–	–	–
ΔI_t:												
b	1.506	1.695	–	–	–	–	–	–	–	–	.7479	–
S.E.	.612	.838	–	–	–	–	–	–	–	–	.3088	–
S_t:												
b	.7058	.5775	.8517	.9988	-5.191	.8302	.5913	.5620	.4634	1.132	1.007	1.163
S.E.	.1520	.2041	.0842	.0464	5.789	.0846	.1241	.0969	.0569	.197	.136	.152
$F_{t-2} \times L_{t-2}$:												
b	1.724	3.315	2.110	3.060	-432.3	2.037	-.4859	-.05678	.8050	.04288	-.2287	.8986
S.E.	2.118	2.165	1.055	.752	368.9	.867	1.0930	.87010	.7317	.51770	.8093	1.0470
$F_{t-1} \times L_{t-1}$:												
b	-6.496	-7.519	–	–	–	-.02122	–	–	–	–	–	–
S.E.	1.792	3.164	–	–	–	.81230	–	–	–	–	–	–
$F_t \times \overset{*}{L}_t$:												
b	-1.147	-.4376	-1.245	-.4403	–	–	–	-.2973	-.1191	–	–	–
S.E.	.682	1.1010	.886	.4894	–	–	–	.6104	.5706	–	–	–
Constant:												
a	165.8	167.6	26.3	-33.6	10,460	-35.3	31.6	12.9	-10.7	1.2	39.5	-7.3
S.E.	51.7	74.0	30.8	22.4	9,029	30.4	40.9	24.1	8.1	15.9	34.2	43.6

Note: – = variable that does not enter the equation.

Table 11—Coefficients for reduced-form equations to predict price (3-SLS)

Variable	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
I_t	0.03716	0.03732	0.05840	0.06993	0.000677	0.05199	0.03074	0.05636	0.08878	0.05364	0.04134	0.05840
ΔI_t	.5074	.5315	–	–	–	–	–	–	–	–	.3652	–
$\overset{*}{I}_{t+1}$	–	–	–	–	.04813	–	–	–	–	–	–	–
E_t	–	–	–	–	–	–	5.945	–	–	–	–	–
S_t	–.09912	–.1325	–.08883	–.00082	–.05146	–.1518	–.1522	–.2282	–.3808	[1].0662	[1].0034	[1].1055
Q_t	–.3369	–.3136	–.5972	–.6849	–.008312	–.8940	–.3725	–.5209	–.7097	–.5018	–.4883	–.6470
$F_{t-2} \times L_{t-2}$	.5808	1.040	1.260	2.096	–3.593	1.821	–.1810	–.02958	.5713	.02152	–.1117	.5801
$F_{t-1} \times L_{t-1}$	–2.189	–2.452	–	–	–	–.01897	–	–	–	–	–	–
$F_t \times \overset{*}{L}_t$	–.3864	–.1372	–.7435	–.3016	–	–	–	–.1549	–.08453	–	–	–
Constant	120.1	100.5	111.7	94.6	88.6	136.4	17.4	109.9	120.3	103.6	106.0	110.1

Note: – = variable that does not enter the equation.
[1] Sign was contrary to economic expectations.

Table 12—Calculated and actual values for variables simultaneously predicted by models and first-round equations, January 1970-June 1972

Item[1]	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1970:												
P_t:												
Actual	45.0	43.0	42.5	40.9	40.9	41.1	42.6	37.2	32.9	25.8	24.1	22.0
Calculated from:												
(A)	44.1	43.3	41.7	41.4	43.9	42.9	41.2	36.6	32.6	26.5	24.2	21.4
(B)	44.8	44.3	42.4	41.9	43.4	42.4	40.2	36.5	32.0	26.0	24.2	20.8
(C)	43.9	45.1	44.6	36.5	44.0	39.2	43.5	41.9	35.9	27.7	23.0	15.9
C_t:												
Actual	191	155	177	190	172	191	205	199	219	218	205	208
Calculated	190	158	180	188	174	191	207	202	217	225	209	220
S_{t+1}:												
Actual	37.0	47.1	61.1	74.0	82.1	67.3	39.3	20.4	9.8	21.2	42.1	76.4
Calculated	37.5	44.5	57.9	75.7	79.1	67.0	37.0	17.4	11.7	13.7	38.0	67.6
1971:												
P_t:												
Actual	22.0	24.6	22.6	22.6	22.9	24.3	24.0	24.2	23.7	24.2	24.8	28.0
Calculated from:												
(A)	24.6	24.0	28.6	27.2	29.1	24.3	24.5	19.8	12.7	14.1	23.9	26.6
(B)	23.1	25.3	31.1	29.8	31.1	26.3	25.0	20.0	12.8	18.2	26.8	27.3
(C)	26.2	31.2	16.8	29.9	29.0	5.2	32.2	17.6	15.6	41.3	24.4	30.7
C_t:												
Actual	220	187	214	211	194	224	220	238	237	211	214	213
Calculated	226	187	214	204	207	226	242	249	252	204	212	205
S_{t+1}:												
Actual	82.8	84.5	113.5	133.4	148.4	138.9	107.0	71.5	51.5	53.9	68.9	86.3
Calculated	76.3	84.9	113.4	140.8	133.0	136.4	85.1	61.2	36.7	60.8	71.0	94.2
1972:[2]												
P_t:												
Actual	35.3	34.5	33.4	33.9	35.4	35.8						
Calculated from:												
(A)	26.3	28.3	34.9	34.9	37.9	33.8						
(B)	26.4	29.3	37.3	36.9	39.6	35.5						
(C)	36.9	31.6	26.7	37.0	37.9	31.1						
C_t:												
Actual	194	180	209	175	201	218						
Calculated	213	191	208	197	194	204						
S_{t+1}:												
Actual	84.2	87.9	107.5	130.9	133.0	105.6						
Calculated	65.5	76.8	108.8	130.1	122.6	120.9						

[1] A—based on first-round equations with all variables in total terms.
B—based on first-round equations that initially included two variables on a per capita basis.
C—based on reduced-form equations for models based on total data.
[2] Q_t was estimated for April, May and June; and S_t was estimated for June.

quotations existed between cash prices of pork bellies and the February and March 1972 contracts. The models do not reflect fully the effects of this unusual demand factor. Forecasts for price improved during the second quarter of 1972 when conditions were more nearly normal.

Table 13 contains the Theil U_2 coefficients for each of the three variables and the three price equations by month, based on data over the period of fit. First-round equations for price gave better results for all months than did reduced-form equations. In contrast, reduced-form equations were best in five of the eight comparisons in the quarterly models. In all but 1 month, results for method (B) were better than for method (A). Theil coefficients were less than unity for all year-to-year comparisons but exceeded unity for several month-to-month comparisons, particularly in reduced-form equations relating to price.

Based on month-to-month comparisons for the most recent price cycle (table 12), all Theil coefficients for price exceeded unity. Coefficients for methods (A) and (B) were nearly identical at 1.6. For method (C), the coefficient was 2.5. It should be remembered that the period was unusual; for a number of months, stocks were far above any previous record.

As a result of this information, we concluded that a month is too short a timespan to permit accurate measurement of the factors that affect the pork belly economy. Livestock and meat production flow continuously; a division into quarter years may have meaning, but a division into arbitrary 30-day periods (months) apparently does not in relation to econometric models of this type. The first-round equations may be valuable in measuring expected price variations by month when monthly predictions are desired and this aspect is discussed later on.

EQUATIONS DESIGNED TO PREDICT PORK BELLY PRODUCTION FOR TWO QUARTERS AHEAD FOLLOWING EACH *HOGS AND PIGS*

The major purpose of the quarterly and monthly models was to indicate what prices should have been in a past period, based on known values of the predetermined or nonsimultaneously determined variables. In connection with pork belly futures, however, quotations may reflect anticipation regarding future marketings. Many elements of the trade, including meatpackers, commodity brokerage houses, and private services, analyze data from the *Hogs and Pigs* reports in an effort to predict likely changes in hog slaughter and pork belly production. In this section, analyses relating to liveweight slaughter of hogs are discussed. These analyses are believed comparable with studies made by persons in the trade who are acquainted with multiple regression studies of slaughter. Because production of pork bellies is a direct function of liveweight slaughter of hogs, these analyses also can be used to project production of bellies.

Sources of Data

As noted earlier, the *Hogs and Pigs* reports (40) issued in June and December contain data for the United States, 10 Corn Belt States, and individual States. Reports issued in March and September contain data only for the 10 Corn Belt States and Hawaii. In each issue, certain figures relate to numbers of hogs on hand on the first of the month in which the report is issued; others relate to sows farrowing by quarters, pigs per litter, and pig crops. The latter two items are shown by quarter for the Corn Belt States and by 6-month period for the United States.

Besides the data on pig crops given in 1,000 head, the following inventory items were used in the analysis discussed in this section:

All hogs and pigs kept for breeding (1,000 head)

Market hogs and pigs by weight groups (1,000 head):

- Under 60 pounds
- 60-119 pounds
- 120-179 pounds
- 180-219 pounds
- 220 pounds and over

Data discussed so far were used as independent variables in the analyses of numbers of barrows and gilts or sows to be slaughtered. Data on inventories by weight class are available only back to 1963. All of the data for these regression analyses came from the latest revisions published in *Hogs and Pigs*. SRS may revise numbers of sows farrowing and

Table 13—Theil U_2 coefficients based on year-to-year and month-to-month comparisons, 1957-January 1971[1]

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Based on year-to-year comparisons:												
Price:												
(A)	0.096	0.122	0.202	0.249	0.297	0.230	0.200	0.195	0.179	0.308	0.230	0.182
(B)	.095	.134	.151	.207	.269	.200	.192	.179	.123	.106	.132	.145
(C)	.176	.164	.506	.657	.302	.646	.268	.363	.470	.502	.310	.414
Consumption	.192	.262	.526	.396	.362	.346	.201	.153	.153	.243	.273	.249
Ending stocks	.465	.159	.211	.378	.471	.346	.524	.161	.289	.369	.249	.175
Based on month-to-month comparisons:												
Price:												
(A)	.526	.766	.577	1.015	.705	.776	.752	.660	.715	.456	1.377	.714
(B)	.519	.838	.429	.849	.641	.676	.723	.611	.495	.158	.788	.566
(C)	.964	1.027	1.442	2.690	.720	2.[illegible]84	1.012	1.235	1.885	.744	1.858	1.616
Consumption	.246	.129	.304	.318	.396	.274	.278	.171	.173	.283	.234	.388
Ending stocks	1.223	.255	.312	.856	1.914	.527	.373	.096	.156	.689	.286	.201

[1] Data relating to consumption and stocks begin in February 1957. Computations began with the earliest t−1 comparison.

A—based on first-round equations with all variables in total terms.

B—based on first-round equations that initially included two variables on a per capita basis.

C—based on reduced-form equations for models based on total data.

pigs per litter later based on the 5-year censuses of agriculture. Calculated prices for a 1968-71 test period relating chiefly to futures quotations were based on data published in reports as near the assumed date of the forecast as possible, or in *earlier* reports. These prices are discussed later on.

Methods for obtaining estimates of barrows and gilts and sows slaughtered commercially by month were described on pages 2-3. Data on slaughter weights (pounds) per head were based on averages for eight (now seven) major markets. Related analyses were based on data for 1957-70. Historical data are given in table 137 of the 1970 Supplement to *Livestock and Meat Statistics* (32) and prior issues. Weekly data are carried currently in the *Livestock Meat Wool Market News* (30). Monthly averages for barrows and gilts frequently are included in the *Livestock and Meat Situation* (31).

Additional independent variables were current or lagged values of the following or their ratio: (1) Price of No. 2 Yellow corn at Chicago (dollars per bushel) and (2) price of No. 1 and 2 barrows and gilts (200-220 pounds) at Chicago (now Omaha) (dollars per hundredweight). The first is published in the USDA weekly *Grain Market News* (29). Weekly averages for the second are given in the *Livestock Meat Wool Market News.* Monthly averages are shown in *Livestock and Meat Situation.* These will be referred to as "economic variables" in subsequent comments.

A time trend, for which 1957 equals 57, was used in most analyses. The size of the corn crop in billion bushels also was used. This statistic was based on *Prospective Plantings* (43) for the April-June quarter; the July estimate from *Crop Production* (38) for the July-September quarter; the September estimate for the October-December quarter; and the estimate for the preceding crop from the *Annual Summary* (39) for the January-March quarter. For the monthly analyses, the current estimate in *Crop Production* was used for July through November and the estimate from the *Annual Summary* was used for December through March. Estimated production based on intended acreage times a trend yield, published in *Prospective Plantings*, was used for remaining months.

Published Studies

A number of published studies contain equations relating to hog slaughter as a function of pig crops and other variables. Only two studies have been found in which inventory data by weight class are used. Hayenga and Hacklander (13, pp. 13-16) discuss a set of six equations that predict pork production for each of 6 months after *Hogs and Pigs* reports are released and that are based on ratios of hog numbers in each weight category to those on hand a year earlier in that category times pork production a year earlier. Variation explained ranged from 57 to 72 percent, based on data for 1963-68.

In a second report (12), these authors used an equation as part of a larger model containing two simultaneously determined variables: (1) The price of hogs relative to that a year earlier; and (2) commercial liveweight hog slaughter per slaughter workday; and as independent variables, numbers of hogs in each of three weight classes. Estimates of the coefficients were obtained by 2-SLS. Dummy variables permitted the intercepts to vary by month. When slaughter was treated as a dependent variable, 84 percent of the variation was explained for April 1963-June 1968.

Neither of these studies gave the detail desired for our research. Thus, the seven basic sets of analyses discussed here were developed. Two relate, respectively, to average weight per head for barrows and gilts and for sows. Two involve slaughter numbers for each of these classes for the nearby quarter. Two consider slaughter numbers for the far quarter; that is, two quarters ahead. The final set allows for the slight adjustment needed to go from the data used as dependent variables in these analyses to total commercial slaughter for the 48 States. Analyses for all but the far-quarter numbers were run both by month and quarter. Full details are given in Williams (46, pp. 36-43). Only the best analyses and methods are discussed here, except that monthly analyses are shown for all sets.

Analyses of Average Live Weight Per Head

The independent variables used were a time trend and various combinations of the economic variables mentioned previously, plus the prospective corn crop. All were run by ordinary least squares. To the extent that current hog prices affected the dependent variable, a method allowing for this simultaneity (such as 3-SLS) should have been used. As the simultaneous effect was considered slight, these least-squares equations appeared satisfactory as a first approximation, particularly in connection with price-forecasting models for bellies, which make up only part of the hog carcass. In a study relating to factors that affect hog prices, Foote and Sadler (8) reran by 2-SLS any analyses in the best sets that treated current hog price as a casual variable. As expected, differences between the coefficients obtained by OLS and 2-SLS in no case were statistically significant based on the standard errors obtained by 2-SLS.

In all analyses relating to weight per head, the time trend came in with a positive sign. In all but three of the 32 analyses run, the coefficient differed significantly from zero at a probability level of 5 percent or less.

Barrows and Gilts

Results of both the monthly and quarterly analyses are shown in table 14. Based on the R^2 times 100, the variables included explained over 70 percent of the variation in 9 of the 12 months and three of the four quarters. The lowest percentage explained was 44 percent, but total variation was small for those periods with small R's. In all periods, the predicted weight was expected to be within 4-6¼ pounds of the actual weight 95 percent of the time. This prediction was computed based on the standard error of estimate (S.E.) times the appropriate t-statistic, which suggests errors of 2-3 percent or less. In most months, only one economic variable came in with a sign consistent with economic expectations. In the April-June and July-September quarters, expected new-crop corn production had a positive effect on average weights. In only one month did the current price of hogs have a measurable effect, and the coefficient failed to differ significantly from zero. Current price of corn had an effect consistent with economic expectations in several months, although the coefficients also failed to differ significantly from zero. Corn prices chiefly were determined by characteristics of the price-support program for feed grains over the period of fit and thus probably were nearly exogenous with respect to the hog economy.

Sows

Results of analyzing average live weight per head for sows are shown in table 15. Variation explained by the included variables was 74 percent or more in all months. Sows are heavier than barrows and gilts; hence, the standard errors of estimate are larger. In 11 months and all quarters, predicted weights were expected to be between 8-13 pounds of the actual weights 95 percent of the time; for the remaining month, the corresponding figure was 18 pounds. Except for the one month, these predictions also suggest errors of 2-3 percent or less. Economic variables entering the analyses with signs that met economic expectations were similar to those for barrows and gilts. The current price of hogs had an expected sign in only 2 of the 16 months. For these, the coefficients differed significantly from zero at a probability level of 5 percent or less. Both related to the October-December quarter.

Slaughter Numbers One Quarter Ahead

Two alternative but not mutually exclusive procedures were considered. One concerned whether to predict numbers for individual months and add these to obtain a quarterly total or to predict directly a quarterly total. The second involved whether to use data for the Corn Belt States (available in all quarters) or for all States from the two *Hogs and Pigs* reports per year that covered all States. In the direct quarterly analyses, lagged values of economic variables related to averages for the month in which *Hogs and Pigs* was released or to the October-December quarter of the preceeding calendar year. Research by Harlow (11) suggested that hog producers frequently make major decisions on future production in the October-December quarter and then follow through for the next 6 months or so, regardless of current economic conditions.

Monthly analyses were based only on data for the 10 Corn Belt States; all are shown in the tables that give results. Only the best quarterly results were included and only if they were better or nearly as good for prediction for the quarter as the data obtained by summing predictions for the months included. Calculated values in relation to actual values were checked over the 8 to 9 years for which data on inventories by weight class are available.

Economic variables used resembled those in the analyses of average weights. However, because of the small number of observations for which data were available, only one variable was considered in each analysis. Choice of the best variable was based on the size of the multiple coefficient of determination if its sign was consistent with economic expectations. For the barrow and gilt analyses, no signs were specified for the price variables because slaughter numbers would increase if animals were carried over from the preceding period but would decrease if animals were carried into the next period. Signs were specified in the analyses for sows. In a few months, use of an economic variable resulted in a negative sign on the inventory variables. In these cases, the economic variable was dropped.

One additional variable was considered a dummy (0-1) variable used to help explain variations in slaughter of breeding stock. The cycle of seasonally adjusted hog slaughter was segregated into increasing and decreasing phases. A 10-month lag from each cycle's peak and trough was used to represent the time lag from breeding to market. A value of 1 was assigned to periods when breeding stock would be held back for expansion of herds. Thus, this variable should have a negative effect on slaughter. It was used only for the quarterly analyses. For forecasting, this variable must be assigned

Table 14--Barrows and gilts: Regression analyses for average live weight per head slaughtered

Period	R^2	S.E.	Inter-cept	Partial regression coefficient for variable specified[1]				
				Time	Price			Corn production
					Corn	Hogs	Hog-corn ratio	
		Pounds						
Jan.	0.44	2.8	218	0.157	—	[2]0.419	—	—
				(.205)		(.187)		
Feb.	.51	2.3	212	.202	—	[2].152	[2]0.281	—
				(.157)		(.326)	(.418)	
Mar.	.62	2.1	213	.169	—	[2].429	—	—
				(.148)		(.148)		
Apr.	.72	2.1	201	.383	—	—	[3].603	—
				(.138)			(.184)	
May	.76	2.4	187	.652	—	—	[3].513	—
				(.168)			(.209)	
June	.87	1.8	176	.831	—	—	[3].365	
				(.153)			(.192)	
July	.83	2.5	164	1.297	[4]-11.83	—	—	—
				(.169)	(7.50)			
Aug.	.81	2.8	152	.279	[4]-9.15	—	—	—
				(.190)	(6.64)			
Sept.	.84	2.6	142	1.316	[4]-1.99	—	—	—
				(.171)	(5.98)			
Oct	.83	2.5	155	1.207	[2]-2.21	—	—	—
				(.171)	(5.73)			
Nov.	.85	2.0	167	1.009	—	—	[4].178	—
				(.141)			(.172)	
Dec.	.77	2.1	188	.628	—	[2].348	—	—
				(.155)		(.168)		
Jan.-Mar.	.63	2.0	211	.236	—	[5].392	—	—
				(.154)		(.136)		
Apr.-June	.82	2.0	204	.149	—	[5].428	—	[6]3.46
				(.302)		(.162)		(2.07)
July-Sept.	.88	2.3	170	.796	[4]-8.91	—	—	[7]3.85
				(.320)	(6.18)			(2.42)
Oct.-Dec.	.84	2.0	173	.840	—	[5].297	—	—
				(.155)		(.198)		

Note: — = variable that does not enter the equation.

[1] Numbers in parentheses are standard errors of the regression coefficients.

[2] For preceding month for monthly analyses or quarter for quarterly analyses.

[3] For last quarter of preceding calendar year.

[4] For current month or quarter.

[5] For month in which (40) was issued.

[6] Based on (43, March).

[7] Based on (36, July).

Table 15—Sows: Regression analyses for average live weight per head slaughtered

Period	R^2	S.E.	Inter-cept	Partial regression coefficient for variable specified[1]				
				Time	Price			Corn production
					Corn	Hogs	Hog-corn ratio	
		Pounds						
Jan.	0.87	3.9	351	1.047	–	[2]1.411	–	–
				(.287)		(.262)		
Feb.	.77	5.6	316	1.572	–	–	[2]1.291	–
				(.368)			(.487)	
Mar.	.84	4.8	303	1.706	–	–	[3]1.247	–
				(.310)			(.411)	
Apr.	.86	4.8	289	1.895	–	–	[3]1.283	–
				(.311)			(.412)	
May	.94	4.0	229	2.821	–	–	[3]1.197	–
				(.257)			(.341)	
June	.97	3.7	190	3.996	[2]-37.76	[2]1.048	–	–
				(.322)	(17.27)	(.449)		
July	.87	8.4	103	4.739	[2]-1.27	–	–	–
				(.557)	(24.75)			
Aug.	.96	3.8	140	4.370	[4]-19.72	–	–	–
				(.258)	(9.02)			
Sept.	.94	4.0	184	3.882	[4]-23.01	–	–	–
				(.311)	(10.44)			
Oct.	.89	4.3	252	2.386	–	–	[5]1.000	–
				(.312)			(.452)	
Nov.	.74	6.0	352	1.372	[4]-27.77	[4]1.385	–	–
				(.526)	(18.59)	(.499)		
Dec.	.89	3.9	309	1.995	[2]-8.47	[2].842	–	–
				(.345)	(12.19)	(.327)		
Jan.-Mar.	.78	5.2	314	1.733	–	[6].619	–	–
				(.396)		(.351)		
Apr.-June	.98	2.5	281	1.181	–	[6]1.040	–	[7]12.58
				(.374)		(.200)		(2.56)
July-Sept.	.94	5.3	174	2.770	–	–	[6]1.054	[8]8.01
				(.795)			(.620)	(5.62)
Oct.-Dec.	.81	4.9	302	1.648	–	–	[6]1.471	
				(.311)			(.539)	–

Note: – = variable that does not enter the equation.

[1] Numbers in parentheses are standard errors of the regression coefficients.

[2] For preceding month for monthly analyses or quarter for quarterly analyses.

[3] For last quarter of preceding calendar year.

[4] For current month or quarter.

[5] Current hog price divided by corn price for the preceding month.

[6] For month in which (40) was issued.

[7] Based on (43, March).

[8] Based on (38, July).

a value of 0 or 1 on a judgment basis. Another way to consider this variable is as follows. Sows or gilts that might be marketed in January-March, if held for breeding, would farrow probably about 6 months later in June-August or September-November. Thus, a value of 1 should be assigned if farrowings 6 months later are above those a year earlier.

Barrows and Gilts

An initial decision involved which weight class of barrows and gilts to use each month. (The discussion relates to the January-March quarter.) Data came from the December *Hogs and Pigs* and applied to December 1. Barrows and gilts are assumed to gain at the rate of 1.5 pounds per day (13, p. 8). The pattern by month is shown in table 16. A similar pattern was used for months in the other quarters. All four inventory categories were tested in the quarterly analyses. Inventory variables were required to enter with a positive sign.

Table 16 – Barrows and gilts: Weight class variables considered in explaining near-quarter slaughter numbers, January-March quarter[1]

Weight class	January	February	March	Quarter
First – 180-219 pounds	x			x
Second – 120-179 pounds	x	x		x
Third – 60-119 pounds		x	x	x
Fourth – Under 60 pounds			x	x

[1] Based on data from (40, Dec. issue).

Results of these analyses are shown in table 17. Monthly analyses gave best results for July-September and October-December; they were equal to those from the direct quarterly approach based on 10-State data for April-June. For January-March, the direct approach based on data for 10 States was best (see table 21). Hence, results from the quarterly analyses in table 17 are shown only for January-March and April-June.

Variation explained exceeded 70 percent for 10 of the months and for the two quarters for which results are shown. Minimum variation explained was 45 percent. The hog-corn ratio based on current prices was the most frequent economic variable; it entered for six of the analyses shown and was statistically significant in four of them. Current or lagged corn prices were significant in three analyses, and current hog price as a ratio to the corn price in the preceding month entered one analysis with a statistically significant effect. The predicted slaughter for all months and quarters would be expected to be within 1.1 million head or less of the actual number 95 percent of the time.

Sows

In general, the percentage of variation explained was less for sows than for barrows and gilts, reflecting chiefly the fact that inventory variables available were of less value in relation to current slaughter. Economic variables, the dummy variable relating to the phase of the hog cycle, and expected corn production tended to be more important.

Monthly analyses were best in explaining quarterly sow numbers in January-March. Direct quarterly analyses based on data for the 10 States were best in April-June and October-December. The direct analysis based on data for all States was best in July-September (table 21). Hence, table 18 shows results for each month and three of the quarters.

Seven monthly and all quarterly analyses shown explained 60 percent or more of the variation in sow slaughter. The lowest percentage accounted for was 27 percent. Predicted slaughter for all months was expected to be within 125,000 head or less of the actual slaughter 95 percent of the time. For the quarterly analyses, the corresponding figure was 337,000 head.

The hog-corn price ratio had a statistically significant effect in each month in the January-March quarter. The dummy variable was statistically significant in February, November, December, and the October-December quarter. Prospective corn production was a significant influence in April, December, and the October-December quarter.

Slaughter Numbers Two Quarters Ahead

Analyses for April-June were run based on data for the 10 Corn Belt States and all States from December *Hogs*

Table 17–Barrows and gilts for near quarter: Regression analyses for numbers slaughtered based on data for 10 Corn Belt States

Period	R^2	S.E.	Inter-cept	Partial regression coefficient for variable specified[1]					
				Inventory variable[2]				Price	
				First	Second	Third	Fourth	Corn	Hog-corn ratio
		1,000 head							
Jan.	0.88	316	-9,385	2.768 (.683)	–	–	–	–	[3] 132.07 (68.69)
Feb.	.71	324	1,574	–	.636 (.182)	–	–	[3] -432 (924)	–
Mar.	.98	102	-1,353	–	–	.509 (.048)	–	[4] 2,452 (301)	–
Apr.	.97	138	-4,039	.753 (.433)	.753 (.292)	–	–	–	[5] 83.04 (18.11)
May	.82	322	-7,341	–	1.368 (.280)	–	–	–	[3] 144.73 (59.82)
June	.74	380	-2,346	–	–	–	.693 (.176)	–	[3] -26.59 (46.59)
July	.95	165	2,596	1.539 (.144)	–	–	–	[3] -1,636 (593)	–
Aug.	.86	342	470	–	1.425 (.277)	–	–	[3] -2,150 (1,011)	–
Sept.	.65	397	-2,377	–	–	.796 (.239)	–	–	[3] 103.72 (53.77)
Oct.	.84	289	-10,895	3.355 (.639)	–	–	–	–	[3] 55.26 (40.01)
Nov.	.45	511	-1,508	–	.105 (.064)	.701 (.319)	–	–	–
Dec.	.85	328	-1,239	–	–	–	.556 (.089)	–	–
Jan.-Mar.	.94	537	-1,719	–	–	1.922 (.258)	–	[6] 1,432 (1,551)	–
Apr.-June	.98	309	-16,449	–	2.491 (.524)	–	.952 (.302)	–	[3] 205.12 (79.31)

Note: – = variable that does not enter the equation.

[1] Numbers in parentheses are standard errors of the regression coefficients.

[2] See table 16 for variables involved.

[3] For current month or quarter.

[4] For preceding month.

[5] Current hog price as a ratio to corn price in the preceding month.

[6] For month in which (40) is released.

and Pigs. For studies of January-March (based on the September report) and July-September (based on the March report), only 10-State data are published. No far-quarter analyses were run for October-December since no pork belly futures contracts are delivered in those months. No monthly analyses were run because inventory data did not lend themselves to such a breakdown.

Table 18--Sows for near quarter: Regression analyses for numbers slaughtered based on data for 10 Corn Belt States

Period	R^2	S.E.	Inter-cept	Partial regression coefficient for variable specified[1]						
				Sows farrowing		Breeding stock kept	Price		Dummy variable	Corn production
				Present quarter	Preceding quarter		Corn	Hog-corn ratio		
		1,000 head								
Jan.	0.77	42	314	0.160 (.129)	–	–	–	[2]-8.22 (3.74)	-61.4 (33.2)	–
Feb.	.89	18	211	–	0.099 (.037)	–	–	[2]-4.51 (1.88)	-24.9 (13.6)	–
Mar.	.86	22	1,059	–	–	-0.0766 (.0365)	–	[2]-9.96 (2.41)	-20.5 (23.6)	–
Apr.	.52	34	885	.005 (.073)	–	–		–	–	[3]-112.3 (48.8)
May	.27	54	749	.037 (.092)	–	–	–	–	–	[3]-92.1 (68.5)
June	.34	74	724	.027 (.135)	–	–	–	[4]-14.53 (9.78)	–	–
July	.62	95	102	–	.354 (.329)	–	–	–	–	[5]-163.2 (159.2)
Aug.	.63	62	11	–	.267 (.104)	–	–	–	–	[5]-68.9 (45.5)
Sept.	.39	51	86	–	–	–	[4]363.8 (197.6)	–	-77.6 (45.4)	–
Oct.	.47	42	-33	–	.159 (.079)	–	[2]130.0 (149.5)	–	–	–
Nov.	.96	12	1,017	–	–	-.0409 (.0129)	–	[4]-12.37 (1.37)	-27.3 (8.7)	–
Dec.	.72	48	585	.138 (.086)	–	–	–	–	-96.9 (32.9)	[6]-71.5 (33.2)
10-State data										
Apr.-June	.71	105	2,648	.083 (.179)	–	–	–	[4]-14.84 (13.05)	–	[3]-280.0 (189.3)
Oct.-Dec.	.85	73	1,717	.489 (.143)	–	–	–	–	-182.5 (49.9)	[7]-267.1 (63.2)
All-State data										
July-Sept.	.69	158	2,823	[8].281 (.227)	–	–	–	[2]-30.68 (30.68)	–	[5]-520.6 (330.1)

Note: -- = variable that does not enter the equation.

[1] Numbers in parentheses are standard errors of the regression coefficients.

[2] For current month or quarter.

[3] Based on (43, March).

[4] For preceding month for monthly analyses or quarter for quarterly analyses.

[5] Based on (38) for the current month for monthly analyses and the first month of the quarter for quarterly analyses.

[6] Based on (39).

[7] Based on (38, September).

[8] Farrowings are for the 6-month period June-November.

For the one quarter for which two approaches were used, the analyses based on 10-State data were chosen as best for both barrows and gilts and for sows (tables 19 and 20).

Barrows and Gilts

Only 10-State data on sows farrowing are published in *Hogs and Pigs* for the pig crop of interest here. Hence, this variable, along with a time trend to allow for increasing pigs per litter, was used with data on inventories of young pigs weighing under 60 pounds. For all States, however, the report shows pigs per litter based on a weighted trend projection by State and on the implied pig crop. This published projection of the pig crop was used for the analysis based on data for all States. For the 10-State data, farrowings relate to the quarter beginning in the month of the report; for all States, the pig crop relates to a similar 6-month period.

Variation explained for these analyses ranged from 89 to 94 percent. Sows farrowing was the only inventory variable entering with a correct sign. The coefficient on this variable was statistically significant in two of the three quarter analyses. Time entered with a statistically significant effect in the third quarter. The hog-corn price ratio for the quarter following publication of the report was statistically significant for all quarters. The predicted slaughter for all quarters was expected to be within 1.6 million head or less of the actual slaughter 95 percent of the time.

Sows

For the near quarter, the percentage of variation explained was less for sows than for barrows and gilts. The range was 45 to 84 percent. The hog-corn price ratio based on data for the quarter following that in which *Hogs and Pigs* is released had a statistically significant effect in the January-March and April-June quarters. Sows farrowing for the corresponding quarter had a similar effect for the July-September quarter. Only these variables came in with signs consistent with expectations that had a statistically significant effect. Predicted slaughter was expected to be within 300,000 head of the actual slaughter 95 percent of the time.

Average Errors in Slaughter Numbers from the Several Approaches

Table 21 shows average absolute errors for the several sets of analyses for the near and far quarters, based on 1964-71. As previously noted, far-quarter analyses were not run for October-December. Data relating to barrows and

Table 19—Barrows and gilts for far quarter: Regression analyses for numbers slaughtered based on data for 10 Corn Belt States

Quarter	R^2	S.E.	Inter-cept	Partial regression coefficient for variable specified[1]		
				Sows farrowing[2]	Time	Hog-corn price ratio[2]
		1,000 head				
Jan.-Mar.	0.94	530	9,016	6.14 (1.11)	–	-157.4 (57.8)
Apr.-June	.94	637	-10,313	10.56 (3.99)	180.7 (222.7)	-139.8 (68.7)
July-Sept.	.89	770	-31,069	1.89 (1.44)	678.6 (107.3)	-211.7 (104.2)

Note: – = variable that does not enter the equation.

[1] Numbers in parentheses are standard errors of the regression coefficients.

[2] For the quarter following that in which (40) was released.

Table 20—Sows for far quarter: Regression analyses for numbers slaughtered based on data for 10 Corn Belt States

Quarter	R^2	S.E.	Inter-cept	Partial regression coefficient for variable specified[1]				
				Sows farrowing[2]	Breeding stock kept	Hog-corn price ratio[2]	Dummy variable	Corn production
		1,000 head						
Jan.-Mar.	0.84	68	1,157	0.165 (.149)	–	–23.42 (8.48)	–5.2 (55.0)	–
Apr.-June	.45	128	2,987	–	–.158 (.180)	–26.85 (13.17)	–	–
July-Sept.	.61	161	–22	.747 (.273)	–	–	–	[3]–169.8 (211.0)

Note: – = variable that does not enter the equation.
[1] Numbers in parentheses are standard errors of the regression coefficients.
[2] For quarter following that in which the report was released.
[3] Based on (43).

gilts for all States were available for the full period used for other analyses in only one of the four annual *Hogs and Pigs* reports.

Errors for the near quarter were at a minimum, based on the sum-of-the-months method for July-September and October-December for barrows and gilts. These errors equaled those for the direct approach based on 10-State data for April-June. For sows, the monthly approach was best only for January-March. Minimums in other quarters for sows occurred in the direct approach based on 10-State data for April-June and October-December and for all States for July-September. For barrows and gilts, the minimum for January-March (the only quarter for which a comparison was available) occurred in the similar approach based on data for 10 States. For the far quarter, the direct approach for both barrows and gilts and sows based on data for 10 States was chosen as best for all quarters, although the difference in April-June for sows was small. Here, an alternative approach was available in only one quarter. In all cases, errors for the best method for the near quarter were smaller than for the best method for the far quarter, although the difference in January-March for barrows and gilts was negligible.

Adjustments for Converting Calculated Liveweight Slaughter to 48-State Total

When calculations of estimated liveweight slaughter were completed, a discovery was made. Average weights per head as used in the analyses times number slaughtered, when combined for barrows and gilts and for sows, did not equal total commercial liveweight slaughter. Three factors may have been involved: (1) Average weights per head were based on eight (now seven) markets, (2) proportions between numbers of barrows and gilts and sows for federally inspected plants were assumed to apply to total commercial slaughter, and (3) small numbers of stags and boars are slaughtered. Hence, scatter diagrams were prepared for each month and quarter showing the relations between acutal commercial liveweight slaughter and a calculated value based on the four dependent variables used in the four sets of statistical analyses. Freehand lines were fitted through the means for these variables, and estimates were made of the respective regression equations.

The estimated equations are shown below. Y is commercial liveweight slaughter for the 48 States. X is a calculation based on (1) estimated number of barrows and gilts slaughtered commercially times the average weight of these in eight (now seven) markets plus (2) estimated number of sows slaughtered commercially times the average weight of these in eight markets.

Table 21.–Barrows and gilts and sows for near and far quarters: Average absolute errors for numbers slaughtered as estimated by alternative methods[1]

Quarter	Near quarter based on–			Far quarter: Direct from data for–	
	Sum of months	Direct from data for–			
		10 Corn Belt States	All States	10 Corn Belt States	All States
	1,000 head				
Barrows and gilts:					
Jan.-Mar.	502	360	389	361	–
Apr.-June	176	176	–	[2]391	363
July-Sept.	347	493	–	481	–
Oct.-Dec.	423	586	–	–	–
Sows:					
Jan.-Mar.	34	39	41	40	–
Apr.-June	90	68	–	87	90
July-Sept.	100	138	93	115	–
Oct.-Dec.	53	43	–	–	–

Note: – = variable that does not enter the equation.

[1] Based on data for 1964-71. Best methods for each set (that is, for near or far quarter) are underlined.

[2] Although the average absolute error is larger based on data for the 10 States, the greatest individual errors were much larger based on data for all States. Hence, the 10-State analysis was chosen as best. This choice was confirmed by the relative standard errors of estimate for the respective analyses.

Period	*Equation*
January	$Y = 11 + 0.96\ X$
February	$Y = -65 + 1.01\ X$
March	$Y = -11 + .98\ X$
April	$Y = -8 + .97\ X$
May	$Y = -48 + .99\ X$
June	$Y = 6 + .96\ X$
July	$Y = -6 + .98\ X$
August	$Y = 151 + .89\ X$
September	$Y = 232 + .84\ X$
October	$Y = 39 + .96\ X$
November	$Y = 20 + .96\ X$
December	$Y = -40 + .99\ X$
January-March	$Y = 115 + .95\ X$
April-June	$Y = -17 + .97\ X$
July-September	$Y = 416 + .89\ X$
October-December	$Y = -187 + 1.006\ X$

Probable Magnitude of Commercial Liveweight Hog Slaughter and Errors in Predicting Future Pork Belly Production Based on Best Methods

Calculated values for live weight slaughtered were obtained by multiplying calculated weights per head by calculated numbers slaughtered for barrows and gilts and sows, summing the products, and adjusting the totals by the equations discussed in the preceding section. In each case, the previously chosen "best" analysis was used for slaughter numbers. If this analysis was based on monthly data, numbers were multiplied by calculated monthly weights per head. If the analysis related directly to quarterly data, numbers were multiplied by calculated quarterly weights per head.

Two measures of reliability were used. One related to average absolute errors over the 1964-71 test period. These are shown in table 22 both in million pounds and as a percentage of the totals to which they relate. The other measure of reliability relates to Theil's inequality coefficients (see pp. 22-23). The actual commercial liveweight hog slaughter in the quarter in which *Hogs and Pigs* was released was used as the base for both near- and far-quarter calculations of the Theil coefficients. These results also are shown in table 22. All Theil coefficients were less than 0.4.

Since pork belly production equaled 11.5 percent of liveweight commercial slaughter of hogs, all measures except average errors in million pounds were the same for bellies and hog slaughter. The largest average error for production of bellies based on the best analysis for each quarter was 14 million pounds for the near quarter and 11 million pounds for the far quarter. Errors were the same or slightly larger for the far quarter, when both were available.

Table 22–Liveweight slaughter of hogs and production of pork bellies: Measures of reliability of the "best" approaches

Quarter	Near quarter			Far quarter		
	Average absolute error		Theil coefficient[1]	Average absolute error		Theil coefficient[1]
	Actual[1]	Percentage		Actual[2]	Percentage	
	Million pounds	*Percent*		*Million pounds*	*Percent*	
Liveweight hog slaughter in–						
Jan.-Mar.	98	1.9	0.308	98	1.9	0.182
Apr.-June	65	1.4	.211	86	1.8	.130
July-Sept.	88	1.9	.379	86	1.9	.174
Oct.-Dec.	125	2.3	.159	–	–	–
Pork belly production in–						
Jan.-Mar.	11	–	–	11	–	–
Apr.-June	7	–	–	10	–	–
July-Sept.	10	–	–	10	–	–
Oct.-Dec.	14	–	–	–	–	–

Note: – = variable that does not enter the equation.

[1] Actual commercial liveweight hog slaughter in the quarter in which (40) was released served as the base.

[2] Average absolute errors in million pounds for 1964-71.

Lower Theil coefficients for the far quarter, despite larger absolute errors in some quarters, reflect the nature of these coefficients. They relate to errors as a ratio to the magnitude of actual change from a base. In far-quarter predictions, the denominator of the ratio increased more than the numerator.

NORMAL RELATIONS BETWEEN CASH AND FUTURES QUOTATIONS IN THE DELIVERY MONTH

Active trading in pork belly futures began with the July 1964 contract. For each of the currently traded contracts—February through August—comparisons were made between cash quotations for fresh and frozen bellies and the close for the futures on (1) the first business day of the delivery month, (2) the business day closest to the 15th of the delivery month, and (3) the last day of trading. The pattern of cash prices for the balance of the delivery month also was checked. Comparisons were made for each contract during 1964-71 for which the open interest just prior to the delivery month exceeded 50 contracts.

Relations appeared to stabilize fairly well from 1968 on. Variations in the differential between cash prices and futures occurred at times early in the delivery month when the trade was attempting to assess whether cash or futures were out of line. Quotations on the last day of trading occasionally appeared nonrepresentative in terms of differentials between cash and futures. An explanation of these apparent abnormalities is given in the footnotes to table 23, which shows these differentials. With these exceptions, differentials on the last day of trading were averaged over 1968-71. These were rounded slightly to obtain the assumed normal basis (futures minus cash) shown below for each contract. Spreads in 1972 differed considerably from the assumed level.

Futures tended to trade above cash for the February, March, and May contracts, suggesting higher quality standards for deliverable bellies than for those normally sold in cash markets. Futures tended to be below cash for fresh bellies in July and August, reflecting the fact that stored bellies normally are not carried much beyond September. Normal future-cash spreads from 1968 on were assumed to be:

February	3.45
March, May	2.70
July, August	−3.50

PREDICTIONS OF CASH AND FUTURES QUOTATIONS FOLLOWING EACH *HOGS AND PIGS* REPORT, SEPTEMBER 1967-MARCH 1972

Prediction of Cash Prices

In this section, an attempt is made to determine how accurately cash prices can be estimated from information given in each *Hogs and Pigs* report and related information known at the time. Sources of error are also measured. To simplify the analysis, certain variables were assumed to be known. Sources of error due to prediction of these variables could be measured in the same way as were sources due to certain other factors relating directly to the hog economy if exact prediction formulas were available. The variables assumed to be known and possible sources of predictions are discussed below.

1.—*First-of-quarter stocks of bellies for near-quarter predictions*—The *Hogs and Pigs* report is issued around the 21st of the month. Data on total U.S. stocks for the beginning of a month are published around the 15th of that month. Data on stocks at the Chicago Merchantile Exchange are published daily. Information on stocks at other Exchange-approved warehouses are published weekly in the *Daily Information Bulletin* of the Chicago Merchantile Exchange. It was assumed that the required 10-day projection and blow-up to a U.S. total could be made accurately.

2.—*Personal disposable income for two quarters following the report*—The Wharton forecasts (see p. 7) are a possible source of personal disposable income. These are made for up to 18 months ahead.

3.—*Consumption of shell eggs for two quarters ahead*—Methods for a one-quarter prediction are given in Roy and Johnson (32). Forecasts for the second quarter could probably be based partly on factors used by Roy and Johnson and on the forecaster's judgment.

4.—*Population for two quarters ahead for models based on per capita data*—These projections are available from (33).

5.—*Prices of hogs and corn required for projections of pork belly production*—Models relating to hog prices that depend chiefly on information in the *Hogs and Pigs* report are discussed in Foote and Sadler (8). Forecasts are available from

Table 23—Differentials between cash prices for fresh pork bellies weighing 12-14 pounds and closing futures quotations on specified dates in the delivery month

Contract and date	Futures minus cash in—							
	1964	1965	1966	1967	1968	1969	1970	1971
	Cents/pound							
February:								
First of month			0.68	1.48	1.90	2.88	2.93	-0.15
Midmonth	[1]	[1]	.35	1.35	1.74	3.46	4.35	3.45
Last day of trading			.43	1.73	3.38	2.90	3.00 to 3.75	4.12
March:								
First of month		2.25	1.00	2.10	1.29	2.55	2.25	4.60
Midmonth	[1]	2.27	-.45	1.70	1.95	2.92	3.82	4.44
Last day of trading		1.82	1.60	1.08	1.90	3.06	2.42	3.65
May:								
First of month		1.70	1.58	2.56	2.16	2.80	2.33	2.65
Midmonth	[1]	.25	1.15	1.35	2.10	2.22	.14	3.98
Last day of trading		.86	-.30 to 2.00	-.30 to .75	[2] .32	1.70	[2] -.18 to 1.00	3.67
July:								
First of month	-3.00	-2.26	-4.18	-2.70	-2.89	-2.30	-4.00	-1.01
Midmonth	-1.50	-2.65	-.92	-3.65	-.78	-2.24	-4.25	-2.60
Last day of trading	-3.05	-.02	-.40	-1.45	-4.45	-3.55	[3] 2.08	-2.50
August:								
First of month	-.80	-.52	-5.90	-3.45	-2.88	-5.58	-1.64	-1.73
Midmonth	-.11	-2.85	-1.92	-3.10	-1.48	-5.53	-2.68	-2.47
Last day of trading	-1.75	-2.40	-1.95	-1.42	-4.43 to -3.75	[4] -1.10 to -.20	-3.52	-2.98

[1] Open interest was no more than 50 contracts.

[2] Cash prices declined steadily after the close, dropping by 3-1/2 to 4 cents from the level that prevailed on the last day of trading up to the end of the delivery month.

[3] Open interest was 1,530 contracts on the opening of the last day of trading. Futures were under cash 2 days prior to the close.

[4] Cash prices made a low for the month on the last day of trading. On that date, they were 4-1/4 cents below the midmonth quote and 5-1/2 cents below the level reached by the end of the month.

various other sources, including the *Livestock and Meat Situation*. Corn prices can be estimated fairly accurately by considering aspects of the price-support program for feed grains. Possible errors in forecasting hog slaughter due to errors in these predictions are discussed in (8).

6.- *Probable level of July estimate of corn crop as of late June*—This level would be based on (1) official reports of weather and crop conditions up to late June plus (2) allowance for any changes in acreage control programs announced after early March and possibly (3) private surveys of likely acreage planted as supplements to information in *Prospective Plantings.*

Likely errors in price predictions due to errors in projections of these variables are believed to be small relative to errors that we did allow for in this section, as shown below.

7.–*Errors in estimating pork belly production two quarters ahead based on the best equations (discussed on pp. 32-45)*– In these analyses, data on independent variables published in each *Hogs and Pigs* were used. Additionally, in some of the analyses, prices of hogs or corn for up to one quarter ahead were used. In others, based on data in the June *Hogs and Pigs*, the official July estimate of corn production was assumed to be known. Initial data on hog numbers published in the current issue of *Hogs and Pigs* in relation to the year of forecast were used each year.

8.–*Errors in estimating the size of three successive pig crops, given a correct estimate of belly production*–The models are based on data for all States. For issues of *Hogs and Pigs* with data only for 10 States, are made an estimate for all States. Also, quarterly pigs per litter had to be estimated from each report.

This all-State estimate was obtained as follows (using December 1971 and March 1972 reports to illustrate). In the December report, December-May farrowings for 1972 were projected at 90 percent of 1971 for all States and at 91 percent for the 10 Corn Belt States. All percentages of a year earlier for the 10 States in the March report were lowered by one percentage point to apply to all States. U.S. data for the preceding year, shown in the December 1971 *Hogs and Pigs*, were used as a base.

Pigs per litter were handled in the usual way based on the most recent U.S./10-State differential (see p. 63).

9.–*Errors in estimating stocks beyond the first of the quarter following the report*–Beginning stocks were needed for the far quarter and also for months other than the first in each near or far quarter. Beginning stocks for the far quarter were assumed to equal stocks at the end of the near quarter as predicted by the models. Given these and other data for the analyses, stocks at the end of the far quarter could be predicted from the models. The projected level of stocks at the beginning and end of each quarter was tabulated and interpolations made for intervening months based on seasonal patterns prior to the year for which the projection was being made.

10.–*Errors due to the basic equations when all predetermined variables were at their actual levels*–Three sets of equations were used in these studies. The first were reduced-form equations from the best of the quarterly models. Based on Theil coefficients shown in tables 4 and 5, these models were built partly on both per capita data for January-March, July-September, and October-December and also on the model that used total data for April-June. The second set were the best of the first-round equations from the quarterly models; again, this choice was based on the coefficients in tables 4 and 5. These equations were based in part on per capita data for April-June, July-September, and October-December and on the model based only on total data for January-March. The third set were the best of the equations from the monthly models for the five contract-delivery months; the choice was based on Theil coefficients shown in table 13. These were first-round equations based on total data for February and first-round equations built in part on per capita data for the remaining months. These three sets are referred to as methods A, B, and C, respectively, in tables 24-28.

Prediction of Final Closes for Futures Contracts

Although these models and equations were not designed to predict prices for a single day, a decision was made to make this test based on the average closing range for the final day on which the contract was traded. The following additional sources of error had to be measured.

1.–*Errors due to differences in time periods*–Quarterly models apply to a quarterly average price and monthly equations to a monthly average price. The error quantified under this heading is the difference between the cash price on the closing day for the contract and the average actual cash price for the period covered by the price equations.

2.–*Errors due to a basis other than that assumed as normal*–The preceding major section listed "normal" differentials between futures quotations and cash prices over 1968-71. This column shows the average difference between the assumed basis and the actual basis at the close for the contract.

Summary of Results

Tables 24 and 25 show the relative magnitude of each error source for near and far quarters, respectively. The first column contains the average difference between (1) the predicted cash price based on initial estimates plus the assumed normal basis and (2) the actual closing range for each futures contract. All figures in these tables are sums of errors without regard to signs, divided by the number of observations. Remaining columns represent errors from each source. The sum of these columns by row is larger than the net error in the first column because some of the individual errors are offsetting.

Table 24--Near-quarter predictions for pork belly futures quotations, average of closing range: Sources of of error[1]

Contract (month) and Method[2]	Net error	Source of error: Errors in estimates for— Q	Pig crops given Q	S_t	Due to equation set	Difference in period	Assumed basis
	Cents/pound						
February:							
A	2.1	0.5	0.3	–	2.0	0.9	1.1
B	2.0	–	.4	–	2.0	.9	
C	2.6	–	.8	0.3	2.0	1.2	
March:							
A	3.3	.5	.3	–	2.0	1.5	1.3
B	2.9	–	.4	–	2.0	1.5	
C	2.1	–	.4	.4	2.4	.9	
May:							
A	3.0	.4	.5	–	1.7	.8	1.7
B	3.6	–	.6	–	2.0	.8	
C	4.9	–	.9	.2	3.2	.6	
July:							
A	2.5	2.2	.1	–	1.8	2.1	1.9
B	4.2	–	.9	–	1.0	2.1	
C	3.4	–	.8	–	1.8	1.1	
August:							
A	3.9	2.2	.1	–	1.8	.9	1.0
B	2.0	–	.9	–	1.0	.9	
C	3.4	–	.8	3.6	3.0	1.7	

Note: – = variable that does not enter the equation.

[1] Average absolute errors from each source for February 1968-May 1972 contracts. See text for exact definition of error sources.

[2] Methods:

A = Quarterly reduced-form equation

B = Quarterly first-round equation

C = Monthly first-round equation

1.—*Net error*—The range, on the average, was between 2 and 5 cents per pound for near-quarter predictions, and between 3 and 7 cents per pound for far-quarter predictions. Differences in the magnitude of the errors between contracts did not appear significant, but on the average the quarterly equations were superior to the monthly equations for the near-quarter predictions.

2.—*Errors due to faulty estimates of Q and the pig crops*—Q is involved only for method A; comparisons between methods should be made based on the sum of the two columns. This source of error contributed 1 to 2 cents to the overall error for the near quarter and 1 to 3 cents for the far quarter. Errors for the far quarter were considerably larger when based on reports for the 10 States (except in May) than when based on reports covering all States.

Table 25—Far-quarter predictions for pork belly futures quotations, average of closing range: Sources of error[1]

Contract (month) and method[2]	Net error	Source of error: Errors in estimates for— Q	Pig crops given Q	S_t	Due to equation set	Difference in period	Assumed basis
	Cents/pound						
February:							
A	5.2	0.9	2.2	1.5	2.0	0.9	
B	5.5	–	2.9	1.8	2.0	.9	1.1
C	6.2	–	3.2	1.8	2.0	1.2	
March:							
A	6.6	.9	2.2	1.5	2.0	1.5	
B	6.9	–	2.9	1.8	2.0	1.5	1.3
C	5.1	–	2.9	.4	2.4	.9	
May:							
A	3.0	.3	.5	1.0	1.7	.8	
B	3.8	–	.6	1.0	2.0	.8	1.7
C	5.0	–	1.0	1.0	3.2	.6	
July:							
A	7.0	2.4	.2	2.7	1.8	2.1	
B	6.4	–	2.4	3.4	1.0	2.1	1.9
C	5.9	–	1.8	3.8	1.8	1.1	
August:							
A	6.4	2.4	.2	2.7	1.8	.9	
B	5.3	–	2.4	3.4	1.0	.9	1.0
C	5.7	–	2.7	4.0	3.0	1.7	

Note: – variable that does not enter the equation.

[1] Average absolute errors from each source for February 1968-May 1972 contracts. See text for exact definition of error sources.

[2] Methods:

A = Quarterly reduced-form equation
B = Quarterly first-round equation
C = Monthly first-round equation

3.—*Errors due to faulty estimates of stocks*—Except for the August contract for method C, these errors were minor for near-quarter predictions. They contributed 1 to 4 cents to the errors in far-quarter predictions and are larger in July and August than in other months.

4.—*Errors due to the basic equations*—These errors were the same for near and far quarters because they are based on final values for all predetermined variables. On the average, they contributed 1 to 3 cents to the overall error.

5.—*Remaining error sources*—Each source contributed 1 to 2 cents on the average. The basis for individual years for some contracts differed greatly from the assumed normal.

SHORT-TERM PRICE ANALYSES FOR PORK BELLIES

Weekly Models

For certain commodities, a single major report is followed widely by the trade. The most widely used report relating to pork bellies is the *Daily Information Bulletin* issued by the Chicago Mercantile Exchange. In addition to futures quotations and volume and open-interest data for all commodities traded on the Exchange, a number of basic statistical series are also included. In 1972, these contained the following information for bellies: (1) Daily storage movement (in, out, and onhand) for 11 Chicago warehouses approved by the Exchange, (2) estimated national daily slaughter of hogs under Federal inspection and a cumulative figure for the week, and (3) sliced-bacon production under Federal inspection for a week ending 3 weeks earlier (usually reported on Monday). Total slaughter and slicings data for the preceding week are normally reported on Monday along with corresponding data for a week and a year earlier. Stocks for the preceding Thursday are also reported on Monday along with stocks for the corresponding date a year earlier. The slaughter estimate often undergoes considerable revision. However, revisions in the other figures are negligible, except for an occasional major revision in slicings issued a day or two after the initial report. Slicings data frequently are published later than Monday, sometimes by several days.

1.—*Variables used*—Regression analyses involving the following variables were run for data from the week ended October 4, 1969, through that ending February 19, 1972. Thus, two full and one partial October-September marketing year were covered. As discussed later, data for the full period and a number of subperiods were analysed. Considerable work is involved in compiling these data and this period was assumed to be long enough for a reasonable test of the approach. The following variables were used.

Dependent variables:

P_H — High for the nearby futures quotation on Tuesday through Friday of the current week in cents per pound.

P_L — Low for the nearby futures quotation in the same period in cents per pound.

Basic independent variables:

B — Bacon slicings for the latest week as published normally on Monday of the current week in million pounds.

St — Stocks of pork bellies on hand in Exchange-approved Chicago warehouses on Thursday of the preceding week in million pounds; this figure is normally published on Monday of the current week.

Sl — Federally inspected hog slaughter, total for the preceding week in 1,000 head; this figure is normally published on Monday of the current week.

P_F — The settlement price for the futures contract to which P_H and P_L relate as of Friday of the preceding week in cents per pound; this price is published in the report for Monday of the current week.

Lagged independent variables:

Let Δw refer to the change from the figure for a week earlier and Δy refer to the change from the figure for a year earlier. The lagged figure is that given in the report for the current Monday, if this figure is shown.

The following lagged variables were used:

ΔwB	ΔwSt	ΔwSl
ΔyB	ΔySt	ΔySl

Weeks in which a monthly *Cold Storage* report or a quarterly *Hogs and Pigs* report came out were eliminated from the initial calculations. Calculated values for the week in which the monthly *Cold Storage* report was issued were used later in special analyses.

Quotations for the nearby future were used through the week in which the 15th day of the delivery month fell, except when this day was a Sunday. In the latter case, the nearby future was used only through the preceding week. Since P_F related to the same contract as the dependent variables, no problem resulted from rolling forward into the following contract.

2.—*Basic Models*—

Model I — Variables as shown above.

Model II — St and Sl moved ahead 1 week on the assumption that the trade might anticipate the end-of-week data as they developed each day.

No clear-cut advantage in predictive ability was shown for one model versus the other. Of the eight final equations chosen, three are based on Model I and five on Model II.

3.–*Sample periods*–From late August into January, the nearby future relates to the following February. In other periods, contract months are spaced more closely. Also, during part of the total period, prices were rising sharply; in other parts, prices were declining or stable. The total period was divided into four subperiods (table 26).

Subperiods were used chiefly to determine whether the more homogeneous groups of data would provide improved results, as measured by smaller standard errors of estimate. If they did not do so, results from larger groupings were used. Regression analyses were run for the following groups: A, B, C, D, AD, BC, AB, CD, and all data.

4.–*Selection of variables for the final analyses for each set*–The first set of analyses included P_H or P_L as a function of B, ΔwB, ΔyB, St, ΔwSt, ΔySt, Sl, ΔwSl, ΔySl, and P_F. These were run as models I or II, depending on the way St and Sl and related variables were handled with respect to lags. For practically all these analyses, P_F alone accounted for over 95 percent of the variation in P_H or P_L. For this reason, a second set of analyses was run using as dependent variables $P_H - P_F$ or $P_L - P_F$ and including all independent variables shown above except P_F. Percentage of variation explained for most of these was reduced sharply, but the standard errors of estimate in many cases were nearly the same as before. The latter analyses are referred to as IΔ or IIΔ, respectively, because they reflect factors during the week that affect the change in price from the end of the preceding week.

Signs on regression coefficients for B and related variables were expected to be positive because once bacon is sliced it will move into consumption. Signs on coefficients for St (stocks) and Sl (slaughter) and related variables were expected to be negative since these relate to supply. "Wrong" signs were expected on some variables because of the relatively small samples for some analyses and the problems of multicollinearity. Following the initial run, variables with "wrong" signs were dropped, subject to the restriction that at least one variable from the following pairs should be retained: (B or ΔyB), (St or ΔyS), (Sl or ΔySl). After the second run, variables with wrong signs were dropped. Tables 27 to 30 show the highest-order partial correlation coefficients for variables that came in with "right" signs in the final analysis for each set. Each multiple correlation coefficient is shown also.

5.–*Choice and nature of final analyses*–The multiple correlation coefficients mostly were extremely high for models I and II and were relatively low for models IΔ and IIΔ because of the inclusion or exclusion of P_F. Thus, P_F was not judged to be a good criterion in choosing the final analyses. Instead, reliance was placed on the relative standard errors of estimate (table 31). Two decimals are shown when two were sufficient for choice, and when three decimals were required, these are shown. The analyses for subperiod B relating to highs indicate the basis for these choices. The best analysis for subperiod B had a standard error of estimate of 0.95 cent per pound. The best for AB was 0.93. The best for "all data" was 0.906. As a larger grouping was preferred over a smaller one, analysis I for the complete data set is recommended when highs for subperiod B are involved. For subperiod D analyses relating to lows, II was chosen over IIΔ because more variables came in with signs that were consistent with economic theory. Table 32 shows the analysis chosen for each subperiod.

All final analyses were checked for correlation of the successive residuals based on the Durbin-Watson test. Positive autocorrelation is the type most commonly observed in economic data. No evidence of autocorrelation was found

Table 26–Subperiods used for weekly models

Symbol	Designation	Ending dates covered	Number of observations
A	Rising prices, no nearby future	Oct. 4, 1969-Jan. 3, 1970 Aug. 28, 1971-Jan. 8, 1972	24
B	Rising prices, active nearby contract	Jan. 10-Feb. 14, 1970 Jan. 23-Aug. 21, 1971 Jan. 15-Feb. 19, 1972	31
C	Stable or falling prices, active nearby contract	Feb. 21-Aug. 15, 1970	18
D	Stable or falling prices, no nearby future	Aug. 22, 1970-Jan. 15, 1971	14

Table 27—Weekly analyses for pork belly prices based on model I: Highest-order partial correlation coefficients for final analyses for variables showing signs consistent with economic theory and the multiple correlation coefficient

Subperiod	Partial correlation coefficients on—										R
	B	ΔwB	ΔyB	St	ΔwSt	ΔySt	Sl	ΔwSl	ΔySl	P_F	
Analyses for highs (P_H):											
A[1]	–	–	0.16	–	–	−0.55	–	−0.23	–	0.84	0.995
B	–	0.05	–	−0.38	–	–	−0.05	–	–	.99	.995
C	–	.20	–	−.13	–	–	–	–	–	.97	.972
D	–	.27	–	–	–	−.35	−.17	–	–	.78	.984
AD	–	.19	–	–	−0.22	–	–	−0.10	–	.99	.993
BC	–	.13	–	−.35	–	–	–	–	–	.99	.996
AB	–	.09	–	−.12	−.06	−.20	−.002	−.07	–	.96	.995
CD	–	.23	–	−.11	–	−.25	−.14	–	–	.98	.995
All data[1]	–	.13	–	–	−.11	–	–	−.002	–	.99	.994
Analyses for lows (P_L):											
A	–	–	.12	−.20	–	−.56	–	−.28	–	.70	.994
B	–	–	.08	−.27	–	–	–	–	–	.97	.993
C	–	.47	–	–	.09	–	−.09	–	–	.90	.971
D	–	.60	–	−.34	–	–	–	–	–	.98	.991
AD	–	.10	–	–	−.24	–	–	−.20	–	.99	.992
BC	–	.01	.12	−.08	–	−.14	–	–	–	.96	.994
AB	–	–	.09	−.31	–	–	–	−.16	–	.97	.993
CD	–	.46	.05	−.27	–	−.20	–	–	–	.98	.994
All data	–	.04	.05	−.09	–	–	–	−.06	–	.98	.993

Note: – = variable that does not enter the equation.

[1] Used in final set of analyses.

Table 28.–Weekly analyses for pork belly prices based on model II: Highest-order partial correlation coefficients for final analyses for variables showing signs consistent with economic theory and the multiple correlation coefficient

Subperiod	Partial correlation coefficient on–										R
	B	ΔwB	ΔyB	St	ΔwSt	ΔySt	Sl	ΔwSl	ΔySl	P_F	
Analyses for highs (P_H):											
A	–	0.11	0.12	−0.22	−0.06	−0.47	−0.10	–	−0.15	0.73	0.995
B	–	–	–	–	–	−.38	–	−0.28	−.18	.94	.993
C	–	.33	–	–	−.20	–	–	–	−.49	.90	.976
D	–	.14	–	–	−.37	−.56	–	–	−.14	.52	.987
AD	–	.31	.06	–	−.13	–	–	–	−.30	.99	.994
BC	–	–	–	−.12	–	−.20	–	−.19	−.21	.95	.994
AB	–	.04	–	−.10	−.02	−.24	–	−.12	−.16	.93	.993
CD	0.01	.28	–	–	−.05	−.12	–	–	−.29	.95	.994
All data	–	.08	–	–	−.02	−.09	–	−.02	−.21	.95	.993
Analyses for lows (P_L):											
A[1]	–	–	–	−.31	–	−.57	−.36	–	–	.62	.993
B	–	–	.07	–	–	−.33	–	–	−.23	.93	.993
C	–	.39	.17	–	−.04	–	–	–	−.41	.86	.975
D[1]	–	.29	.08	–	−.34	−.60	–	–	−.48	.75	.994
AD	–	.17	.04	−.004	−.18	−.04	–	−.03	−.18	.96	.993
BC	–	–	.16	–	–	−.25	–	–	−.25	.95	.994
AB	–	–	.09	−.18	–	−.16	–	–	−.17	.93	.993
CD[1]	–	.42	.17	−.18	–	−.17	–	–	−.32	.97	.995
All data[1]	–	.01	.11	−.06	–	−.10	–	–	−.25	.95	.993

Note: – = variable that does not enter the equation.
[1] Used in final set of analyses.

Table 29 · Weekly analyses for pork belly prices based on model IΔ: Highest-order partial correlation coefficients for final analyses for variables showing signs consistent with economic theory and the multiple correlation coefficient

Subperiod	Partial correlation coefficient on–									R
	B	ΔwB	ΔyB	St	ΔwSt	ΔySt	SI	ΔwSI	ΔySI	
Analyses for highs (P_H):										
A	–	0.18		–	–	−0.15	–	−0.19	–	0.403
B	–	.05	–	−0.43	·	–	–	–	–	.434
C	0.24	.06	–	−.05	–	–	–	–	–	.336
D		.46	–	–	–	−.42	–	–	–	.521
AD		.21	–	–	−0.15	–	–	−.08	−0.30	.421
BC		.11	·	−.31	−.04	–	–	–	–	.325
AB	–	.06	0.09	−.10	−.05	−.11	–	−.08	–	.356
CD[1]		.22	–	−.09	–	−.33	−0.14	–	–	.466
All data	–	.15	–	−.08	−.09	–	–	–	–	.195
Analyses for lows (P_L):										
A	–	.05	–	–	–	–	–	−.23	–	.289
B	.05	–	–	–	–	–	–	–	–	.052
C	–	.41	.06	−.02	–	–	−.02	–	–	.466
D	–	.54	–	−.11	–	−.24	–	–	–	.707
AD	–	.10	–	–	−.24	–	–	−.20	–	.341
BC	–	–	.28	−.04	–	−.01	–	–	–	.304
AB	–	–	.26	−.13	–	–	–	−.11	–	.278
CD	–	.46	.02	−.26	–	−.29	–	–	–	.493
All data	–	.01	.18	−.02	–	–	–	−.06	–	.202

Note: – = variable that does not enter the equation.

[1] Used in final set of analyses.

Table 30—Weekly analyses for pork belly prices based on model IIΔ: Highest-order partial correlation coefficients for final analyses for variables showing signs consistent with economic theory and the multiple correlation coefficient

Subperiod	Partial correlation coefficient on—									R
	B	ΔwB	ΔyB	St	ΔwSt	ΔySt	SI	ΔwSI	ΔySI	
Analyses for highs (P_H):										
A	–	0.24	0.11	–	−0.11	−0.16	–	−0.01	−0.13	0.417
B	0.02		–	−0.15	−.01	–	–	−.24	–	.273
C	–	.34	–	–	−.36	–	–	–	−.49	.560
D[1]		.46	–	–	–	−.45	–	–	–	.535
AD		.33	.04	–	−.12	–	–	–	−.37	.532
BC	.001	–		–	−.05	−.06	–	−.19	−.04	.235
AB	–	.04	.02	–	−.08	−.14	–	−.10	–	.205
CD	.06	.27	–	–	−.08	−.11	–	–	−.31	.560
All data	–	.09	–	–	−.07	–	–	−.04	−.20	.256
Analyses for lows (P_L):										
A	–	–	.15	–	−.04	–	−0.09	–	–	.244
B	–	–	.32	−.08	–	–	–	−.06	–	.332
C	–	.43	.18	–	−.12	–	–	–	−.41	.594
D	–	.58	.12	–	–	−.53	–	–	−.32	.759
AD	–	.19	.09	–	−.21	–	–	−.05	−.13	.353
BC	–	–	.29	–	–	−.02	–	−.03	−.09	.318
AB	–	–	.23	−.11	–	–	–	–	−.01	.252
CD	–	.46	.19	−.24	–	−.11	–	−.01	−.28	.555
All data			.22	–	–	–	–	−.02	−.13	.231

Note: = variable that does not enter the equation.

[1] Used in final set of analyses.

Table 31 –Weekly analyses relating to pork belly prices: Standard errors of estimate from final analyses within each set[1]

Subperiod	High				Low			
	I	II	IΔ	IIΔ	I	II	IΔ	IIΔ
	Cents per pound							
A	0.72	0.83	0.84	0.90	0.84	0.831	0.99	1.03
B	.98	1.18	.95	1.26	1.10	1.08	1.18	1.15
C	.87	.87	.86	.84	.97	.93	.98	.89
D	.60	.57	.563	.557	.44	.421	.43	.421
AD	.82	.79	.83	.78	.85	.89	.834	.86
BC	.906	1.08	.92	1.14	1.07	1.02	1.07	1.07
AB	.93	1.08	.93	1.11	1.03	1.04	1.07	1.08
CD (Use for C)	.76	.79	.75	.78	.76	.73	.74	.74
All data (Use for B)	.906	1.01	.909	1.00	.99	.97	.99	.99

[1] Chosen analyses are underlined.

for any of these analyses. Inconclusive results for positive or negative autocorrelation were noted for four of the eight analyses; for the remainder, the test showed no evidence of autocorrelation.

Certain variables came into these analyses with t-ratios that were statistically significant at at least the 5-percent level (based on a one-tailed test). These variables were: ΔwB for subperiod C based on lows; ΔySt for subperiod A for both highs and lows, for subperiod C based on highs, and for subperiod D based on lows; and ΔySl for subperiod B based on lows. For models I and II, $P_{F'}$ was significant for all analyses.

Table 33 shows the regression coefficients and the constant term for each of the final analyses.

Analyses Measuring Effects of Monthly *Cold Storage* Report on Price

The trade follows closely changes in stocks of pork bellies in Chicago warehouses and, to a lesser extent, changes in other warehouses certified for delivery on futures contracts. Figures for Chicago are available daily. Data for "out-

Table 32–Weekly analyses chosen best for each subperiod

Subperiod	High		Low	
	Analysis	Based on–	Analysis	Based on–
A	I	A	II	A
B	I	All data	II	All data
C	IΔ	CD	II	CD
D	IIΔ	D	II	D

Table 33 - Weekly analyses relating to pork belly prices: Regression coefficients and constant terms from final analyses for each subperiod

Coefficient	High				Low			
	A	B	C[1]	D[1]	A	B	C	D
Regression coefficient on–								
ΔwB		0.04415	0.07766	0.1091	–	0.003741	0.1544	0.05644
ΔyB	.04846	–	–	–	–	.04915	.06385	.01180
St	–	–	-.009324	–	-0.05642	-.004558	-.01601	–
ΔwSt	–	-.05701	–	–	–	–	–	-.1640
ΔySt	-.1949	–	-.04409	-.04937	-.2375	-.01348	-.02611	-.1562
Sl	–	–	-.000748	–	-.002086	–	–	–
ΔwSl	-.000817	-.000010	–	–	–	–	–	–
ΔySl	–	–	–	–	–	-.001958	-.002230	-.001546
P_F	.72014	1.0201	–	–	.50764	.93106	.96340	.67671
Constant	13.20	.09	1.52	.18	24.10	1.86	.68	9.43

Note: – = variable that does not enter the equation.
[1] Value of P_F must be added to estimate a price level.

side" warehouses are published once a week. Stocks at Chicago were used for detailed analysis because they are regularly published in the *Daily Information Bulletin.* Data on the outside warehouses have been published from time to time in this bulletin but were not carried regularly throughout the period we analyzed. The monthly *Cold Storage* report relating to total stocks in the United States affects the market chiefly when its figures differ from the prediction based on previously published information.

1. - *Variables used*–The following variables were used in these analyses:

Dependent variables:

$(P_H - P_R)$ was the high for the nearby future in cents per pound over the 3 days following release of *Cold Storage* less the settlement price on the day preceding the report for those months in which ΔmM was less than ΔmC (defined below).

$(P_L - P_R)$ was the low for the nearby future in cents per pound over the 3 days following release of *Cold Storage* less the settlement price on the day preceding the report for those months in which ΔmM was larger than ΔmC.

If ΔmM was within two percentage points of ΔmC, no computation was made and data for that month were omitted from the analysis.

Independent variables:

ΔmM was the ratio of stocks at the end of the preceding month to stocks at the end of the month 2 months earlier published in the *Cold Storage* issue released during the current month.

ΔyM was the ratio of stocks at the end of the preceding month to stocks a year earlier published in the *Cold Storage* issue released during the current month. Ratios that exceeded 2.0 were reduced to 2.0; ratios for small numbers can become very large.

ΔmC was the ratio of stocks at Chicago warehouses approved by the Chicago Mercantile Exchange at the end of the preceding month to stocks at the end of the month 2 months earlier. At times, this comparison is shown in the *Bulletin* just prior to the release of *Cold Storage*. At other times, the reader must determine the comparison by examining the report issued a month earlier.

$(\hat{P}_H - P_R)$ or $(\hat{P}_L - P_R)$ were calculated highs $(\hat{P}_H)$ or lows $(\hat{P}_L)$ in cents per pound from the weekly price analyses for the week in which *Cold Storage* is released less the settlement price on the day preceding release of the monthly report. $(\hat{P}_H - P_R)$ was used with $(P_H - P_R)$; $(\hat{P}_L - P_R)$ was used with $(P_L - P_R)$.

Futures contracts in each case were based on the same rules as for weekly analyses.

2. *Selection of variables for the final analyses* Analyses were run initially with $(P_H - P_R)$ or $(P_L - P_R)$ as a function of ΔmM, ΔyM, ΔmC, and $(\hat{P}_H - P_R)$ or $(\hat{P}_L - P_R)$. Analyses were run separately for the highs, the lows, and the highs and lows combined, because expectations about signs on the several independent variables were the same for highs and lows. Twelve observations were available for highs and 13 for lows over release dates from October 1969 through March 1972. During this period, 5 months were omitted because ΔmM and ΔmC were nearly the same.

The regression coefficient on $(\hat{P}_H - P_R)$ and $(\hat{P}_L - P_R)$, whichever was used, was expected to be positive because this expectation reflected the influence of factors other than the monthly stock report on price. Coefficients on ΔmM and ΔyM were expected to be negative. However, the coefficient on ΔyM was positive for all initial analyses. ΔyM was dropped, based on the reasoning that this variable was probably already in P_R and hence should have had little effect on the dependent variables used. Standard errors of estimate were nearly the same with or without ΔyM. The coefficient on ΔmC was expected to be positive for somewhat complex reasons. At least in part, ΔmC reflects knowledge of the change in stocks over the past month which the trade would have prior to release of the monthly report. For any given small change in ΔmM shown in that report, the trade could have expected a large increase (a ratio greater than one). If so, the given change would trend to advance the price sharply. Or if the trade had expected a large decrease (a ratio of less than one), the given change would tend to cause a sharp drop in price. Thus, increases in price, other things being equal, would be associated with ratios greater than one for ΔmC, and decreases in price, with ratios of less than one. The same reasoning can be applied to changes of any given magnitude for ΔmM. These two variables could have been brought into the initial analyses in the form $(\Delta mM - \Delta mC)$, thus forcing a common coefficient of opposite sign for the two variables. However, a given percentage change in ΔmM could have had a larger influence, as this variable relates to the United States, whereas ΔmC relates only to Chicago. If this reasoning is correct, the coefficient on ΔmM should exceed that on ΔmC. However, for the analysis based on highs, the coefficient on ΔmM was -0.45 while that on ΔmC was 0.92. For the other two analyses, the coefficients, except for sign, were nearly identical. For both the highs and lows, the simple coefficient of determination between ΔmM and ΔmC exceeded 0.94, making it difficult to measure their separate effects. For this reason, idependent variables used in each final analysis were $(\Delta mM - \Delta mC)$ and either $(\hat{P}_H - P_R)$ or $(\hat{P}_L - P_R)$. Standard errors of estimate when ΔmM and ΔmC came in separately were somewhat larger than when their difference was used as a single variable.

3. *Coefficients for the final eqr ıtions*–Regression and related coefficients for each of the three final equations are shown in table 34. Differences of coefficients for the analyses relating to highs or lows from the difference for the analysis based on both were not statistically significant. Thus, the analysis for both can be used. The F-ratio relating to the variation explained by the analysis was significant at the 1-percent point, and the t-ratio for $(\Delta mM - \Delta mC)$ also was sig-

Table 34–Analyses relating to prices following the monthly *Cold Storage* report: Regression coefficients and related variables for each analysis

Coefficients	Analyses based on–		
	Highs	Lows	All data
Partial regressions on–			
$(\hat{P}_H - P_R)$ or $(\hat{P}_L - P_R)$	0.1200	0.1636	0.2001
$(\Delta mM - \Delta mC)$	−1.585	−1.683	−2.045
Constant	−.09	−.36	−.24
Standard error of estimate	.57	.88	.70
Multiple correlation	.43	.35	.62

nificant at this level. Magnitudes of both regression coefficients appeared reasonable. The coefficient on ($\Delta mM - \Delta mC$) suggested that for every discrepancy of one percentage point between these two estimates of stock changes, prices of pork bellies will change about 2 percent in the opposite direction. The Durbin-Watson test for this analysis showed no evidence of serial correlation in the residuals.

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APPENDIX

Sources and computations involved in obtaining the data are discussed below.

As previously mentioned, Q is computed by taking 11.5 percent of total commercial liveweight slaughter of hogs in million pounds. Pertinent data are published monthly in *Livestock Slaughter* (41). Revised data for the preceding year are given in a report issued in April entitled *Livestock Slaughter and Meat Production Annual Summary* (42). Historic data appear in the annual supplements to *Livestock and Meat Statistics* (32, table 141).

Data on S are published in the monthly report *Cold Storage* (37). Revisions for the preceding month frequently are carried in the current issue. Historic data are shown in the Chicago Merchantile Exchange *Year Book* (3). As published initially, data apply to the end of each month but frequently are labeled in tabulations as applying to the first of the following month.

C is computed from data for Q and S by use of equation (1).

Data for P are available currently from the *National Provisioner* (18) or a half-page summary of "Spot Commodities" prices given in the daily New York Journal of Commerce (14). Daily prices for three weight classes for Fresh or FFA bellies and frozen bellies for the current calendar year are published in the Exchange year books (3). The series used in this report was obtained from a meatpacker and is based on averages of Wednesday quotations for each month.

Quarterly data on I are available currently from the *Survey of Current Business* (44, p. S-2). Historic data on a total basis came from a *Working Data for Demand Analysis* (36, p. 11); figures are shown on both a total and a per capita basis. As mentioned previously, per capita data used in the models discussed here differ slightly from the official series because of a different population divisor.

Historic data for E on a per capita basis are shown by quarter for 1960-71 in the *Poultry and Egg Situation* for June 1972 (34, table 4) and for 1949-59 in *Selected Statistical Series for Poultry and Eggs Through 1968* (35, table 16). Nearly comparable monthly data on a total basis (1,000 cases) are shown in a table entitled "selected poultry and egg statistics" in each issue of the *Poultry and Egg Situation*. Revised quarterly per capita data are carried annually in the June issue of this publication. Per capita data were converted to a total basis by multiplying by the population eating from civilian food supplies. This series for specified dates within each year, with projections for a year or more in advance, can be obtained from *Population Estimates for Per Capita Series* (33).

Data on F are published currently in the June and December issues of *Hogs and Pigs* (40). Data for the 10 Corn Belt States appear in all four quarterly issues. The 10-State data in the March and September reports can be converted to a U.S. total based on relations between the two series in the June and December reports or by other methods. Historic data are given in *Livestock and Meat Statistics* (32, table 26).

Data on L for the United States are published only for December-May and June-November. For the 10 States, however, data from 1963 to date are available for all four quarters. Data sources for L are the same as for F except that the 10-State data historically came from (32, table 32).

For 1963 to date, the following procedures were used: (1) Pigs per litter for the 10 States were computed for December-May and June-November by dividing the pig crops for these periods by the number of sows farrowing. (2) Pigs per litter for the United States for the comparable periods were compared with those for the 10 States. For example, for December-May 1971, the published U.S. figure was 7.19 pigs and the computed 10-State figure was 7.15, obtained from data in the December 1971 *Hogs and Pigs*. (3) The U.S. figure by quarter was found by adding the difference--0.04--to the 10-State quarterly figures of 6.99 for December-May and 7.25 for March-May.

Prior to 1963, 10-State data by quarter were not available. Differentials of the quarterly figures from the respective 6-month figures were tabulated for each year from 1963 through 1970. The pattern appeared to be somewhat different for 1967-70 than for 1963-66. For this reason, 1963-66 average differentials were applied to the published 6-month figures for the United States before 1963 to obtain quarterly data for use in the earlier years.

Substantial revisions of previously published figures frequently are made in *Hogs and Pigs*. After each census of agriculture, revisions for the previous 5 years are published, if need be. For purposes of fitting the models in this report, latest available revisions at the time the analyses were run were used.

Published projections of $\overset{*}{L}$ were compiled from the June and December issues of *Hogs and Pigs* or the *Pig Crop Report* for earlier years. The published projection for each 6-month period was compared with the reported actual for the preceding year in each report. The difference was added algebraically to the revised corresponding quarterly figure for the preceding year to obtain revised quarterly projections for use in the study.

Since some of these series were derived for this report and others were available historically only in the Mercantile Exchange year books, all series that were not easily obtainable from official sources—except bacon slicings—are shown on a monthly or quarterly basis from 1957 to date in the following tables.

Appendix table 1—Pork bellies: Estimated production, 48 States, 1957-72[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Million pounds											
1957	185	159	170	161	162	137	139	139	152	187	174	178
1958	180	142	153	161	148	142	143	141	162	185	171	191
1959	192	180	183	184	165	165	170	158	183	210	205	225
1960	210	185	194	179	179	170	144	169	167	174	187	188
1961	186	162	192	163	184	171	144	165	164	195	202	186
1962	196	169	195	181	188	168	156	169	151	211	205	193
1963	205	178	202	199	190	160	163	165	183	213	205	215
1964	223	186	201	205	178	169	164	157	178	216	210	214
1965	193	165	202	183	153	154	142	149	171	172	177	162
1966	154	148	184	172	163	157	139	163	183	191	202	204
1967	204	180	208	186	174	170	155	185	192	212	209	200
1968	208	179	192	203	204	165	173	182	193	228	207	209
1969	211	188	202	205	185	174	176	170	195	215	181	199
1970	189	165	191	203	180	176	177	180	208	229	226	245
1971	226	189	243	231	209	214	188	203	217	213	229	230
1972[2]	192	184	229	198	203	191	157					

[1] Computed by multiplying total commercial slaughter of hogs on a liveweight basis, as published in (41), by 0.115.
[2] Preliminary.

Appendix table 2—Pork bellies: Stocks in cold storage, as of first of the month, 48 States, 1957-72[1]

Year	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Million pounds											
1957	[2]	64.3	78.8	92.5	95.5	91.9	69.4	37.7	19.4	9.8	14.4	24.1
1958	44.2	59.3	74.0	83.6	89.6	85.0	62.7	37.7	19.8	9.9	12.6	30.2
1959	45.9	54.8	86.3	113.7	127.4	121.2	97.3	65.7	38.8	22.5	25.5	42.4
1960	73.0	92.5	108.4	115.8	132.0	130.7	113.3	75.6	44.7	18.8	15.8	20.7
1961	33.5	43.0	58.9	74.8	78.1	80.0	64.8	33.8	11.7	5.6	7.2	22.8
1962	39.4	44.4	61.0	84.6	99.4	109.5	91.4	61.6	34.5	12.5	15.9	35.1
1963	57.8	64.2	73.3	103.4	119.9	112.4	94.8	65.9	36.8	22.1	23.1	38.5
1964	60.8	84.2	113.7	139.5	156.6	154.8	133.2	86.3	46.5	22.2	34.0	54.2
1965	74.6	84.6	97.9	113.8	120.9	103.1	73.5	40.9	21.6	8.8	9.0	16.2
1966	25.3	29.5	38.5	48.8	62.7	65.8	47.7	27.0	12.5	7.0	9.3	19.8
1967	44.9	50.2	67.8	91.8	108.5	100.5	89.0	60.6	33.3	20.8	32.1	48.8
1968	68.9	66.7	77.2	91.9	115.7	128.3	102.9	59.5	27.4	15.8	20.1	33.8
1969	49.1	46.7	56.2	76.0	96.2	96.7	84.3	46.8	21.7	12.2	19.6	26.1
1970	38.7	37.0	47.1	61.1	74.0	82.1	67.3	39.3	20.4	9.8	21.2	42.1
1971	76.4	82.8	84.5	113.5	131.3	146.1	140.8	107.0	71.5	51.5	53.9	68.9
1972	86.3	84.2	87.9	107.5	130.9	133.0	105.6					

[1] Current source: (37, table 1, section on meats). End-of-month stocks as shown in that report are assumed to apply to the first of the following month.

[2] Not available prior to January 31, 1957.

Appendix table 3—Pork bellies: Derived consumption, 48 States, 1957-72[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Million pounds											
1957	[2]	145	156	158	166	160	171	157	162	182	164	158
1958	165	127	143	155	153	164	168	159	172	182	153	175
1959	183	149	156	170	171	189	202	185	200	207	188	194
1960	191	169	187	163	180	187	182	200	193	177	182	175
1961	177	146	176	160	182	186	175	187	170	193	186	169
1962	191	152	171	166	178	186	186	196	173	208	186	170
1963	199	169	172	183	198	178	192	194	198	212	190	193
1964	200	156	175	188	180	191	211	197	202	204	190	194
1965	183	152	186	176	171	184	175	168	184	172	170	153
1966	150	139	174	158	160	175	160	178	188	189	192	179
1967	199	162	184	169	182	182	183	212	205	201	192	180
1968	210	169	177	179	191	190	216	214	205	224	193	193
1969	214	179	182	185	185	186	214	195	205	208	175	186
1970	191	155	177	190	172	191	205	199	219	218	205	208
1971	220	187	214	211	194	224	220	238	237	211	214	213
1972[3]	194	180	209	175	201	218						

[1] Computed by adjusting production as shown in app. table 1 by changes in stocks as shown in app. table 2.

[2] Not available prior to January 31, 1957.

[3] Preliminary.

Appendix table 4 -Pork bellies: Price of fresh or FFA, 12-14 pounds, at Chicago[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						Cents per pound						
1957	31.1	28.2	29.9	32.3	34.8	38.4	42.4	41.1	36.8	29.2	29.0	31.8
1958	34.6	34.8	35.2	37.0	38.3	40.5	43.0	39.3	38.6	29.4	28.5	28.4
1959	26.5	24.6	26.1	27.6	26.8	26.6	24.2	22.5	19.6	17.5	15.9	16.2
1960	19.3	19.4	24.2	28.2	27.2	27.8	30.2	28.0	27.3	26.4	27.2	28.0
1961	30.5	30.4	28.5	28.7	28.6	29.2	31.9	33.8	35.4	27.8	24.5	25.0
1962	26.6	26.4	26.4	26.9	27.0	29.3	31.6	30.4	30.3	24.1	24.2	23.9
1963	23.8	21.8	21.0	22.1	23.4	27.9	30.4	27.7	24.9	21.7	21.1	22.2
1964	24.6	24.4	24.6	24.8	25.0	23.4	25.0	25.9	24.4	23.5	23.5	24.8
1965	28.4	28.6	28.7	29.4	33.6	39.6	45.0	44.0	42.9	40.1	41.2	51.2
1966	51.8	48.7	42.0	43.7	44.8	47.1	50.2	47.2	43.4	35.4	33.2	33.4
1967	34.3	33.2	33.1	32.3	40.7	39.9	36.8	32.3	30.4	29.4	28.6	29.1
1968	31.4	32.0	32.4	35.7	32.4	30.6	31.0	29.5	31.1	28.0	26.9	29.6
1969	30.4	31.5	34.3	33.7	36.8	36.6	38.2	43.7	41.7	38.1	40.9	43.3
1970	45.0	43.0	42.5	40.9	40.9	41.1	42.6	37.2	32.9	25.8	24.1	22.0
1971	22.0	24.6	22.6	22.6	22.9	24.3	24.0	24.2	23.7	24.2	24.8	28.0
1972	35.3	34.5	33.4	33.9	35.4	35.8	39.7	39.7				

[1] Current source: Average of Wednesday quotations (14).

Appendix table 5 --Pigs per litter: Reported for 10 Corn Belt States and estimated for all States, by quarter

Year	Dec.-May[1]						June--Nov.					
	10 States			All States			10 States			All States		
	Dec.-Feb.[2]	Mar.-May[2]	Dec.-May[3]	Dec.-May[2]	Dec.-Feb.[4]	Mar.-May[4]	June-Aug[2]	Sept.-Nov.[2]	June-Nov.[3]	June-Nov.[2]	June-Aug.[4]	Sept.-Nov.[4]
1956	–	–	–	6.94	6.88	6.97	–	–	–	7.01	6.97	7.03
1957	–	–	–	7.12	7.06	7.15	–	–	–	7.06	7.02	7.08
1958	–	–	–	7.05	6.99	7.08	–	–	–	7.17	7.13	7.19
1959	–	–	–	7.08	7.02	7.11	–	–	–	6.98	6.94	7.00
1960	–	–	–	6.96	6.90	6.99	–	–	–	7.02	6.98	7.04
1961	–	–	–	7.18	7.12	7.21	–	–	–	7.16	7.12	7.18
1962	–	–	–	7.08	7.02	7.11	–	–	–	7.23	7.19	7.25
1963	6.99	7.28	7.18	7.15	6.96	7.25	7.23	7.26	7.25	7.23	7.21	7.24
1964	7.23	7.26	7.25	7.23	7.21	7.24	7.21	7.23	7.22	7.21	7.20	7.22
1965	7.23	7.23	7.23	7.22	7.22	7.22	7.24	7.30	7.28	7.27	7.23	7.29
1966	7.35	7.36	7.36	7.32	7.31	7.32	7.20	7.31	7.28	7.25	7.17	7.28
1967	7.32	7.37	7.36	7.34	7.30	7.35	7.38	7.40	7.39	7.38	7.37	7.39
1968	7.28	7.49	7.42	7.37	7.23	7.44	7.39	7.37	7.38	7.35	7.36	7.34
1969	7.23	7.38	7.33	7.36	7.26	7.41	7.35	7.26	7.30	7.34	7.35	7.32
1970	7.22	7.37	7.32	7.33	7.23	7.38	7.18	7.15	7.16	7.21	7.23	7.20
1971	6.99	7.25	7.15	7.19	7.03	7.29	7.25	7.25	7.25	7.29	7.29	7.29
1972	7.30	7.30	7.30	7.33	7.33	7.33						

Note: - = not reported.

[1] December of preceding year.

[2] As published in (40).

[3] Computed by dividing pig crop by sows farrowing shown in (40) for the 10 States.

[4] 1963-date: Differential for 6-month period added to published 3-month figure for the 10 States. Data for earlier years based on 1963-66 differential for the 3-month figures in relation to the 6-month figure for all States. Adjustments were made in a few years to allow for known abnormal weather conditions by region.

Appendix table 6—Estimated and projected pig crops by quarter, all States[1]

Year	Dec.-Feb.[2]		March-May		June-Aug.		Sept.-Nov.	
	$F_t L_t$	$F_t \overset{*}{L}_t$	$F_t L_t$	$F_t \overset{*}{L}_t$	$F_t L_t$	$F_t \overset{*}{L}_t$	$F_t L_t$	$F_t \overset{*}{L}_t$
	Million head							
1956	17.5	17.4	35.7	35.5	18.4	17.9	19.9	17.3
1957	16.9	16.3	34.4	33.3	18.8	18.8	17.0	17.1
1958	18.7	19.0	32.6	33.0	22.4	22.0	19.7	19.4
1959	21.4	21.5	35.1	35.2	23.2	24.0	19.5	20.1
1960	17.3	17.6	29.9	30.5	21.2	21.3	19.7	19.8
1961	17.9	17.5	32.4	31.6	21.9	21.6	20.4	20.1
1962	18.1	18.2	31.4	31.5	22.6	22.2	21.4	21.1
1963	18.0	18.1	32.7	32.8	22.5	22.3	20.7	20.5
1964	17.1	16.5	30.6	30.8	20.9	20.9	18.9	19.0
1965	15.7	15.7	26.8	26.8	18.4	18.4	17.8	17.8
1966	16.2	16.1	29.1	28.9	21.6	21.8	20.4	20.5
1967	17.9	18.0	30.3	30.3	21.9	21.4	21.6	21.4
1968	18.5	18.7	30.6	30.3	23.2	23.3	21.9	22.1
1969	18.7	18.7	28.1	28.2	21.5	21.7	20.5	20.7
1970	19.9	20.1	32.6	32.9	25.2	25.7	24.5	25.0
1971	21.1	21.8	31.0	31.6	23.3	23.4	22.6	22.5
1972	19.5	19.5	28.7	29.0				

[1] F_t equals sows farrowing shown in (40). Historic data were in (32, table 26 and 26A). L_t equals estimated pigs per litter for all States as shown in app. table 5. $\overset{*}{L}_t$ is a projected pigs per litter based on a trend projection by State weighted by sows farrowing. It is shown in the December and June issues of (40) on a 6-month basis. Quarterly estimates were derived by a method comparable with that for reported pigs per litter for all States as shown in app. table 5.

[2] December of preceding year.

Appendix table 7 – Estimated barrows and gilts slaughtered commercially, 48 States[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1,000 head											
1957	6,488	5,678	5,986	5,475	5,133	3,767	3,845	4,402	5,499	6,769	6,079	6,075
1958	6,309	5,114	5,392	5,428	4,685	4,139	4,227	4,688	5,596	6,455	5,685	6,349
1959	6,607	6,314	6,347	6,122	5,198	4,944	5,194	5,045	6,270	7,186	6,753	7,598
1960	7,311	6,588	6,912	6,073	5,888	5,360	4,464	4,971	5,595	5,970	6,198	6,204
1961	6,340	5,691	6,764	5,535	5,972	5,171	4,351	5,298	5,569	6,723	6,787	6,201
1962	6,665	5,865	6,765	6,122	6,139	5,201	4,729	5,357	5,163	7,099	6,769	6,397
1963	6,924	6,227	7,138	6,838	6,322	4,987	4,960	5,270	6,245	7,274	6,736	7,068
1964	7,422	6,426	7,002	6,921	5,810	5,221	4,963	5,000	6,005	7,205	6,850	6,968
1965	6,513	5,817	7,090	6,182	5,018	4,832	4,587	4,971	5,865	5,805	5,815	5,343
1966	5,173	5,111	6,334	5,740	5,188	4,807	4,271	4,321	6,163	6,430	6,623	6,733
1967	6,822	6,193	7,250	6,328	5,641	5,355	4,949	6,072	6,448	7,177	6,935	6,612
1968	7,060	6,240	6,766	6,888	6,741	5,355	5,607	6,193	6,646	7,817	6,851	6,951
1969	7,188	6,584	7,127	7,105	6,216	5,628	5,744	5,737	6,636	7,174	5,977	6,552
1970	6,435	5,739	6,693	6,903	6,011	5,740	5,715	5,981	7,053	7,747	7,485	8,202
1971	7,731	6,596	8,485	7,984	7,020	6,934	6,273	6,867	7,384	7,251	7,617	7,631
1972[2]	6,582	6,453	7,982	6,893	6,880	6,277	5,219					

[1] Percentage for this class under Federal inspection, shown on the last page of (41), times total commercial slaughter of hogs, shown on the inside cover page of that report.

[2] Preliminary.

Appendix table 8 – Estimated sows slaughtered commercially, 48 States[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1,000 head											
1957	658	300	370	472	710	997	1142	876	474	433	438	489
1958	376	287	371	462	588	832	888	631	536	503	510	584
1959	408	383	443	543	673	865	923	846	603	628	650	628
1960	460	400	397	488	586	708	684	777	597	465	571	564
1961	408	313	357	387	572	806	773	775	556	524	568	526
1962	465	349	396	422	560	690	763	741	451	579	562	501
1963	437	330	355	463	524	677	842	749	547	543	582	619
1964	520	362	356	461	508	653	765	662	517	546	606	661
1965	401	314	391	462	463	603	530	520	438	413	468	430
1966	332	276	349	375	509	647	643	695	540	479	531	501
1967	446	362	408	413	534	619	554	626	626	468	524	499
1968	469	358	328	442	494	487	559	498	449	448	534	543
1969	454	364	346	385	414	495	540	509	528	544	433	482
1970	341	285	288	350	366	469	605	589	551	542	550	556
1971	462	386	422	398	460	593	456	571	543	467	526	570
1972[2]	379	321	353	305	373	449	301					

[1] Percentage for this class under Federal inspection, shown on the last page of (41), times total commercial slaughter of hogs, shown on the inside cover page of that report.

[2] Preliminary.

Appendix table 9.–Per capita linearized consumption of pork bellies, per capita disposable personal income, and total civilian consumption of shell eggs as used in the quarterly models

Year	Pork belly consumption[1]				Income[2]				Egg consumption[3]			
	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.
	Pounds				*Dollars*				*Billion*			
1957		2.83	2.88	2.95		1,799	1,816	1,809		13.7	13.5	14.5
1958	2.54	2.72	2.88	2.92	1,805	1,811	1,844	1,864	14.4	13.6	13.6	14.7
1959	2.77	3.00	3.29	3.30	1,882	1,912	1,904	1,920	14.5	13.4	13.3	14.3
1960	3.04	2.95	3.18	2.95	1,937	1,951	1,953	1,942	14.1	13.2	13.0	13.9
1961	2.75	2.89	2.92	2.99	1,953	1,976	2,002	2,036	13.6	13.0	13.1	14.0
1962	1.79	2.87	2.99	3.03	2,051	2,072	2,080	2,093	13.9	13.2	13.1	14.1
1963	2.87	2.98	3.12	3.14	2,117	2,130	2,156	2,182	13.6	13.1	13.2	13.9
1964	2.76	2.93	3.17	3.07	2,230	2,285	2,316	2,342	13.9	13.0	13.3	13.9
1965	2.71	2.74	2.72	2.54	2,367	2,406	2,482	2,530	13.7	13.4	13.4	14.0
1966	2.36	2.52	2.69	2.85	2,565	2,587	2,631	2,675	13.7	13.3	13.4	14.3
1967	2.76	2.70	3.03	2.90	2,713	2,742	2,783	2,821	14.0	13.6	13.9	14.8
1968	2.80	2.81	3.18	3.06	2,889	2,945	2,978	3,022	14.6	13.9	13.8	14.4
1969	2.87	2.76	3.04	2.80	3,052	3,108	3,186	3,232	14.3	14.0	14.0	13.8
1970	2.57	2.72	3.05	3.12	3,287	3,368	3,408	3,427	14.3	14.0	14.2	14.8
1971	3.04	3.08	3.40	3.10	3,517	3,594	3,628	3,650	14.6	14.4	14.1	14.8
1972[4]	2.81	2.87			3,713	3,771						

[1] Let C_t = consumption for the quarter computed from monthly data in app. table 3 and N_t = total population for the 48 States as shown in app. table 10. The linear approximation to C_t/N_t is $[\bar{C}_t/\bar{N}_t + C_t/\bar{N}_t - (\bar{C}_t/\bar{N}_t^2) N_t]$. Values by quarters for the constants involved are as follows:

Quarter	$\bar{C}_t/\bar{N}_t$	$1/\bar{N}_t$	$-(\bar{C}_t/\bar{N}_t^2)$
Jan.-Mar.	2.761	0.005255	-0.01451
Apr.-June	2.811	.005308	- .01492
July-Sept.	3.006	.005291	- .01591
Oct.-Dec.	2.965	.005271	- .01563

[2] Current source for total income is table S-2 in (44). By error, total income was divided by total population for 48 States (see app. table 10).

[3] Civilian consumption of shell eggs per capita is published annually in the June issue of (34). These figures were multiplied by population eating from civilian supplies (see app. table 10).

[4] Preliminary.

Appendix table 10--Population data and expected disposable personal income as used in the quarterly models

Year	Population, 48 States[1]								Expected income[2]			
	Total				Eating from civilian supplies							
	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.
	Million								*Billion dollars*			
1957	170.1	170.9	171.6	172.3	167.3	168.0	168.8	169.7	–	311	316	312
1958	173.0	173.7	174.5	175.3	170.5	171.2	171.8	172.6	313	317	329	332
1959	176.0	176.7	177.5	178.2	173.3	174.1	174.8	175.6	336	345	338	346
1960	178.9	179.6	180.3	181.1	176.4	177.0	177.7	178.5	351	354	354	351
1961	181.7	182.5	183.3	184.0	179.2	180.0	180.6	181.3	358	366	373	382
1962	184.7	185.3	186.0	186.7	181.9	182.5	183.2	184.0	383	389	390	395
1963	187.4	188.1	188.7	189.5	184.7	185.3	186.0	186.7	403	405	413	421
1964	190.1	190.7	191.3	192.0	187.3	187.9	188.5	189.3	434	448	450	456
1965	192.6	193.1	193.7	194.3	189.9	190.4	191.0	191.4	462	474	497	502
1966	194.9	195.4	195.9	196.4	191.9	192.3	192.7	193.2	508	511	525	535
1967	196.9	197.5	197.9	198.5	193.7	194.1	194.6	195.0	543	549	560	569
1968	199.0	199.6	200.0	200.5	195.5	195.9	196.4	196.9	590	602	603	616
1969	200.9	201.4	201.9	202.5	197.4	197.9	198.4	199.1	620	639	660	666
1970	203.1	203.6	204.1	204.7	199.7	200.4	201.0	201.7	681	704	707	707
1971	205.3	205.8	206.3	206.8	202.3	202.9	203.5	204.1	742	757	757	762
1972[3]	207.2	207.6	208.0	208.4	204.7	205.2	205.6	206.1	776	782	795	

[1] Current source: Interpolations from data in (33).

[2] Let I_t equal disposable personal income as shown in table S-2 in the (44) for the current quarter, and I_{t-1} equal the same for the preceding quarter. Then expected income for the next quarter (to be used in analyses for the current quarter) equals:

$$I_t + (I_t - I_{t-1}) = 2\,I_t - I_{t-1}.$$

[3] Preliminary.

END