PRICE RELATIONSHIPS AMONG SELECTED WHOLESALE BEEF AND PORK CUTS

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This is to certify that the

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ABSTRACT

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by Duane Hacklander

This study focused on explaining and predicting monthly beef and pork cut price fluctuations at the wholesale level where the storage mechanism is used in conjunction with exports and imports to alleviate short-run supply and demand maladjustments. Several approaches were utilized in analyzing the price variations.

The objective of Model I, consisting of 20 simultaneous equations, was to obtain realistic structural coefficients which explain recent monthly price level fluctuations for the wholesale cuts. An alternative way of examining wholesale cut price behavior, was to determine the relevant explanatory variables explaining the relative behavioral relationships among the wholesale beef and pork cut prices (Model II). Two "margin" approaches were used in Model III to analyze the relative relationships between the wholesale cut prices and live steer or hog price. The short-run forecastability of monthly beef and pork wholesale cut prices was also briefly analyzed.

As expected, beef quantity was inversely related to the wholesale beef cut prices but the arm chuck price was found to be less flexible to quantity changes than beef loin and rib prices, contrary to expectations. Round price was

found to be relatively inflexible with respect to "income" while rib price was the most flexible of the beef cuts. Calculated price flexibilities with respect to quantity for the wholesale pork cuts were generally slightly more flexible than for the beef cuts. Belly price, in particular, was very responsive to quantity changes indicating its rather limited use as bacon for which substitutes are presently limited. Compared to pork, beef generally appeared to be a more prestigous item which consumers favored purchasing when their "incomes" increased.

The estimated positive quantity coefficients suggested complementarity between belly price and beef quantity and between wholesale pork cut prices and poultry quantity. Beginning pork storage levels were inversely related to pork cut prices while the change in pork storage was generally directly related to pork prices.

In the beef supply equation, producers appeared to look at current price levels as a sign of continued future trends. Hog producers appeared to interpret change in live price as a short-run price trend which they expected to continue, and adjusted their marketings accordingly. In the supply equations, the expected shift in response from the heavier weight inventory groups in the quarterly report month to the lighter weight groups by the second month following the quarterly report month was not always found.

In the beef wholesale cut price ratio equations, the suggested relative price flexibilities with respect to quantity and "income" were not consistent with the calculated flexibilities in the simultaneous equation model. Likewise, the suggested relative price flexibilities in the pork price ratio equations showed some inconsistencies with the calculated flexibilities in Model I.

Both beef and pork quantity coefficients were significant in the equations relating beef cut prices to pork cut prices. The "income" coefficients were generally positive suggesting somewhat higher "income" flexibilities for beef relative to pork, consistent with the Model I results.

Relative to the wholesale beef cut prices, the response of steer price to beef quantity levels was proportionally more in the price ratio equations but was less in terms of cents per pound in the price difference equations. Steer price responded proportionally more to changes in the "income" level than wholesale prices but less in terms of cents per pound.

In the equations relating wholesale pork cut prices to live hog prices, the significant responses to the hog quantity variable were similar to the responses between beef quantity and wholesale beef cut prices. Beef quantity levels were a relevant explanatory variable in the pork cut/hog price ratio equations. The "income" variable was only of limited importance in explaining the differences between wholesale pork cut prices and live hog price.

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A seven month trial forecast period was used to evaluate the usefulness of the forecasting equations in which forecast prices were compared to actual prices. Usefulness of the forecasting equations may have been obscured by the fact that somewhat atypical sharp price fluctuations occurred during the trial period. The mean absolute percentage error ranged from 2% to 8% for the nine forecasting equations. Direction of price change was forecast correctly all seven months for one cut and only missed one month for three others. But, for four cuts the directional price change was correctly forecast only four of the seven months.

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By

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CHAPTER I

PURPOSE AND APPROACH OF STUDY

Introduction

Meat plays an important role in the United States economy. The amount of a consumer's food dollar spent on meat typically ranges between 20 and 25 percent. Consumer groups protesting high food prices usually single out meat prices, especially beef, for special criticism. Likewise, livestock production plays a major part in the agricultural sector. In 1969, cash receipts from the sales of cattle and calves amounted to 12.5 billion dollars or 26.5 percent of the cash receipts from all farm marketings.[1] The 4.7 billion dollars receipts from the sale of hogs accounted for 9.9% of farm cash receipts.

Fluctuations in meat prices are a major concern to producers, meat packers and processors, retailers, and consumers. The explanation and anticipation of the price levels, as well as the relative differences among farm, wholesale, and retail price levels, have a pronounced impact on the profits and competitive position of the participants in the meat industry. Concern expressed over changes in meat prices is evidenced by

[1] Obtained from the Farm Income Estimates Section, Economic and Statistical Analysis Division, ERS, USDA.

an influx of inquiries to the U.S. Department of Agriculture about the cause of the change. Responses to the inquiries are usually made in terms of the live to retail price spread, or in terms of the recent changes in the retail price relative to the changes in the live price. This study was designed to focus on monthly wholesale price levels for beef and pork and their relationship to supply levels and live prices.

The U.S. Department of Agriculture could use results of this study in their ongoing price spread analysis. Further, the results would be helpful in policy analysis, such as the effect that beef import changes would have on beef prices. The results of this study may be useful to relatively small wholesalers, packers, or retailers who don't have access to a research department. It may provide guidelines to the relative effects of the different market factors on wholesale price levels which they can expect. In addition, other analysts of the market for meat products may find it informative.

<u>Literature of Related Studies</u>

Analyses of wholesale meat price behavior are practically non-existent in the literature. An exception to this vacuum is a bulletin by Maki titled, <u>Forecasting Beef Cattle and Hog Price by Quarter-Years</u>. (20)[1] Maki

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[1] Numbers in brackets refer to References Cited, pp 149

used the wholesale market as the central level in price determination. The results of his analysis indicated that beef quantity had a significant effect on the beef wholesale price variable while pork quantity, disposable income, and linear trend coefficients were not significantly different from zero at the .01 level. For the wholesale pork price equation both beef and pork quantities, as well as disposable income, appeared to have a significant effect.

Recently several theses dealing with beef and pork prices using monthly data have been completed. A master's thesis by George H. Hoffman dealt with a short run price forecasting model for beef (14;25). Hoffman dealt primarily with the live level but he did devote a small section to looking at wholesale prices. In a table showing the two month predictive equations for a five market wholesale price of beef it was evidenced that the only predictive variable used was a lagged price variable in all months except November, where an index of prices received for feed grains and hay in the U.S. was also used. A lagged 5 market wholesale price was the most prevalent of these lagged price variables. The R^2 for these equations varied from .23 in September to .85 in November.

Another master's thesis dealing with farm level demand for slaughter cattle using monthly data was done by Prato (22;23). Prato's statistical model consisted of four equations--demand, supply, and stock holding relations and a market clearing condition. Again, as in the previous study, equations were fitted for each month. Two-stage least-squares techniques were used to estimate the monthly demand fuctions in the model. In order to minimize the number of variables in the equations, all data were adjusted by population and the price level prior to the computational analysis.

After adjustment for population, the demand relations were expressed as the price received by farmers as a function of per capita volume of slaughter cattle, per capita cold storage holdings of beef, and per capita income. In the actual variate form of the model the quantity coefficients were significantly different from zero at the .01 level of probability, the personal income variable was significant at the .05 level, except for January, while the cold storage holdings of beef coefficient was significant for only six months (February-June and August).

Using a model of eight behaviorial equations and two identity relationships, Myers, Havlicek, and Henderson analyzed the monthly structure of the hog-pork sector (21).[1]

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[1] Based on L. H. Myers Ph. D. thesis at Purdue.

The normalized dependent variables for the equations included monthly supplies of live hogs and cattle for slaughter, farm-retail margins for beef and pork, monthly supply of pork for consumption, and monthly demands for pork, beef, and broilers for consumption. With ten jointly determined variables in the model, the two-stage least-squares method of estimation was used.

For the live hog supply for slaughter equation, live hog price was found to have a negative, but significant, influence. The other explanatory variables included in the equation were an inventory of live hogs on farm, interest rate, price of corn, a measure of cyclical production patterns in hogs, and a linear trend variable plus eleven monthly dummy variables. The coefficients of the interest rate and cyclical production patterns variables were smaller than their standard error. Similar variables were included in the live cattle supply for slaughter. Again, the negative relationship was found for live cattle prices. These negative relationships led the authors to conclude that in short-term decisions the response to expected prices was greater than to current prices since current prices are a component of expected future prices.

The equations for retail pork and beef demand equated per capita consumption of pork and beef with the retail prices of beef, pork, and chicken, disposable income and eleven monthly dummy variables. The only insignificant coefficient resulted for the price of chicken variable in the retail beef demand equation. The signs of the coefficients were consistent with *a priori* expectations.

Another recent thesis by Bullock included a monthly price forecasting model for slaughter cattle. (3) Since the emphasis was on forecasting, the model was set up with some structural simplications and fitted by ordinary least squares. The model was concerned with the price forecasts by months up to 12 months in advance for 900-1100 pound Choice grade slaughter steers at El Centro, California. Slaughter cattle price was fitted as a function of projected marketings of fed cattle for five regions and lagged slaughter cattle prices.

Leuthold shortened the time period for analysis to a daily basis (17;18). He found that daily prices offered for slaughter hogs responded very little to daily changes in quantity. Quantity supplied was a factor though in influencing prices for three consecutive days. Wholesale prices of pork cuts from the previous day affected the buyers' bid price for live hogs. The price was also influenced by the day of the week. The terminal market supply of hogs was found to be extremely responsive to the change in live price. The day of the week was also found to influence the producers' marketing decisions.

In a study utilizing retail price cut data, Riley utilized consumer panel data of weekly prices and quantities from July 1951 to June 1953, to obtain some measurements of consumer demand for meats (24). He found that, during a period of rapidly declining prices, the price elasticities of demand were inelastic for ground beef, slightly elastic for beef roasts, and highly elastic for steaks. For selected pork cuts the demand for pork chops and ham was found to be elastic while the demand foo bacon was slightly inelastic. Also it was found that the demand for some of the fat pork cuts may shift considerably from winter to summer.

The lagged response of selected pork cuts was studied by Snell (28). He concluded that there was no lag between farm and wholesale prices on a weekly basis. For farm to retail a one week lag was evidenced. These conclusions were drawn from fitting, individually, wholesale loin and butt prices and retail pork chops and pork roast prices as a function of live hog price and beef and pork quantities. Then the explanatory variables were lagged up to three months. For the wholesale cut prices the best fit in terms of variance explained (R^2) occurred in the same time period. For the retail prices the best fit occurred in the "t-1" time period. Snell found no difference between an upward or a downward price movement.

The related lagged price response of retail prices to changes in price direction at the live level on a monthly basis has been reported in two USDA bulletins dealing with price spreads for beef and pork (2;4). The lag was observed for periods of increasing and decreasing prices as well as for both the beginning and end of a period. The lag of the retail beef prices to a change in direction of live steer price for the beginning of a period of increasing prices (or end of a period of decreasing prices) averaged out to be .9 months. The lag for the end of a period of increasing prices (or beginning of a period of decreasing prices) was .6-.7 months. For pork the retail lag averaged about .9 months for both the beginning and the end of the periods.

Probably the most influencing factors on this study were prior analyses done by Hayenga and Hacklander. These analyses incorporated many of the ideas brought forth from the review of related studies. The prior analyses consisted of two parts, the first being primarily concerned with forecasting techniques by months for live steers and hogs (12) while the second part was concerned more from a structural viewpoint with possible simultaneous effects between supply and price for steers and hogs at the live level (11).

The forecasting part was completed first. Variables chosen for the forecasting equations were included not only on their ability to improve the forecast but also because of their reasonableness. Consequently the variables used in the forecasting equations were also incorporated into the behavioral model used in the second part of the study. The review of the study shall be focused primarily on the second part.

A behavioral model of the live level for beef and pork consisting of five equations was developed and fitted using two-stage least-squares techniques. The endogeneous variables in the model were the live prices of steers and hogs, changes in pork storage levels and commerical beef and pork production. Steer and hog prices were negatively responsive to their own supply levels and positively responsive to per capita income levels. Choice grade steer prices were also affected by the quality composition of the supply as well as the competitive supply level of pork. Hog prices were influenced by both the absolute level of pork storage and the change that occurred in the amount of pork stored during the month. The effect of beef production on hog prices resulted in an unexpected positive relationship. This result may have been a spurious statistical result or might conceivably be attributed to consumers' desire to maintain some variety in their meat purchases with high levels of beef consumption.

Change in pork storage (beef storage was a very minor item) levels were found to be influenced by the storage level at the beginning of the month, the quantity of pork produced, and the live hog price. Slaughter levels of beef and pork were fairly well explained by cattle and hog inventories on farms by weight categories plus recent price behavior. Live price monthly changes appeared to affect the cattle and hog producers' expectation of future price changes differently. Hog producers appeared to expect an upward price movement to continue for some finite period; thus, they held back their production from the market. Cattle producers appeared to view an upward price movement in this month as an indication that it would fall during the next period; thus, the quantity they supplied for slaughter increased.

Several other studies provided a good background framework to the development of demand and supply analysis for livestock. These included: The Analysis of Demand for Farm Products by Karl A. Fox (7), A Statistical Study of Livestock Production and Marketing by Hildreth and Jarrett, (13) Demand for Meat by Elmer J. Working (42), Demand and Prices for Meat-Factors Influencing Their Historical Development by Harold Breimyer (1), Factors Affecting the Price and Supply of Hogs by Arthur A. Harlow (10), and Demand and Price Analysis by Fred Waugh (41). All of these studies were somewhat peripheral to this study because they focused at either the live or retail levels and used annual data.

Problem

The related literature pointed up the gap in published research between the live and retail levels for monthly beef and pork prices. Literature has recently been forthcoming dealing with monthly demand and supply relationships at the live and retail levels, but not at wholesale level. Another gap found was the lack of studies dealing with behavioral relationships for beef and pork prices on a cut or primal basis, especially using time series data. The problem focus of this study is to fill, to some degree, these gaps at the wholesale level.

Objectives

This study focuses on explaining and predicting monthly beef and pork price fluctuations at the wholesale level where the storage mechanism is used in conjunction with exports and imports to alleviate short run supply and demand maladjustments. This study endeavors to broaden the usual scope by focusing on individual wholesale beef and pork cut prices instead of average prices for all beef or pork wholesale cuts. Relationships among individual cuts as well as the live and wholesale cut price levels will be analyzed.

More specifically the objectives of this study are to:

1. Determine factors affecting monthly demand and supply for selected wholesale cuts of beef and pork.

2. Estimate selected monthly beef and pork wholesale cut demand and supply relationships.

3. Analyze monthly price relationships among the selected wholesale cuts.

4. Analyze monthly live-wholesale price relationships.

5. Tentatively assess the forecastability of prices of selected cuts of wholesale beef and pork for several months in advance.

Approach

Monthly wholesale price levels over a recent time period, January 1962 - May 1969, are graphically presented for selected beef and pork cuts in Figures 1 and 2. A wholesale price analyst must not only concern himself with explaining and forecasting the monthly fluctuations but also must consider the divergence between cut prices as well as between price levels. The general price patterns of the wholesale pork cuts were similar, but there were differences in the price change magnitude and the month when changes began. Sometimes, during short-run periods, prices of cuts actually moved in opposite directions, for example, from July to December 1968 pork loin price fell while the price of hams rose. The wholesale beef cut price patterns showed slight divergences between cut prices. With a general price pattern of increasing prices, the higher-price beef cuts increased at a faster rate than the lower-price cuts.

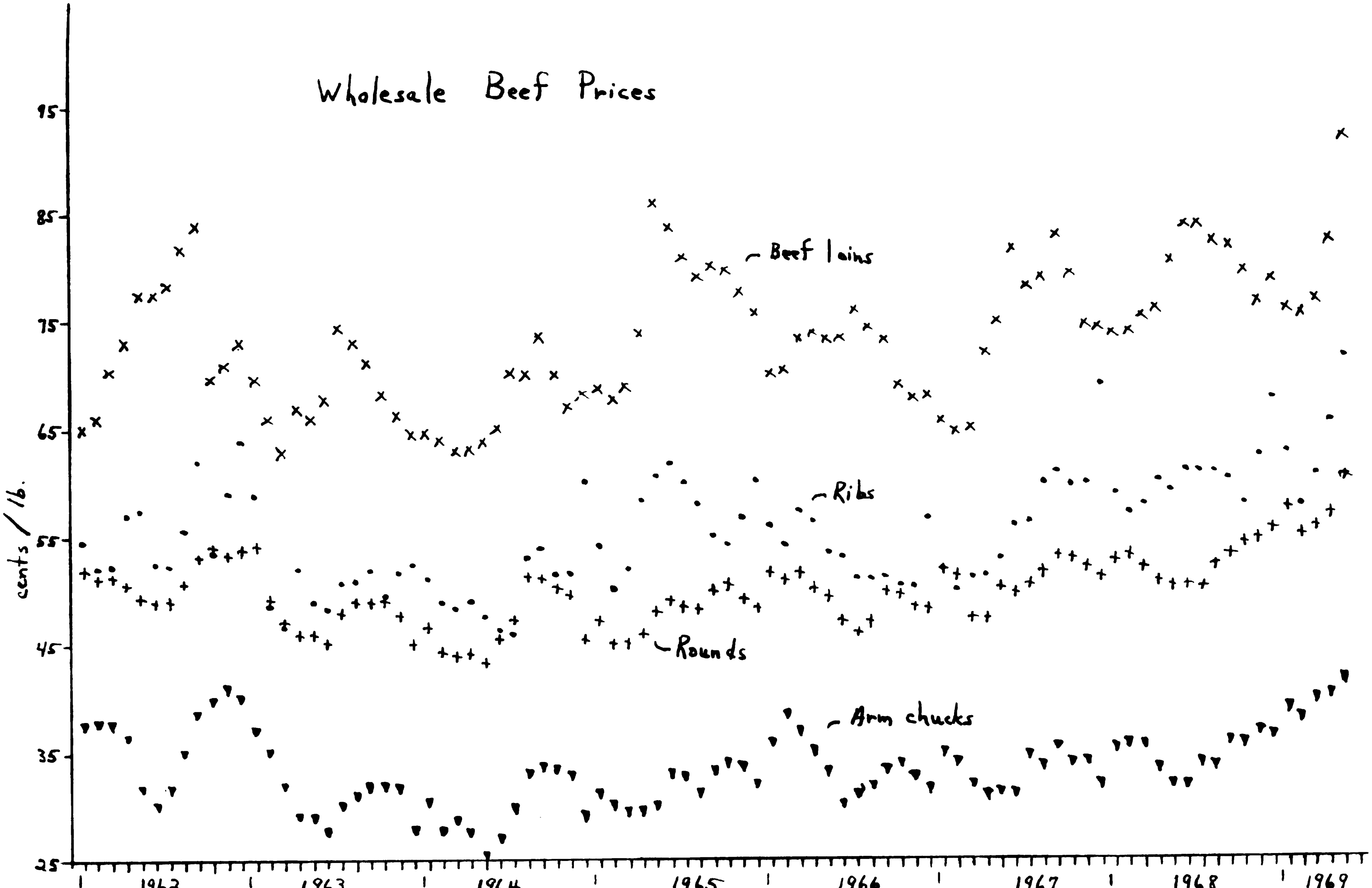
Wholesale Beef Prices
95
85
75
65
55
45
35
25
cents / lb.
Beef loins
Ribs
Rounds
Arm chucks
1962
1963
1964
1965
1966
1967
1968
1969

Figure 1.

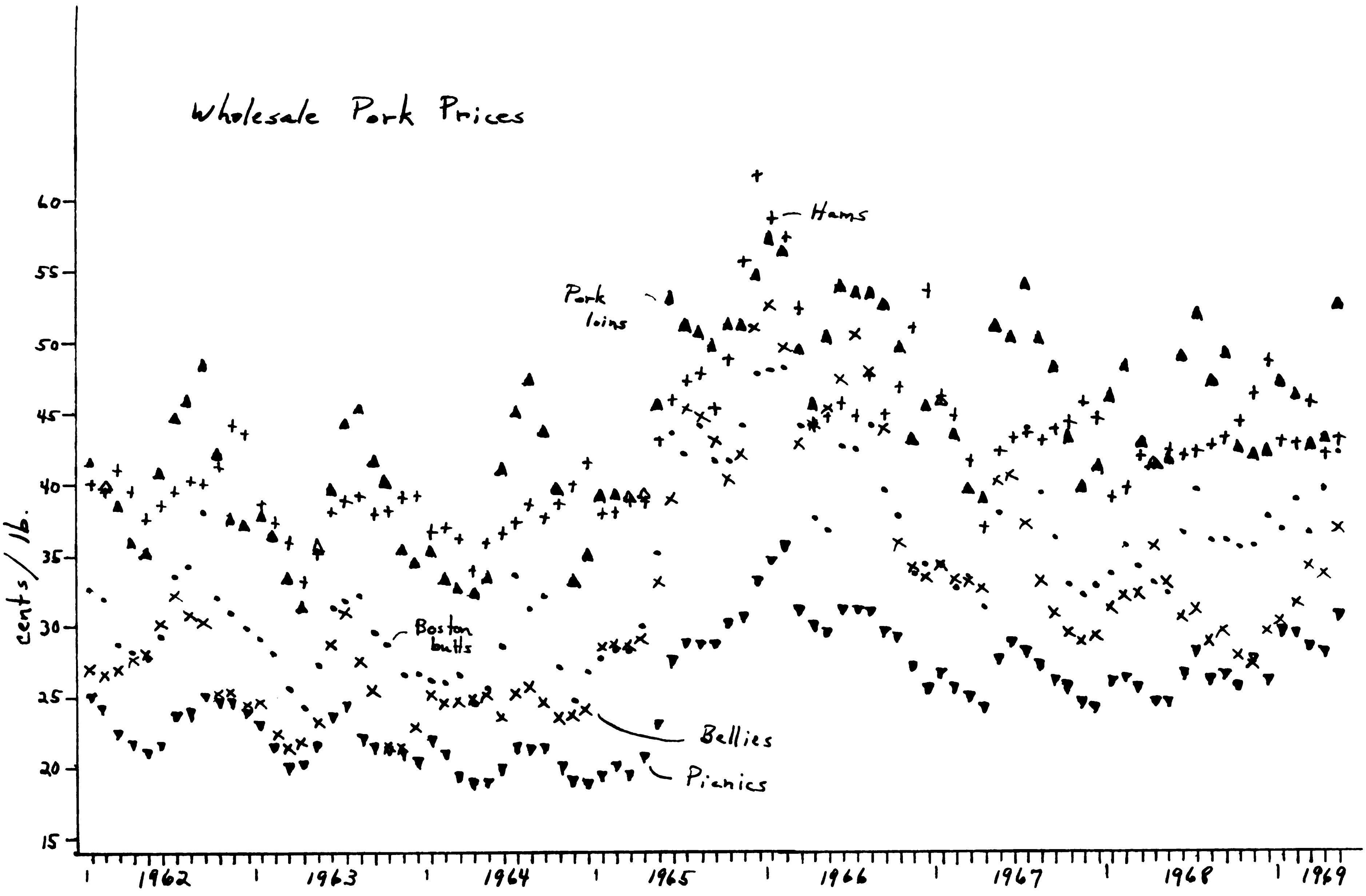
Wholesale Pork Prices
cents/lb.
60
55
50
45
40
35
30
25
20
15
Hams
Pork loins
Boston butts
Bellies
Picnics
1962
1963
1964
1965
1966
1967
1968
1969

Figure 2.

To fill the gap in the lack of published research analyzing beef and pork wholesale prices, the problem is approached in several ways. A simultaneous equation model will be formulated containing the behavioral wholesale demand and supply relationships envisioned for beef and pork. An alternative analysis of wholesale cut prices focuses on the relative relationships among the wholesale cuts. Relationships between the live and wholesale cut price levels are also examined. Finally, the feasibility of forecasting wholesale cut prices will be tentatively assessed by estimating, by least squares, the wholesale cut price equations in the simultaneous equations model, and using the resulting coefficients in forecasting prices for the next seven months. By comparing actual and forecast prices the usefulness of these forecasting equations can be tentatively assessed.

The following chapters are organized for reporting the procedures used and the results obtained to the different approaches. Chapter II will be concerned with the presentation of the analytical procedures used for the selection of the relevant variables and the construction of the behavioral relationships in the study. A brief description of the criteria used for the selection of the major wholesale cut prices and their price fluctuations over the period covered in this study will also be included in Chapter II. The estimated coefficients, and their implications, of the simultaneous model will be reported in Chapter III. The behavioral relationships among the wholesale cuts will be presented in Chapter IV, while Chapter V will contain the estimated coefficients of the relationships between the wholesale cuts and the live price levels. Comparisons of forecasting results with actual prices over a short-run time span will be undertaken in Chapter VI. Chapter VII, a "Conclusions" chapter, will draw together the major findings of the study relative to what has been found in prior analyses and also point out possible further research areas.

CHAPTER II

ANALYTICAL PROCEDURE

Several approaches are utilized in analyzing the price variations for the wholesale beef and pork cuts. Since the focus of these approaches varies, the following discussion is broken down accordingly to deal with: 1) explaining monthly beef and pork wholesale cut price behavior--Model I, 2) explaining changes in relative wholesale cut prices--Model II, 3) explaining live and wholesale price ratios and differences--Model III, 4) equations for short-run forecasting, and 5) estimation procedures and data sources.

Model I - Simultaneous Equations

The objective of Model I is to obtain realistic structural coefficients which explain recent monthly price level fluctuations for the wholesale cuts. The supply and demand structure thought to be the basic underlying cause of observed price behavior was carefully studied, and the variables which were quantifiable and consistent with the expected underlying structure are incorporated into the model. Model I utilizes live and wholesale cut prices, commercial production, and change in storage levels of pork cuts as endogenous variables. Referral to the functional description of Model I on pages 27-29 may aid in following the upcoming discussion of the relevant behavioral relationships.

Seemingly, prices which wholesalers offer for beef and pork cuts would be strongly influenced by the current commercial production of that cut.[1] Total commercial production is used to represent these quantity factors since published production data for each cut were not available. Substitution of total production variables for individual wholesale cut production variables was done under the assumption that the carcass proportions and cutout procedures remained approximately the same over the period studied.

Because the number of days, weekends, and holidays differ between months, the monthly commercial production figures are divided by the number of packer workdays in each month. Commercial production divided by workdays for each month provides a more standardized index of the quantity pressure affecting wholesale cut prices during each month.

The particular workday variable selected resulted from looking at data for daily volume of federally inspected beef and pork slaughter for the region including

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[1] Commercial indicates that both federally and non-federally inspected production are included. Production, used here, indicates that the data are in terms of carcass weight and not live weight.

Chicago from July, 1966-January, 1967.[1] The average percentage of slaughter being done on each weekday was similar for both beef and pork. Variation between the days from Monday through Friday was minor, so these weekdays were simply assigned equal weights of 1 unless a holiday occurred.[2] Slaughter occurring on Saturday appeared to be about one-third that of the other weekdays and thus was weighted 1/3, unless a holiday. The influence of holidays was noted by assigning a weight of 1/2 to that day when it fell on Monday through Friday, since it appeared that there was a slight slaughter increase on the other days during a week with a holiday. When the holiday fell on Saturday no slaughter increase during that week was noted. Consequently, Saturday received zero weight when a holiday.

The price quoted for aisingle grade of beef, Choice, is used for this analysis, therefore another factor to consider is the substitutability among the different grades of beef. Since total beef production includes all grades

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[1] Actually three different versions of the weighting procedure were tried at the live level and it was found that the explanatory power, in terms of R^2, of the selected version was better than the version which did not weight holidays and differed only slightly from the most difficult version to compute using the actual average percentages.

[2] Holidays: January 1, May 30, July 4, Labor Day, Thanksgiving, December 25.

of beef, a modifying variable is incorporated into the normalized equations for beef prices to account for monthly variations in the quality composition of the total beef production variable. The variable incorporated is the percent of the total federally inspected beef numbers consisting of cows. One would expect that an increase in the percentage of total slaughter made up of cows would reduce the relative supply of beef which most strongly competes with and affects the price of Choice grade beef. The positive relationship between Choice grade beef prices and percent cows is expected to be stronger for the higher-price cuts relative to those cuts more competitive with lower quality beef products.

Beef and pork production may be placed into storage for later consumption if price increases are expected. Storage data are published for individual wholesale cuts for pork, but only on an aggregate basis for beef. During the period, 1962-1969, only a small amount of beef was frozen or cured and stored. The corresponding small storage volume variation from month to month of individual beef cuts probably has had little impact on beef cut prices. Because of its presumed insignificant impact, storage variables are not incorporated into the wholesale beef equations.

Pork products were stored in greater volume than beef and exhibited substantial variations among months. Pork storage volume is reported for each wholesale cut at the end of each month, or conversely, the beginning of the next month. Both the volume of a particular pork cut stored at the beginning of a month and the change in storage during the month are expected to influence wholesale pork prices. If the quantity stored of a particular pork cut is relatively high at the beginning of the month, the relative wholesale price of that cut would probably be depressed because of the threat (or actual movement) of this quantity moving onto the market. If storage levels are low, wholesale pork prices probably are relatively higher because of the demand to increase the storage levels and the lack of threat from high storage levels. Changes in storage levels during the month influence wholesale pork prices by affecting the total quantity of pork moving in or out of the wholesale distribution channel. Changes in storage levels during the month may also be a reflection of anticipated prices which in turn are related to current prices.

Two other variables which would affect quantity directly are imports and exports. Here again data were reported by species, but not by cuts. Neither pork imports nor exports influenced total pork production much in recent years. The percentage of pork production imported in 1969 was 3 per cent while the percentage of production exported was 2 per cent. (35) Further, these flows remained fairly constant throughout the years under consideration. Since pork export and import variations seemed to be of minor importance in the pork supply picture, they were eliminated from consideration in the wholesale pork price equations. Beef exports were a very minor factor in relation to commercial production (1969 beef exports/1969 commercial beef production = .004) and remained fairly constant throughout the recent years. Thus, beef exports were eliminated from further consideration in the wholesale beef price equations. Beef imports appeared to be somewhat more prominent in the supply picture (1969 beef imports/1969 commercial beef production = .08). Also there tended to be more month to month variation within a year than was evidenced for beef exports and pork imports and exports. Thus, beef imports are included in the beef price equations to assess their impact on wholesale beef prices.

The supply of substitutable commodities is another major factor expected to affect the price offered for wholesale beef and pork cuts. Competition between beef and pork would be expected to be important as they are the major red meats consumed in the U.S. Thus, both beef and pork production per workday are included in each wholesale beef and pork price equation. Poultry consumption and production has increased in recent years to a point where it might have a fairly strong competitive impact on both beef and pork; thus, a poultry production variable is included in the wholesale price equations. The main components of poultry production are turkey and chicken. Since chicken production may have an impact different from the more seasonal turkey production, both chicken and turkey production variables are included in wholesale beef and pork price equations.

The primary factors expected to influence the demand for each wholesale cut are prices of closely competitive products. Reality and theoretical considerations dictate that the wholesale price of one individual cut is determined simultaneously with the prices of other cuts of that species and cuts from closely competing species. A case might also be made for simultaneity between poultry prices and wholesale beef and pork prices since poultry production has been suggested as a likely explanatory factor affecting beef and pork prices and vice versa. However, it was assumed that the current beef-pork influence on monthly poultry prices is small relative to other factors; therefore it was ignored.

Other factors expected to influence the demand for meat at the retail and, correspondingly, the wholesale level are population and per capita income. These two variables are very highly correlated. Thus, the per capita income variable is included as a proxy for both population and per capita income, as well as any other closely related factors.

Monthly dummy variables are used to pick up otherwise unquantified variations normally associated with each month. Potentially important variables which are not quantified include weather, buyers' expectations, seasonal demand patterns related to temperature, menu pattern variations due to holidays and religious observance, or other recurring seasonal or institutional factors affecting demand.

Commercial production per workday would seemingly be affected by the relative level of prices. In periods of low prices when the producers expect prices to rise in the near future they would hold their livestock off the market and feed to heavier weights. Where as in periods of high prices with an expectation of declining prices producers probably sell their livestock at lighter weights and thus presumably somewhat earlier than originally anticipated. Livestock prices have already been hypothesized as being responsive to total production levels.

The other explanatory variables included in the production equations are the quarterly inventory data published by weight groups of the number of steers and heifers on feed and the number of hogs and pigs on farms. Quarterly dummy variables, corresponding to the three months following the month in which the inventory data are published, are included in the beef and pork commercial production equations to account for unspecified normal quarterly differences. Factors which could potentially cause such seasonal variations are seasonal temperature or feeder cattle acquisition patterns and corresponding feeding and selling patterns in different seasons of the year.

Livestock producers are probably more responsive to live prices than wholesale prices. Consequently, the supplies of hogs and steers for slaughter, represented by commercial production of beef and pork per workday, are related to live prices rather than wholesale prices. Live prices, in turn, are related directly to their respective beef and pork wholesale prices. Such a relationship between live and wholesale prices seemed theoretically consistent and is supported by Snell's findings that the timing and magnitudes of price changes at the live and wholesale levels coincided on a monthly basis. (28) Price changes at the retail level have been found to lag about a month after changes at the live and wholesale levels have occurred and the magnitude of changes differed in that retailers tended to even out their price fluctuations relative to the live and wholesale levels. (2;4)

Theoretical considerations also suggest that the change in the storage of wholesale pork cuts during the current month is also an endogenous variable. Once hogs are slaughtered the pork can go rather quickly to the final consumer; otherwise it must be stored. The amount of pork quantity moving into storage or the amount of pork stored moving into the wholesale market is affected by current price and vice versa. The explanatory variables included in the change in storage equations are two endogenous variables--the wholesale pork cut price and the current pork quantity, a predetermined variable--storage level at the beginning of the month, and monthly dummy variables to capture the effects of regular, but otherwise unquantified factors affecting storage behavior.

The simultaneity between other relevant explanatory variables and the wholesale prices is assumed sufficiently low that these variables could be considered predetermined or exogenous. The income variable is considered exogenous, realizing that the wholesale beef and pork prices have a minor influence on per capita personal income. Pork storage at the beginning of the month is obviously a predetermined variable. The modifying beef supply variable, percentage of cows slaughtered, is assumed to be predetermined. This assumption was based on the feeling that cows were sent to market based upon considerations related to short-run grass availability, stage of their productive life, and longer run expectations about beef prices. Because of the short production cycle for chickens and turkeys, changes in current beef and pork prices are probably a minor factor in determining the current month's chicken and turkey production. Similarly, because a monthly time period was involved, current beef imports are assumed to be predetermined by previous market behavior and price expectations.

The preceding discussion of Model I is summarized into functional form below.

<u>Model I</u>

1) Rounds* = f(Q_c*, Q_H* I, PERCOW, MPORT, TKPD, CKPD, M.D., u_1)

2) Armchks* = f(" u_2)

3) BLoins* = f(" u_3)

4) Ribs* = f(" u_4)

5) Hams* = f(Q_c*, Q_H*, CHAMST*, HAMST, I, TKPD, CKPD, M.D., u_5)

6) Bellies* = f(" CBELST*, BELST, " u_6)

7) PLoins* = f(" CLOINST*, LOINST, " u_7)

8) Picnics* = f(" CPICNST*, PICNST, " u_8)

9) Butts* = f(" CBUTST*, BUTST, " u_9)

10) Q_c* = f(CSteerP*, INV_c, Q.D., u_{10})

11) Q_H* = f(CHogP*, INV_H, Q.D., u_{11})

12) SteerP* = f(Rounds*, Armchks*, BLoins*, Ribs*, M.D. u_{12})

13) HogP* = f(Hams*, Bellies*, PLoins*, Picnics*, Butts*, M.D., u_{13})

14) CHAMST* = f(Hams*, Q_H*, HAMST, M.D., u_{14})

15) CBELST* = f(Bellies*, Q_H*, BELST, M.D., u_{15})

16) CLOINST* = f(PLoins*, Q_H*, LOINST, M.D., u_{16})

17) CPICNST* = f(Picnics*, Q_H*, PICNST, M.D., u_{17})

18) CBUTST* = f(Butts*, Q_H*, BUTST, M.D., u_{18})

19) Identity: CSteerP*, = $SteerP_t^*$ - $SteerP_{t-1}$

20) Identity : CHogP* = $HogP_t$* - $HogP_{t-1}$

Where: * denotes jointly determined variables and
Rounds = wholesale price of beef rounds, cents/lb.
Armchks = wholesale price of beef arm chucks, cents/lb.
BLoins = wholesale price of beef loins, cents/lb.

Ribs = wholesale price of beef ribs, cents/lb.

Hams = " pork hams, "

Bellies = " pork bellies, "

PLoins " pork loins "

Picnics " pork picnics, "

Butts " pork Boston butts, "

Q_C = Commercial beef production, 48 states, million lbs. divided by the number of industry workdays for the month

Q_H = Commercial hog production, 48 states, million lbs. divided by the number of industry workdays for the month

SteerP = Average price of 900-1100 Choice steers at Chicago, $/cwt.

HogP = Average price of U.S. 1-2,[1] 200-220 lb. hogs at Chicago, $/cwt.

I = U.S. per capita personal income, seasonally adjusted, at annual rates, thousand $

PERCOW = number of cows as a percent of the total federally inspected beef numbers

MPORT = beef imports, carcass weight, million lbs.

TKPD = turkey certified as wholesome in federally inspected plants, ready to consume, million lbs.

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[1] Used price quotation for U.S. 1 and 2, 200 to 220 lbs. hogs until July 1, 1968 when hog grading system was changed. U.S. 2-3, 200-220 lbs. hogs, a closely comparable quotation, was used after that.

CKPD = chicken certified as wholesome in federally inspected plants, ready to consumer, million lbs.

INV_C = quarterly cattle on feed inventory groupings, 1000 head

INV_H = quarterly hogs and pigs on farm inventory groupings, 1000 head

HAMST = Frozen ham: cold storage holdings, beginning of month, 100,000 lbs.

BELST = Frozen pork bellies: cold storage holdings, beginning of month, 100,000 lbs.

LOINST = Frozen pork loins: cold storage holdings, beginning of month, 100,000 lbs.

PICNST = Frozen picnics: cold storage holdings, beginning of month, 100,000 lbs.

BUTST = Frozen Boston butts: cold storage holdings, beginning of month, 100,000 lbs.

C = before pork storage variables refers to change in storage (t + 1 - t)

M.D. = Monthly dummies, January = base

Q.D. = quarterly dummies, (base defined in text)

u's = stochastic disturbance terms

Model II - Cut/Cut Price Ratio Equations

An alternative way of examining wholesale cut price behavior is to determine the relevant explanatory variables explaining the relative behavioral relationships among the wholesale beef and pork cut prices. The relative relationships are expressed as ratios between paired wholesale cut prices. Relative relationships between high and low price cuts and cross relationships between beef and pork primals are of special interest. This model could conceivably be used as a method of forecasting other wholesale cut prices if one wholesale cut price was determined by some other means.

Ratios between the wholesale cut prices are influenced by quantity levels because of different price flexibilities with respect to quantity. Commercial beef production per workday is used as the main quantity variable for beef/beef price ratios while commercial pork production per workday represents the competitive situation. For pork/pork price ratios, pork production per workday represents the main quantity variable while beef production represents the competitive situation. When wholesale pork prices are involved in the ratios, i.e. either pork/pork or beef/pork, the storage figures for those cuts are included in the equations. When the dependent variable involves a ratio of two pork cut prices, the most relevant explanatory storage variable is the storage ratio of those two cuts. The relative effect on wholesale cut prices, of the other quantity variables hypothesized as being relevant explanatory variables in Model I, is assumed similar for each cut. Consequently, when a ratio of wholesale prices is used as the dependent variable, the effect of the other quantity variables tend to cancel out and become of minor importance as explanatory variables. Per capita income, again acting as a proxy for population and any other closely related factors, is included to see if a differential income effect was a factor causing changes in relative price movements over time. Monthly dummy variables are included in the equations to pick up the effects of otherwise unquantified factors associated with each month.

Wholesale prices and certain supply variables were hypothesized as being jointly determined in Model I. However, wholesale price ratios would seem to be relatively unimportant as explanatory variables for determining supply. Consequently, Model II is specified as a series of one equation models. For simplicity these equations are considered as sub-models under Model II and are not given individual numbers.

The functional forms of the three types of equations in Model II are summarized below.

$$P_{Bi}/P_{Bj}^{*} = f(Q_c, Q_H, I, M.D., u_1)$$

$$P_{Pi}/P_{Pj}^{*} \equiv f(Q_c, Q_H, \frac{STORi}{STORj}, I, M.D., u_2)$$

$$P_{Bi}/P_{pj}^{*} = f(Q_c, Q_H, STORj, I, M.D., u_3)$$

where: P_{Bi}/P_{Bj} refers to the different combinations of the wholesale beef prices such that $i \neq j$

P_{Pi}/P_{Bj} refers to the different combinations of the wholesale pork prices such that $i \neq j$

$\frac{STORi}{STORj}$ refers to a combination of the pork storage data corresponding to the P_i and P_j of the pork price ratio

P_{Bi}/P_{pj} refers to the ratio of the i th wholesale beef prices with the j th wholesale pork prices

STORj refers to the storage of the Pj pork cut in the beef/pork price ratio.

* denotes endogenous variables

The other variables are the same as defined in Model I, pp 27-29.

Model III - Wholesale Level to Live Level Equations

Attention by producers, packers and processors, and consumers alike has been focused on price relationships among market levels. Primary focus has been on the live to retail spread. Model III endeavors to explain a smaller portion of this spread, namely the wholesale to live spread. Meat packers and processors are concerned with this spread because of its impact on their profit picture. Because of the availability of adequate price forecasting equations at the live level, Model III also could be envisioned as a means to convert these live level forecasts into corresponding wholesale forecasts by cuts.

Two "margin" approaches are used to analyze the relative relationships between wholesale prices and live prices. One approach uses wholesale cut/live price ratios, expressed as a fraction, as the dependent variables similar to those used in Model II. The other approach involves wholesale cut-live price differences as the dependent variables.

The calculations of the wholesale to live price ratios and price differences in this study involves taking wholesale beef cut prices relative to live steer price and wholesale pork cut prices relative to live hog price. The price differences in this study are not directly comparable to the price spreads published by the U.S. Department of Agriculture. This study's price differences compare wholesale cut prices with the live level while the USDA's wholesale to live spread relates an aggregate wholesale price with the live level. Also, in this study, the price differences are not converted to an equivalent weight basis.[1] The main reason for not converting the live price to an equivalent wholesale weight basis was the unavailability of live prices for cuts. Another reason is that the conversion factor varies among companies and probably even within a given company.

The relevant variables for explaining the ratios and differences between wholesale and live prices are essentially the same as those used in Model II, for the cut/cut price ratio equations. Commercial beef and pork production per workday are included. Pork storage is also included in the pork equations. Per capita income is included again in its role as a proxy for other closely related factors, such as population. In addition to these variables, average weekly earnings for each month in meat packing plants are included. This variable is included as representative of the "services" portion of the difference between the wholesale price and the live price. The explanatory power of the wage variable is weakened because it is only an index of the labor cost of each unit of service, but is not a measure of the changes in the capital/labor mix in the

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[1] Equivalent weight refers to the fact that a pound of Choice grade steer yields only about .6 lb. of carcass beef while a pound of 200-220, No. 2-3 hog yields about .5 lb. of wholesale cuts. (6)

functions performed between the wholesale and live market levels.

As in Model II, the simultaneity between the explanatory variables and the dependent variable is assumed to be minimal. Thus, Model III consists of a series of one equation sub-models. The functional forms of the four types of equations involved in Model III are presented below.

$$\frac{P_{Bi}}{P_c}^* = f(Q_c, Q_H, I, W, M.D., u_1)$$

$$(P_{Bi} - SteerP)^* = f(Q_c, Q_H, I, W, M.D., u_2)$$

$$\frac{P_{pj}}{P_H}^* = f(Q_c, Q_H, STORj, I, W, M.D., u_3)$$

$$(P_{Pj} - HogP)^* = f(Q_c, Q_H, STORj, I, W, M.D., u_4)$$

Where: P_{Bi} = the wholesale beef cut prices, i= Rounds, Armchks, BLoins, Ribs

P_{Pj} = the wholesale pork cut prices, j= Hams, Bellies, PLoins, Picnics, Butts

W = average weekly earnings for each month in meat packing plants, $

* refers to endogeneous variables.

The other variables are the same as defined in Model I and Model II (pages 27-29 and 32).

Forecasting Equations

During periods of rapidly rising or falling beef or pork prices the USDA receives many inquires questioning the reasons behind the recent price changes and asking what can be expected in the near future. The preceding three models are focused at determining the reasons for recent price changes. However, they can also be adapted to price forecasting.

Model I normalized wholesale cut price equations in reduced-form could be used for forecasting. Any one of the reduced-form wholesale cut price equations could be used to project to some desired future time period. Then, the relative cut to cut relationships found in Model II could be used to determine the other wholesale cut prices. Similarly, by some other means, live cattle and hog prices could be forecast and converted to wholesale prices using Model III wholesale to live relationships.

Forecasting equations used in this study are the normalized wholesale price equations in Model I which are each fitted by ordinary least-squares. The use of derived reduced-form equations from Model I for forecasting was considered, but no adequate statistical routine was available to handle the number of variables involved in Model I.

Estimation Procedures and Data Sources

The time period chosen for analysis, January 1962-May 1969 is relatively short. Hopefully, the relationships will also be reasonably representative of the factors affecting current and possible future price relationships. A related consideration in the choice of this particular time period was that this study may become part of a broader overall systems approach to the meat industry which might include consideration of price relationships at the retail level. The USDA continuing study from which the retail beef and pork cuts prices would probably be drawn did not start compiling adequate monthly price data until January, 1962. Even by starting the time period as recently as January, 1962 a problem was encountered in Model I concerning the quarterly hogs on farms inventory data. Hog inventory data were not published on a quarterly basis prior to March, 1963. Thus, rather than try to extrapolate the quarterly hog inventory data back to the beginning of 1962, the time period for Model I was shortened to March, 1963-May, 1969.

Numerous daily Chicago wholesale beef and pork cut prices are published in The National Provisioner, (30) a trade magazine for the meat processing, purveying, packing, and rendering industries.[1] From the daily wholesale

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[1] These prices are taken from The National Provisioner Daily Market Service, which is commonly referred to as the "yellow sheet".

cut prices published, average monthly prices were calculated for several weight classes of nine major primal cuts of beef and pork. These thirty price series were then plotted for the period January 1962-May 1969. The relationships among the price series within each wholesale cut grouping were analyzed and found to be fairly consistent. Thus, the most heavily traded weight class for each wholesale cut was selected for more intensive analysis. The beef cuts selected are the U.S. Choice grade: a) rounds, 70-90 lbs., b) arm chuck, 80-110 lbs., c) loins, 50-70 lbs, d) ribs, 25-35 lbs. Pork cuts are: a) hams, 12-14 lbs., b) loins, 12-16 lbs., c) bellies, 10-12 lbs., d) picnics, 6-8 lbs., e) Boston butts, 4-8 lbs.

Linear functional forms are used for the equations under the assumption that they reasonably reflect the likely behavioral patterns at the wholesale level. The functional forms are linear both from a typical economist's point of view as the variables enter in a linear fashion and from a statistician's viewpoint in that the parameters enter in a linear fashion. The variables are used in form of actual variates without any deflation or indexing. As a comparison against the linear functional form, the use of a log-log functional form was considered because of the ease of obtaining price flexibilities. Since the change in pork storage variable was expected to involve some negative values, the log-log form was not used.

The slopes of the demand and supply functions are assumed approximately constant over time. Consequently, the Models are estimated for the whole year instead of estimating each month separately. Although the slopes are assumed to be approximately equal, the level of the functions are permitted to differ among months by incorporating monthly dummy intercept shifters. Logan and Boles analyzed quarterly retail meat price fluctuations and found that the slopes of the demand functions for selected meats were constant by seasons within the year but that the level of the demand function varied among seasons of the year.(19).

Of the estimation techniques available to obtain unbiased coefficients for the simultaneous equations in Model I, two-stage least-squares was selected. The two-stage least-squares estimation technique yields asymptotic unbiased, asymptotic efficient, and consistent coefficients under the assumptions of serial independence, finite and constant variance, and identification (15, pp 258-260, 275). Normality is also assumed in order to test whether the estimated coefficients are statistically different from zero.by using readily available statistical tables.

All the stochastic equations in Model I are over-identified. The assumption of serial independence is tested by an approximate Durbin-Watson test because the variance formula is asymptotic. The time period from March 1963 to

May 1969 covered in the analysis of Model I is fairly short, hopefully maintaining a fairly constant variance.

Unlike Model I, the cut/cut price ratio and wholesale to live equations in Models II and III are assumed to have only one endogenous variable per equation. Assuming serial independence, finite and constant variance, and normality, estimation by ordinary least squares yields best, linear, unbiased, consistent, and sufficient parameters (15, pp 106-115).

The assumption of normality in Models II and III as well as in Model I is acknowledged as being inconsistent. If u_1 and u_2 are normally distributed in Model I, then the ratio equations in Models II and III have essentially

$\frac{u_1}{u_2}$ as the disturbance term which is clearly non-normal.

Obviously, the assumption of normality for Models I, II, and III cannot be simultaneously true. But, in each case uncertainity exists as to the exact degree of compliance with the assumption. No good method for determining compliance is available since the error terms are unobservable and the estimated error terms are dependent upon the estimation procedure.

As was previously mentioned, the normalized wholesale cut price equations in Model I are fitted by ordinary least-squares for forecasting purposes. The estimated coefficients are biased and statistically inconsistent because there is more than one endogenous variable in each equation (27; 15, pp 232-334). But, the relevant concern for forecasting is that the estimated value of the normalized endogenous variable is efficient and unbiased.

Data Sources

With the exception of the wholesale beef and pork prices, data for this study were obtained from published government reports. As was previously mentioned, the wholesale prices came from The National Provisioner. (30) Per capita income data were obtained from the Survey of Current Business published by the Department of Commerce. (39) The monthly per capita income figure was derived by dividing seasonally adjusted monthly U.S. total personal income at annual rate by total population as of that month. Wage data were published in the Employment and Earnings report of the Department of Labor. (40) Other data were obtained from various reports published by the USDA. The monthly beef and pork data, excluding wholesale prices, were obtained on a current basis from Livestock, Meat, Wool Market News (36) and the Livestock and Meat Situation. (33) A more historical source of this data would be the Livestock and Meat Statistics (35) published annually since 1957. The quarterly inventory data were obtained from the Cattle on Feed (31) report and the Hogs and Pigs (32) report, which prior to June 1968 was titled Pig Crop Report. The poultry production data were obtained from the monthly report entitled, Poultry Slaughtered under Federal Inspection and Poultry Used in Further Processing (38).

CHAPTER III

ESTIMATED COEFFICIENTS FOR THE SIMULTANEOUS EQUATIONS (Model I)

The estimated coefficients of the eighteen stochastic equations in Model I are presented in four major sections-- 1) behavioral demand equations normalized on wholesale cut prices, 2) relation of normalized live prices to wholesale prices, 3) behavioral supply equations normalized on commercial production per workday of beef and pork, and 4) normalized change in pork storage equations.

Wholesale Demand Equations

Beef -- The estimated coefficients for the demand equations, normalized on wholesale beef and pork prices are presented in Table 1. As expected, wholesale beef cut prices were inversely related to the quantity of beef. However, price-quantity relationships differed among the beef cuts. The price flexibilities with respect to quantity found in the first column of Table 2 were calculated using mean values for the period under study. The relative positioning of the various flexibilities was somewhat contrary to expectations. The price of arm chucks was expected to be the most flexible.[1] with respect to

[1] Discussion of relative flexibilities will be in absolute terms throughout.

quantity because of its being a more standard item, with fewer alternative uses, in consumers' meat purchases as roasts, low-priced steaks, and ground beef or chuck. Also, arm chucks had the lowest average price of the four beef cuts studied and probably serves as a buffer when prices change. During price decreases, consumers probably tend to shift to more luxury meat items such as rib roasts, sirloin and round steaks tending to keep the prices of those cuts higher relative to arm chucks whose price would have to decrease even more in order to be purchased in greater amounts by the consumers. During price increases, the relative increase of arm chuck price may be more than for the three higher-price beef cuts as consumers shift some of their demand from these cuts to arm chucks. The price flexibilities with respect to quantity for rounds, ribs, and beef loins were expected to be less flexible than arm chuck prices because of their variety of uses and the relative ease of substituting pork roasts or chops, poultry, as well as lower-price arm chuck for them when their relative prices are high.

All the beef wholesale cut prices were directly related to the per capita personal income variable. As was previously stressed, the income variable is really a proxy for per capita income, population, trend, and other unspecified closely correlated factors. Thus, in looking at the differences in response to this income variable, income will be denoted in quotes. Price flexibilities with respect to "income", presented in column 2 of Table 2, were calculated using the mean values of the beef prices and "income". Beef rib price was the most flexible with respect to "income" indicating that as "incomes" increase the proportional price change of ribs was more than the proportional changes in the other beef cut prices. The "income" flexibilities of arm chuck and loin prices were slightly less. Again, as was found with respect to quantity, round price was the least flexible of the four beef cuts. The relatively high "income" flexibilities of beef rib and loin prices were consistent with prior expectations because of the high status roasts and steaks sold from these cuts at retail.

Three of the wholesale beef cut prices were inversely related to the quantity of pork. Only the pork quantity coefficient in the arm chuck equation was even slightly larger than its standard error. Thus, none of the coefficients for pork production in the wholesale beef price equations were significantly different from zero at the .05 level according to the asymptotic approximation of the "t-test" (coefficient/standard error).[1] The positive relationship

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[1] Significance in this chapter refers to statistical significance with an asymptotic approximation of a t-value judged against a critical .05 probability of a larger value of t, sign ignored, of approximately 2.0 with 75 degrees of freedom, for testing the hypothesis that the coefficients = 0. (29, p. 433)

TABLE 1. ESTIMATED COEFFICIENTS, COEFFICIENTS/STANDARD ERROR,* "R^2", ASYMPTOTIC DURBIN-WATSON STATISTIC FOR THE MODEL I EQUATION NORMALIZED ON WHOLESALE PRICES

Explanatory Variable	Normalized endogenous variable								
	Rounds	Armchks	BLoins	Ribs	Hams	Bellies	PLoins	Picnics	Butts
Intercept	38.80	21.00	46.98	35.86	71.17	72.77	71.04	48.26	66.68
Q_C	-.424	-.391	-1.16	-1.08	.065	.401	-.010	-.013	-.243
	(3.90)	(3.80)	(7.09)	(7.14)	(.423)	(3.20)	(.080)	(.141)	(1.72)
Q_H	-.062	-.133	-.004	.132	-1.36	-1.91	-1.07	-.900	-1.40
	(.543)	(1.24)	(.021)	(.832)	(8.70)	(13.83)	(7.80)	(11.43)	(9.56)
Change in Storage					.025	.028	-.068	.022	.066
					(3.31)	(5.15)	(2.26)	(1.13)	(1.41)
Storage					-.008	-.013	-.073	-.044	-.071
					(2.02)	(7.37)	(4.47)	(7.51)	(2.55)
I	14.46	13.05	31.11	29.57	7.86	3.70	8.73	5.82	15.28
	(7.36)	(7.04)	(10.57)	(10.78)	(2.36)	(1.51)	(3.79)	(2.96)	(5.85)
PERCOW	.230	.426	1.21	1.00					
	(1.58)	(3.11)	(5.54)	(4.95)					
MPORT	.004	.013	-.016	-.015					
	(.400)	(1.43)	(1.14)	(1.14)					
CKPD	-.004	-.002	-.027	-.037	.011	.028	.013	.015	.015
	(.432)	(.210)	(1.85)	(2.75)	(.799)	(2.46)	(1.20)	(1.96)	(1.11)
TKPD	-.012	-.009	.056	.046	.010	.005	.0002	-.007	.003
	(.844)	(.645)	(2.56)	(2.27)	(.513)	(.309)	(.012)	(.628)	(.128)

TABLE 7 -- Continued

Explanatory Variables	Normalized endogenous variable Rounds	Armchks	BLoins	Ribs	Hams	Bellies	PLoins	Picnics	Butts
Dummy Variables[1]									
Feb	-3.24	-1.96	-3.89	-6.77	-.65	-3.26	-3.12	-2.00	-2.95
Mar	-4.23	-2.43	-2.80	-5.32	5.92	- .76	-3.98	-3.39	-3.23
Apr	-4.15	-3.16	1.66	-1.26	-5.09	1.70	-4.51	-3.46	-5.17
May	-2.27	-3.11	8.52	2.62	-2.93	1.13	-4.58	-5.88	-6.31
Jun	-2.47	-4.08	8.96	2.71	-4.94	.97	-4.64	-6.65	-5.48
Jul	-3.08	-3.78	2.97	-3.92	-9.55	.88	-6.39	-8.28	-7.67
Aug	- .59	-3.01	-1.30	-4.99	-7.18	-5.37	-7.45	-8.21	-7.86
Sep	2.05	.41	-1.66	-6.94	-4.41	-3.17	-3.22	-2.87	-1.46
Oct	2.42	.43	-8.35	-11.87	-1.13	-8.89	-3.87	-1.18	- .93
Nov	- .34	-1.61	-18.69	-18.75	10.35	-4.55	-2.35	.80	- .32
Dec	-3.30	-4.50	-12.68	-7.86	12.89	-4.56	-1.20	-.96	- .51
"R^2"[2]	.82	.83	.89	.87	.88	.96	.94	.92	.90
D.W.[3]	.76	.73	1.50	1.39	1.55	2.03	1.45	1.32	1.54

[1]Only operative during the particular month in question with Jan. as the base.

[2]Proportion of variation explained by the coefficients for the specified normalized endogenous variable

[3]Since the range between d_U and d_U increases as the number of predetermined variables increase, the test for the Durbin-Watson statistic was only approximate because the available table (8, p 78) only went up to five predetermined variables. For 75 observations, d_L is 1.42 and d_U is 1.70. If D.W. is less than d_L, positive serial correlation is assumed to exist among the residuals. No serial correlation is assumed to exist if D.W. is greater than d_U. The test is inconclusive if the Durbin-Watson statistic lies between d_L and d_U.

* Figures in parentheses.

TABLE 2. Price flexibilities with respect to quantity and "income" for beef and pork wholesale cuts

	Price flexibilities with respect to:	
	Quantity	"Income"
Beef Cut		
Rounds	- .588	.856
Arm Chucks	- .818	1.167
Loins	-1.087	1.244
Ribs	-1.340	1.567

	Price flexibilities with respect to:	
	Quantity	"Income"
Pork Cut		
Hams	-1.378	.541
Bellies	-2.525	.332
Loins	-1.046	.580
Picnics	-1.529	.672
Butts	-1.747	1.296

between wholesale beef rib price and pork quantity suggested weak complementarity instead of substitutability.

The PERCOW variable, representing the amount of lower-quality beef in the total beef quantity, was positively related to the wholesale beef prices. As the proportion of lower-quality, less-competitive beef increases, it is reasonable to expect a higher price for Choice grade beef when considering only total beef production. The PERCOW variable was somewhat more of a relevant explanatory factor for the two higher-price cuts, as expected.

The effect of beef imports was inconsistent from equation to equation. None of the beef import coefficients were significantly different from zero. Increased imports should have a depressing effect on prices, as was found for beef loins and ribs. Yet, for beef rounds and arm chucks an increase in imports resulted in higher prices.

Chicken production was inversely related to wholesale beef prices but, the magnitude of the impact differed among cuts. For rounds, arm chucks, and loins the coefficients were not significantly different from zero, while for beef ribs the coefficient was significantly different from zero. The impact of chicken production was greatest on the two higher-price beef cuts. This implied stronger substitutability between relatively low-price chicken and high-price beef wholesale cuts than was evidenced between chicken and low-price beef cuts. Budget minded consumers have stronger motivations to substitute chicken for beef loins and ribs when the price of chickens fall than for arm chucks and rounds which are more equal to chicken in price.

The coefficients for turkey production were insignificant in the beef rounds and arm chuck equations. For beef loins and ribs, the coefficient for turkey production was significantly different from zero but with an unexpected positive sign. A satisfactory explanation of the positive sign was not found. It may have been spurious correlation related to the very seasonal turkey production pattern. If turkey is still thought of as a prestige or special occasion item, consumers may judge this prestige by the relative price levels. When turkey production increases in holiday seasons, it may be correlated to the demand increase for all meats which typically cause the price of beef holiday items to increase during those periods.

Monthly dummy intercept shifters (February-December), incorporated into the price equations to account for unspecified factors regularly affecting the level of demand in each month, showed somewhat different patterns for the various beef cuts. Given the level of the other variables, the level of demand related to the unquantified variables was low from February to July relative to the base month of January for rounds. Demand for rounds was highest during September and October before falling below the base again in December. Arm chuck demand started below the base level in February and decreased even further through June before increasing slightly during July and August. The peak demand for arm chucks occurred during September and October, as for rounds. The monthly intercept shifters for arm chucks were somewhat consistent with a prior study by Seaborg which looked at seasonal price variations for beef loins and arm chucks during the 1950's (26). Seaborg found a downward price shift for arm chucks from February to July. The peaks during September and October, for rounds and arm chucks may be associated with the advent of cooler weather and the demand for more roasts. Somewhat different demand shift patterns were evidenced for beef loins and ribs. Peak demand periods occurred during the early summer in May and June, with beef loins demand being above January levels for April-July. This period coincided with the start of the heavy charcoaling season. The demand for both loins and ribs declined from their peak in June to a low level during November, the traditional heavy turkey consumption month. This compares with Seaborg's findings of an upward price shift for beef loins from February to August. (26) The relatively high level of demand for all the beef cuts in January compared to December and February might be due to temporary heavy shift to beef purchases by consumers after the holiday season typified by heavy turkey and ham consumption.

The portion of variation in the wholesale beef price-variables explained by the estimated coefficients was 80 per cent or greater. The best fit ("R^2") was obtained for arm chucks at .89 with rounds being at the other end of the range at .82.

Pork

Wholesale pork prices were inversely related to pork quantity levels, as expected. (Table 1, p 46 and 47). All the price flexibilities with respect to pork quantity for the pork cuts were greater than one. (Table 2, p 48) Belly price was very responsive to quantity changes with a flexibility of -2.5, reflecting its rather limited use as bacon for which substitutes are limited.[1] A high flexibility for butts also indicated relatively limited use. Pork loin price was the least flexible of the pork prices to quantity changes. Pork loins have numerous uses as pork chops, high quality roasts, and a good variety item in the predominant beef meat purchases, which probably accounts for its relative flexibility level. The flexibilities of ham and picnic prices were similar probably because of the close substitutability between them. The wholesale pork price flexibilities with respect to quantity were higher than the wholesale beef price flexibilities with the exception of pork loins.

Response to beef quantity was not consistent among the pork cuts. A significant positive beef quantity coefficient was found in the belly price equation. The positive response of bellies, from which bacon is obtained, indicated that consumers might treat bacon as a complementary product to

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[1] This statement may have to be revised in the near future with the advent of a consumer acceptable synthetic "bacon analog" probably made from soy protein.

beef cuts preferring more "bacon" when the number of beef meals increases.

Pork prices reacted to both the beginning of the month storage levels and to the change in amount stored during the month. Beginning storage levels were inversely related to pork cut prices. When storage levels are high the potential of a sizeable movement into the market is present which depresses prices. The threat does not exist when storage levels are low and, depending on future expectations, the storage demand probably is stronger than usual for additional pork quantities, favoring higher prices. The change in storage coefficients for butts and picnics were not significantly different from zero, perhaps due to small magnitude of storage change, but the change in storage variables had the expected significant positive coefficients in the ham and belly price equations. As pork quantity is diverted from the market place into storage, the market price is expected to increase. Change in pork loin storage had an unexplained significant negative effect on pork loin price.

The response of pork wholesale prices to chicken and turkey production suggested a weak complementarity. Only an insignificant coefficient for turkey production in the picnic equation was negative. In fact all the turkey production coefficients in the pork price equations were insignificant. Only the positive coefficients for chicken production in the bellies and picnics equation were statistically significant. The tendency towards complementarity between poultry and pork may be a result of consumers utilizing poultry and pork jointly as substitutes for beef purchases, with little effect on other meat demands. In 1969 beef consumption per person was 110 pounds. (34) In comparison consumption per person of pork was 64 pounds, chicken 39 pounds, and turkeys 8 pounds. (37)

The expected positive response to the "income" variable was found for pork as it was for beef. Belly prices were only minorly affected by the "income" variable, with a price flexibility with respect to "income" of only .33. (Táble 2, p 48) This result may be at least partially explained by noticing that the flexibility for butts (1.3) is twice as great as that for any of the other pork cuts. Since nearly all of the better quality bellies are already processed into bacon, an increase in demand for bellies due to an "income" response can be met in two ways. One way would be to use lower quality bellies. The other way would be to process bacon from Boston butts. Findings of this model would lend support to the supposition that butts are used to supplement the bacon supply; thus, the "income" response is noted for butts and not so much for bellies. Price flexibility with respect to "income" for the other three pork cuts were similar, nearly twice as great as that found for bellies. In comparison to the beef "income" flexibilities, the pork "income" flexibilities, with the exception of butts, are all less. Thus, as expected, beef was a more prestigous item, in comparison to pork, which consumers favored purchasing when their "incomes" increased.

The monthly intercept shifter pattern for hams revealed the expected holiday influence. The net effect of unquantified variables revealed demand to be high in March during Lent and Easter and again in November and December. Demand for ham was low during the April to September period. Demand for bellies shifted above the base period of January from April to July and hit its low point during October. The pattern of the dummy variables for pork loins, picnics, and butts were mainly below the January base. Of the three, only picnics had a positive dummy coefficient which occurred for November. The three cuts experienced their lowest demand during the hot months of July and August when housewives probably have a greater aversion to hot ovens in already hot kitchens.

The portion of variation in the wholesale pork price variables explained by the estimated coefficients ranged from 88% for hams to 96% for bellies. Thus, the proportion of variance explained was generally higher for the pork wholesale prices relative to the beef wholesale prices.

Relation of normalized live prices

to wholesale cut prices

SteerP = -2.50 -.004 Rounds +.506 Armchks +.140 BLoins
(.063)[1] (7.60) (3.42)

+.022 Ribs +.455 Feb +.855 Mar +.900 Apr
(.454)

+.749 May +.390 Jun -.114 Jul +.439 Aug -.464 Sep

-.242 Oct +.016 Nov +.623 Dec "R^2"[2] = .97

D.W.[3] = 1.25

Hog P = -2.96 +.166 Hams +.191 Bellies +.180 PLoins -.007 Picnics
(6.63) (13.65) (7.21) (.206)

+.060 Butts +.403 Feb +.382 Mar +.772 Apr +.946 May
(1.69)

+.743 Jun +.306 Jul -.018 Aug -.331 Sep -.034 Oct

+.034 Nov -.083 Dec "R^2" = .99

D.W. = 1.40

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1 Figures in parenthese are coefficients/standard errors or asymptotic approximation of "t-values".

2 Proportion of variation explained by the coefficient for the specified normalized endogenous variable.

3 Durbin-Watson statistic. See footnote 3, Table 1, p 47 for further explanation.

Wholesale beef and pork prices were assumed simultaneously determined with live hog and steer prices. The wholesale and live price levels were also closely correlated. But, most producers probably use the live level prices when they are making the decision of whether to send their livestock to market. Thus, live price was used as an explanatory variable in the supply equations and live price was related to the wholesale price level from which it is derived. The simultaneity and close correlation assertions were further strengthened by the good estimation fit, in terms of "R^2", of relating the live prices to their corresponding wholesale prices plus monthly intercept shifters. The close fit using the same time period also corresponded to Snell's findings of no time lag between live and wholesale prices. (28)

Although the relationship between the live and wholesale prices was expected to be close, some variance was anticipated. Consequently, the monthly dummy intercept shifters were incorporated into the live price equations to pick up unspecified factors causing regular monthly differences. Packers may cut their margins to stimulate adequate supplies in the early fall, when less beef quantity is available and when the large spring and summer pig crops are not available, trying to more fully utilize fixed capacity. Packers' margins may widen from February to June when more plentiful quantities are available.

Coefficients for the wholesale prices in the two normalized live price equations are probably not very meaningful because of the high multicollinearity among the wholesale prices. Multicollinearity tends to result in relatively large standard errors compared to a situation of no multicollinearity, perhaps leading to the insignificant coefficient found in each live price equation.

Supply Equations

Whether producers respond to current price, change in prices, or some combination was not clear when the model was specified. Consequently, some experimentation was undertaken using different price alternatives in the supply equations. Comparisons of the price and storage equations in Model I estimated under two different assertions,[1] lagged live prices versus no lagged live prices, showed that the coefficients only differed slightly in magnitude with no differences found for behavioral interpretation.

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[1] Discussion of the other equations in the model was based on the fact that the identity equations, $CP = P_t - P_{t-1}$, were part of the model. Lagged live steer and hog prices were included in the model as predetermined variables. When just current live price levels were included in the supply equations, the identity equations for change in live prices were not part of the model and consequently the lagged live prices were also excluded.

The estimated coefficients and related statistics for the supply equations for beef and pork are presented in Table 3. Equations 1 and 3 follow the original specification for Model I presented on page 27. Equations 2 and 4 are alternate supply equations with live prices replacing changes in live prices as explanatory variables. Supply equations including both live price and change in live price were also estimated and are summarized briefly in the following discussion.

In equation 1 the change in steer price was included as an indicator of short-run price expectations. Beef supply was not significantly influenced by change in steer price. The positive relationship between change in steer price and beef supply indicated that beef producers sold more cattle when steer prices increased in the short-run and sold fewer when steer prices declined. Such price behavior indicated that beef producers expected the beef price movements to be temporary and to reverse themselves quickly. The price pattern was also substantiated by looking at patterns of average weight at which slaughter steers are sold. In periods of recent steer price increases the cattle were sold at lighter weights while price declines seemed to induce producers to hold cattle off the market and feed to heavier weights in anticipation of price increases.

In equation 2 beef supply was inversely related to live steer price. The steer price coefficient was signi-

TABLE 3. ESTIMATED COEFFICIENTS, COEFFICIENTS/STANDARD ERRORS,* "R^2", ASYMPOTOTIC DURBIN-WATSON TEST FOR THE MODEL I NORMALIZED SUPPLY EQUATIONS

Explanatory Variables	Normalized endogenous variables				
	Q_C			Q_H	
	Equation 1	Equation 2		Equation 3	Equation 4
Intercept	27.11	35.88	Intercept	8.13	1.03
CSteerP	.578 (1.16)		CHog P	-.786 (1.90)	
SteerP		-.485 (2.15)	Hog P		.109 (.79)
D1 S11[1]	.016 (3.43)	.013 (3.11)	D1 119	-.0006 (.786)	-.0006 (.831)
D1 S9	.006 (1.22)	.007 (1.53)	D1 179	-.001 (.819)	-.001 (.627)
D1 H9	-.0003 (.045)	.007 (.88)	D1 219	.011 (4.57)	.012 (3.94)
D1 H7	.0007 (.221)	.002 (.71)	D2 119	.003 (2.68)	.003 (2.17)
D2 S11	.013 (3.38)	.012 (3.53)	D2 179	-.002 (.762)	-.0003 (.135)
D2 S9	.011 (2.36)	.008 (1.92)	D2 219	.004 (1.70)	.003 (1.10)
D2 H9	-.006 (.976)	-.001 (.204)	D3 119	.003 (3.28)	.004 (2.93)

TABLE 3 continued

Explanatory Variables	Normalized endogenous variables				
	Q_C			Q_H	
	Equation 1	Equation 2		Equation 3	Equation 4
D2 H 7	.001 (.345)	.008 (1.69)	D3 179	.001 (.545)	.002 (.897)
D3 S11	.007 (1.96)	.007 (2.03)	D3 219	-.002 (.596)	-.003 (1.35)
D3 S9	.007 (1.63)	.006 (1.39)			
D3 H9	.006 (.895)	.009 (1.54)			
D3 H7	.008 (1.78)	.013 (2.86)			
BQ1	-4.41	-4.58	HQ1	2.65	2.89
BQ2	-2.10	-4.54	HQ2	11.18	11.55
BQ4	-.14	-.29	HQ4	2.16	.87
"R^2"[2]	.87	.89	"R^2"	.81	.78
D.W.[3]	.75	.74	D.W.	.43	.57

*Figures in parentheses are the coefficients/standard errors.

[1] The D's in this table refer to the month the quarterly on feed or on farm report is issued plus the following two months. S11 = Steers on feed 9-1100 lbs.; S9 = Steers on feed 700-900 lbs.; H9 = Heifers on feed 700-900 lbs.; H7 = Heifers on feed 500-700 lbs.; 119 = Hogs on farm 60-119 lbs; 179 = Hogs on farm 120-179 lbs.; 219 = Hogs on farm 180-219 lbs.

[2] Proportion of variation explained by the coefficients for the specified normalized endogenous variable.

[3] Durbin-Watson statistic. See footnote 3, Table 1, p 47 for further explanation.

ficantly different from zero. Current price levels may signal conflicting messages to producers. For example, a high price level may encourage producers to sell now and take the assured price and presumably good profit or it could encourage producers to hold off in expectation of even higher prices and profits. The negative coefficient would signify the latter of these two responses which is in conflict with the prior finding of the positive relationship to changes in steer price. When both current price and change in price were included in the same equation the signs of the coefficients were the same as those found when the variables were included individually leading to confusion as to the appropriate interpretation. From the criteria of reasonableness the change in price alternative appeared to be the most appropriate for the beef supply equation.

The confusion was increased even further by the fact that the estimated coefficients for the different pork price alternatives had opposite signs from the comparable beef coefficients, as seen in equations 3 and 4. A possible explanation for the inverse relationship between change in hog price and pork quantity found in equation 3 is that hog producers expect short-run price trends to continue. During rising trends this would imply that producers would hold their pigs off the market in expectation of higher prices forthcoming. The opposite response would be expected during downward trends with producers marketing their pigs early because of expected further drops in live hog price.

The expected direct price relationship was obtained when current hog price was included in equation 4. However, the hog price coefficient was not significant. When both price alternatives were incorporated in the same equation the directional responses were the same as when they were included individually.

The results of the alternative supply equations leave unresolved the question of whether producers are more responsive to short-run price expectations, current live price levels, or a combination of the two. Over the period studied the supply of beef produced was more responsive to live steer price while the supply of pork produced was more responsive to change in live hog price.

The on feed and on farm quarterly inventories by weight groups included in the supply equations were selected as being the relevant weight groups affecting marketings up to two months following the month in which the quarterly report was issued. The two months following the quarterly report month (D1) were distinquished from each other by the use of dummy variables, D2 and D3. The purpose of distinquishing between these months was to allow for marketing shifts among the weight and sex groupings as the lag from the quarterly reporting month increased. The expected shift in response from the heavier weights in the quarterly report month (D1) to the lighter weights by the second month (D3) following the quarterly report month was not always found. The impact of the 900-1100 pound steers on feed decreased from the quarterly report month to the second month following the report month, as expected. The coefficients for the heifer inventory variables had mixed signs resulting in uncertainity as to their impact. The coefficients for the hogs on farm inventory variables also had mixed signs. The expected heavy supply impact of the 180-219 pound hog class in the quarterly report month and of the 60-119 pound class in the second month following the quarterly report month were found. A probably explanation for the lack of a consistent shift from heavier to lighter weights being marketed, as the time following the quarterly report month increased, was that the different cattle on feed and hogs on farm weight groupings were highly correlated (=.9 or above) for both hogs and cattle. Consequently, the estimated coefficients for the weight groupings during the same time period were probably subject to large standard errors and a clear distinction of the effects of each weight group was not possible.

Given the other variables, the quarterly dummy shifters indicated that commercial beef production per work day was lower in the other three quarters relative to the base quarter of August, September, and October. Marketings of grass fed cattle off the range in the fall might be a partial explanation for this finding. The rates of gain during the base quarter might be better than during the preceding hot months and following cold months. The base quarter for the dummy shifters in the commercial hog production per work day was July, August, and September. This base quarter differs from beef because of a one month difference in the timing of the quarterly inventory reports. The supply of hogs, relative to the base quarter was higher for the other three quarterly periods. Hot weather, slower growth rates, and expectations of price declines during the hot summer months may cause hogs to be marketed at lower weights during this period of the year.

The portion of variance explained by the coefficients for the supply equations containing the different price alternatives varied only slightly from each other. For the beef supply equations, the amount ranged from .87 for the equation containing change in price to .89 for current price and for the combination of the price alternatives. For hog supply the range was from .78 for the supply equation incorporating current hog price to .91 for the change in price and combination of price alternatives equations.

<u>Change in pork storage equations</u>

The estimated coefficients and related statistics for these equations are found in Table 4. For the most part higher wholesale pork cut prices were associated with reductions in storage levels. Only the coefficient for ham price was positive, although statistically insignificant. With high prices one would expect movements out of storage and back into the market channels. With one exception, the response to pork quantity was positive. The exception this time was the insignificant coefficient obtained for the change in picnic storage equation. Generally, as pork quantity increased the amount in storage increased. Larger beginning of the month storage stocks resulted in an out-movement of storage stocks during the month. Smaller beginning storage stocks typically were associated with supply moving into storage during the month, probably as a safeguard against the fluctuating and uncertain supply picture or because of an improved outlook for storage profits.

The pattern for the change in monthly storage intercept shifters for hams showed peaks in January, April, and October relative to the rest of the months. These high points might have resulted from the expectation of or replenishing after the more traditional ham eating holiday seasons of Thanksgiving-Christmas and Easter. The patterns of the dummy variables for the change in pork cut storage equations were probably contingent on the unspecified storage profit outlook.

TABLE 4. ESTIMATED COEFFICIENTS, COEFFICIENTS/STANDARD ERRORS*, "R^2", ASYMPTOTIC DURBIN-WATSON TESTS FOR THE MODEL I EQUATIONS NORMALIZED ON CHANGE IN PORK STORAGE

	Normalized endogenous variables				
	CHAMST	CBELST	CLOINST	CPICNST	CBUTST
Intercept	25.85	-95.41	129.77	81.78	18.02
Wholesale pork cut price	.224 (.085)	-1.28 (-.551)	-2.00 (4.44)	-2.07 (2.24)	-.588 (2.06)
Q_H	2.33 (.879)	5.79 (1.77)	.054 (.121)	-.408 (.524)	.387 (1.12)
Storage by cut	-.095 (.983)	-.117 (1.55)	-.444 (5.20)	-.200 (2.38)	-.323 (3.34)
Dummy Variables[1]					
Feb	-25.53	99.74	1.44	.98	1.03
Mar	+187.99	160.54	13.77	20.16	10.38
Apr	48.84	150.70	22.36	11.33	19.45
May	-139.79	5.55	15.67	-4.29	8.49
Jun	-184.57	-155.94	12.53	-14.41	4.42
Jul	-140.71	-294.77	.91	-9.99	-1.08
Aug	-174.95	-282.28	-9.25	-11.64	-5.25
Sep	-50.67	-218.33	-16.73	-6.50	-7.29
Oct	17.83	-67.09	-13.82	2.88	-6.21
Nov	-160.09	17.37	13.84	22.86	3.81
Dec	-261.64	93.03	23.79	16.94	-.56
"R^2" [2]	.80	.89	.81	.53	.63
D.W. [3]	1.87	.95	1.42	1.34	1.64

[1] Only operative during the particular month in question with Jan. being the base month.

[2] Proportion of variation explained by the coefficients for the specified normalized endogenous variable.

[3] Durbin-Watson statistic. See footnote 3, Table 1, p 47 for further explanation.

* Figures in parentheses are the coefficients/standard errors.

This assertion was somehat consistent with the pattern found for change in belly storage shifters. Pork bellies have an active futures market. The futures market might be looked on as a close guideline for future prices as well as a deliverable forward contract. The belly storage shifter showed seasonal outmovements from June through October. Current pork belly contract provisions do not allow delivery on the February through August contracts if the product is stored prior to December 1. (5) Thus, the inmovement of bellies to storage from December to May may have been a consequence of a possible guaranteed picture of future prices and storage profits. The pattern of storage shifters for pork loins, picnics, and butts were similar to the pattern found for bellies. Thus, storage changes probably depended upon the profitability picture of storing these pork cuts, which may have been derived from the belly futures market as well as other factors influencing price expectations.

Summary

Behavioral wholesale demand and supply relationships were formulated into a simultaneous model (Model I). Model I consisted of 20 simultaneous equations--9 wholesale cut price or demand equations, 2 specifying the relationship between live and wholesale prices, 2 specifying the factors influencing beef and pork supply, 5 equations involving factors affecting change in pork cut storage behavior plus

2 identity equations.

As expected, beef quantity was inversely related to the wholesale beef cut prices. Contrary to expectations, arm chuck price was found to be less flexible (-.8) to quantity changes than beef loin (-1.1) and rib (-1.3) prices. Round price was found to be relatively inflexible (.9) with respect to "income". Of the beef cuts, the "income" flexibility of ribs was the highest at 1.6.

The coefficients for pork quantity and beef imports in each of the beef cut demand or price equations were not significantly different from zero. The PERCOW variable, which qualified the beef quantity variable by representing the proportion of lower-quality beef, was positively related to the wholesale beef prices. As the proportion of lower quality, less-competitive beef increased, a higher Choice grade beef price resulted. A greater impact of chicken production on the two higher-price beef cuts suggested stronger substitutability between low-price chicken and higher-price beef cuts relative to the lower-price beef cuts. Turkey production also had more of an impact on the two higher-price beef cuts, but it was an unexpected positive relationship.

Calculated price flexibilities with respect to quantity for the wholesale pork cuts were generally slightly more flexible than for the beef cuts. Belly price was very responsive to quantity changes indicating its rather limited

use as bacon for which substitutes are presently limited. In comparison to the beef "income" flexibilites, the pork "income" flexibilities were less, with the exception of butts. Compared to pork, beef generally appeared to be a more prestigous item which consumers favored purchasing when their "income" increased.

The significant positive beef quantity coefficient found in the belly demand equation indicated that consumers might treat bacon as a complementary product to beef cuts. Complementarity between the wholesale pork prices and chicken and turkey production was suggested by the positive poultry quantity coefficients.

Beginning pork storage levels were inversely related to the pork cut prices. The expected positive change in pork storage coefficients were obtained in all the normalized pork price equations except for pork loins where an unexplained negative coefficient was noted.

It was assumed that cattle and hog feeders respond to live price when they are making their marketing decisions. The simultaneity and close correlation assertions between the wholesale and live price levels were strengthened by the close statistical relationship found between live price and corresponding wholesale prices.

Some experimentation was undertaken using different price alternatives in the supply equations. When the change in live steer price was included in the cattle supply equations an insignificant positive coefficient was obtained. When current steer price was included in the supply equation an unexpected inverse relationship was found. Producers appeared to look at current price levels as a sign of continued future trends. When either change in hog price or current hog price was included in runs of the hog supply equations, its coefficient had opposite signs from the comparable beef price coefficients. Hog producers appeared to interpret change in price as a short-run price trend which they expected to continue, and adjusted their marketings accordingly.

In the supply equations, the expected shift in response from the heavier weight inventory groups in the quarterly report month to the lighter weight groups by the second month following the quarterly report month was not always found. The estimated coefficients for the weight groups were probably subject to large standard errors because of the high correlation among the weight groupings; consequently, the estimated statistical impact of the various inventory weight groups was not always consistent with expectations.

In each of the change in pork cut storage equations, significant negative relationships between the corresponding wholesale pork cut price and storage changes were found.

The level of pork quantity was not a significant explanatory variable in the storage equations. Beginning storage levels were inversely related to change in storage.

CHAPTER IV

FACTORS AFFECTING RELATIVE BEEF AND PORK WHOLESALE PRICES (Model II)

Inquiry in this chapter shifts from the absolute wholesale price levels discussed in Chapter III to relative comparisons among the nine wholesale cut prices. In looking at relative price levels some relevant explanatory variables used in the normalized wholesale price equations in the preceding chapter were expected to have little impact on the wholesale cut price ratios, since the impact would balance out. Further, the simultaneity between beef and pork quantities and the various price ratios appeared to be minimal. Since simultaneity was assumed to be minimal, ordinary least squares techniques were used to fit the cut/cut price ratio equations. Discussion of the results is divided into three major categories of (1) beef/beef, (2) pork/pork, and (3) beef/pork wholesale cut price ratios. To enhance the comparability of the different results, each beef cut price was used as a common denominator relative to the other three beef cut prices, while each pork cut price was used as a common denominator for the other eight beef and pork cut prices.

Beef/Beef Wholesale Cut Price Ratios

a) Relative to rounds

$$\text{Armchks/Rounds} = .977 \underset{(7.36)^{1}}{-.006}\, Q_C \underset{(5.76)}{-.005}\, Q_H \underset{(7.64)}{+1.26}$$

$$\text{I} -.023 \text{ Feb} -.022 \text{ Mar} -.047 \text{ Apr}$$

$$-.081 \text{ May} -.093 \text{ Jun} -.085 \text{ Jul}$$

$$-.081 \text{ Aug} -.016 \text{ Sep} -.001 \text{ Oct} -.003$$

$$\text{Nov} -.047 \text{ Dec} \qquad R^2 = .64^2$$

$$\text{D.W.} = 1.14^3$$

$$\text{BLoins/Rounds} = 1.53 \underset{(.455)}{+.001}\, Q_C \underset{(3.28)}{-.010}\, Q_H \underset{(1.14)}{+.062}\, \text{I}$$

$$+.013 \text{ Feb} +.072 \text{ Mar} +.140 \text{ Apr} +.159$$

$$\text{May} +.166 \text{ Jun} +.163 \text{ Jul} +.122 \text{ Aug}$$

$$+.155 \text{ Sep} +.094 \text{ Oct} +.095 \text{ Nov} +.118 \text{ Dec}$$

$$R^2 = .62$$

$$\text{D.W.} = .66$$

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1 Figures in parentheses refer to calculated "t-values" for testing the hypothesis that coefficients = 0 where the critical "t-value" at the .05 level of approximately 2.0 with 88 degrees of freedom.

2 Proportion of variation explained by the coefficients for the endogenous variable.

3 Durbin-Watson statistic, for 90 observations d_L is 1.48 and d_U is 1.71 for a two-tailed test at a 5% probability level. See footnote 3, Table 1, p 47 for further explanation.

$$\text{Ribs/Rounds} = 1.20 \underset{(1.42)}{-.003}\, Q_c \underset{(2.34)}{-.006}\, Q_H \underset{(2.85)}{+.122}\, I -.061\ \text{Feb} -.019$$

$$\text{Mar} +.044\ \text{Apr} +.016\ \text{May} +.001\ \text{Jun} -.033$$

$$\text{Jul} -.024\ \text{Aug} +.004\ \text{Sep} - .033\ \text{Oct} +.021\ \text{Nov} +.141$$

$$\text{Dec} \qquad R^2 = .50$$

$$\text{D.W.} = .67$$

For beef quantity, the coefficient in the Armchks/ Rounds equation was the only one significantly different from zero. The negative relationship between beef quantity and the price ratio indicated that as beef quantity increased the arm chuck/round price ratio decreased. The decrease in the price ratio was the result of round price decreasing proportionally less than arm chuck price.[1] This suggested that the price flexibility with respect to quantity was greater for arm chucks than rounds. Such relative flexibilities were clearly inconsistent with the calculated flexibilities in Chapter III, (see Table 2, p 48). The more flexible position of arm chucks relative to rounds corresponded to prior expectations with rounds being considered somewhat more of a luxury meat item than chucks

[1] To facilitate more consistent interpretation of the effect of the explanatory variables on the wholesale price ratios the following assumptions are made: 1) an inverse relationship exists between beef and pork quantity and their wholesale cut prices and 2) a direct relationship between income and wholesale cut prices exists.

and adapting to a greater variety of uses. The insignificant beef quantity coefficients in the BLoins/Rounds and Ribs/Rounds equations indicated that price flexibilities with respect to quantity for beef loins, ribs, and rounds probably were similar. The differing coefficient signs suggested that rib price was the most flexible while loin price was the least of these three cut prices.

All the coefficients for pork quantity were significantly different from zero in the beef cuts/rounds price ratio equations. Although the coefficients of pork quantity in the simultaneous wholesale price equations were all insignificant, pork quantity was a relevant variable in explaining the relative differences between round price and the other beef prices. As pork production increased the price of rounds decreased proportionally less than the other three beef cut prices. Pork roasts are possibly more substitutable for arm chuck roasts than for round and rump roasts. When pork quantity increases and presumably prices decrease, the incentive may be higher to substitute for higher-price beef loins and ribs than the more medium-price rounds in striving to lower one's expenditures for meats.

The "income" coefficients were positively related to the price ratios, although the coefficient in the BLoins/Rounds equation was not statistically significant. Consistent with the findings in Chapter III, the price flexibilities with respect to "income" appeared higher for arm chucks, loins, and ribs than rounds. One might expect a relative shift to more expensive cuts as "income" increases but the relative greater shift to a lower price cut, such as arm chucks, was unexplained. One possibility is that, as "income" increases, greater emphasis is placed by the consumer on increasing the quantity of beef purchased relative to shifting to higher-price beef cuts.

Given the specified variables, the pattern of the monthly dummy intercept shifters can be observed in the above equations with January as the base month. Relative to rounds, arm chucks, a traditional roast cut, probably are not preferred by housewives during the hot summer months. The relative demand for beef loins was usually greater during the summer months perhaps due to "charcoaling" demand. Ribs appeared to be a pronounced Christmas-New Year holiday menu item.

b) Relative to arm chucks

$$\text{Rounds/Armchks} = .834 + .013\,Q_C + .012\,Q_H - .280\,I$$

$$(7.44) \quad (5.91) \quad (7.90)$$

$$+ .055\,\text{Feb} + .051\,\text{Mar} + .106\,\text{Apr} + .184\,\text{May}$$

$$+ .213\,\text{Jun} + .188\,\text{Jul} + .179\,\text{Aug} + .036\,\text{Sep}$$

$$+ .003\,\text{Oct} + .009\,\text{Nov} + .106\,\text{Dec}$$

$$R^2 = .66$$

$$\text{D.W.} = 1.18$$

$$\text{BLoin/Armchks} = \underset{}{1.36} \underset{(3.77)}{+.020\,Q_c} \underset{(.328)}{+.002\,Q_H} \underset{(2.83)}{-.305\,I} +.097\,\text{Feb}$$

$$+.177\,\text{Mar} +.356\,\text{Apr} +.506\,\text{May} + .561\,\text{Jun}$$

$$+.509\,\text{Jul} +.437\,\text{Aug} +.277\,\text{Sep} +.144\,\text{Oct}$$

$$+.153\,\text{Nov} +.325\,\text{Dec}$$

$R^2 = .65$

D.W. = .70

$$\text{Ribs/Armchks} = 1.06 \underset{(2.41)}{+.010\,Q_c} \underset{(.999)}{+.005\,Q_H} \underset{(1.53)}{-.127\,I} -.027\,\text{Feb}$$

$$+.029\,\text{Mar} + .182\,\text{Apr} +.227\,\text{May} + .235\,\text{Jun}$$

$$+.156\,\text{Jul} +.162\,\text{Aug} +.044\,\text{Sep} -.045\,\text{Oct}$$

$$+.039\,\text{Nov} +.332\,\text{Dec}$$

$R^2 = .53$

D.W. = .77

Beef quantity was statistically significant in explaining relative differences between arm chuck price versus the other beef prices. The coefficients were directly related to the price ratios suggesting that the price flexibilities with respect to quantities were less for rounds, loins, and ribs than for arm chucks, corresponding to the findings in section a). Only the pork quantity coefficient in the Rounds/Armchks equation was significant. This significance was consistent with the reciprocal relationship in the first equation in section a).

The inverse relationship between "income" and the price ratios suggested that the proportional influence of "income" was greater for arm chucks than for the other three beef cuts. This finding was inconsistent with the beef "income" flexibilities calculated in Table 2 in Chapter III where loin and rib prices were found to be more flexible with respect to"income" than arm chuck price.

The pattern of the monthly intercept shifters were similar. Relative to the base month of January, arm chuck price increased less than the other beef cut prices as the intercept shifted higher to its peak during the summer, non-roast, months before decreasing towards the base level during the fall and early winter. Another sharp upturn was evidenced during December indicating that beef loins, ribs and rounds are more traditional holiday menu items relative to arm chucks.

c) Relative to beef loins

$$\text{Rounds/BLoins} = .682 - \underset{(.755)}{.001\, Q_C} + \underset{(3.08)}{.004\, Q_H} - \underset{(.888)}{.022\, I} - .010\ \text{Feb}$$

$$- .041\ \text{Mar} - .073\ \text{Apr} - .079\ \text{May} - .082\ \text{Jun}$$

$$- .082\ \text{Jul} - .064\ \text{Aug} - .078\ \text{Sep} - .048\ \text{Oct}$$

$$- .049\ \text{Nov} - .062\ \text{Dec}$$

$$R^2 = .63$$

$$\text{D.W.} = .66$$

$$\text{Armchks/BLoins} = .677 \underset{(4.28)}{-.005} Q_c \underset{(.650)}{-.001} Q_H \underset{(3.20)}{+.074} I -.023 \text{ Feb}$$

$$-.044 \text{ Mar} -.083 \text{ Apr} - .109 \text{ May} -.119 \text{ Jun}$$

$$-.115 \text{ Jul} -.100 \text{ Aug} -.065 \text{ Sep} -.033 \text{ Oct}$$

$$-.036 \text{ Nov} -.075 \text{ Dec}$$

$R^2 = .65$

D.W. = .64

$$\text{Ribs/BLoins} = .804 \underset{(3.27)}{-.003} Q_c \underset{(1.10)}{+.001} Q_H \underset{(3.06)}{+.057} I -.054 \text{ Feb}$$

$$-.056 \text{ Mar} -.049 \text{ Apr} -.077 \text{ May} -.089 \text{ Jun}$$

$$-.109 \text{ Jul} -.084 \text{ Aug} -.081 \text{ Sep} -.075 \text{ Oct} -.039$$

$$\text{Nov} +.030 \text{ Dec}$$

$R^2 = .78$

D.W. = 1.53

None of the three specified explanatory variables were statistically significant over all three equations. As stated previously for its reciprocal, pork quantity appeared to be the most relevant explanatory variable in explaining the relative round and beef loin price fluctuations. In explaining the relative differences between arm chuck/beef loin prices and rib/beef loin prices, beef quantity and "income" were more relevant.

The inverse relationship between beef quantity and the price ratios suggested that the price flexibility with respect to quantity for beef loins was less than the flexibilities for the other three beef cuts. The insignificant "income" coefficient in the Rounds/BLoins equation suggested that the "income" flexibilities of beef loin and round prices were similar, with beef loin price being slightly more flexible. The positive "income" coefficients of Ribs/BLoins and Armchks/BLoins equations suggested that rib and arm chuck prices were more flexible than beef loin price with respect to "income".

The patterns of the monthly intercept shifters for the Rounds/BLoins and Armchks/BLoins equations were, as expected, the opposite of the previously discussed BLoins/Rounds and BLoins/Armchks equations in sections a) and b). The monthly intercept pattern for the Ribs/BLoins equation emphasized that the relative rib demand was only greater than loins during the Christmas holiday season.

d) Relative to ribs

$$\text{Rounds/Ribs} = .830 \underset{(1.55)}{+.003}\, Q_c \underset{(2.39)}{+.004}\, Q_H \underset{(3.02)}{-.102}\, I +.053\text{ Feb}$$

$$+.016\text{ Mar} -.034\text{ Apr} -.010\text{ May} +.001\text{ Jun}$$

$$+.030\text{ Jul} +.020\text{ Aug} -.003\text{ Sep} +.029\text{ Oct} -$$

$$-.016\text{ Nov} - .102\text{ Dec}$$

$$R^2 = .50$$

$$D.W. = .68$$

$$\text{Armchks/Ribs} = .835 \underset{(2.57)}{-.004}\, Q_c \underset{(1.08)}{-.002}\, Q_H \underset{(1.58)}{+.046}\, I +.016\text{ Feb}$$

$$-.009\text{ Mar} -.066\text{ Apr} -.080\text{ May} -.085\text{ Jun}$$

$$-.059\text{ Jul} -.060\text{ Aug} -.018\text{ Sep} +.020\text{ Oct}$$

$$-.014\text{ Nov} -.110\text{ Dec} \qquad R^2 = .54$$

$$D.W. = .75$$

$$\text{BLoins/Ribs} = 1.25 \underset{(3.12)}{+.005\, Q_C} \underset{(1.07)}{-.002\, Q_H} \underset{(2.98)}{-.097\, I} +.087\ \text{Feb}$$

$$+.092\ \text{Mar} +.080\ \text{Apr} +.129\ \text{May} +.154\ \text{Jun}$$

$$+.196\ \text{Jul} +.145\ \text{Aug} +.139\ \text{Sep} +.128\ \text{Oct}$$

$$+.064\ \text{Nov} -.038\ \text{Dec} \qquad R^2 = .77$$

$$\text{D.W.} = 1.50$$

These three dependent variables are simply reciprocals of previously discussed variables. The equations are presented to provide a clearer picture of which variables are relevant in explaining the relative differences in rib price versus the other beef cut prices. As for beef loins, no one specified explanatory variable was statistically significant in all three equations. Pork quantity and "income" appeared to be the most relevant explanatory variable in the Rounds/Ribs equation. Only the beef quantity coefficient was significant among the three specified explanatory variables in the Armchks/Ribs equation. For the BLoins/Ribs equation the coefficients for beef quantity and "income" were significantly different from zero.

Now that all the various paired relationships among the beef cuts have been assessed, the consistency of the suggested relative price flexibilities with respect to beef quantity and"income" among the preceding sections a), b), c), and d) can be summarized. Judging from the size and signs of the beef quantity coefficients, the relative price flexibilities with respect to quantity were consistent among the sections. Arm chuck price appeared to be the most flexible. The flexibilities for round, beef loin, and rib prices seemed to differ only slightly with rib price being the most flexible and beef loin price the least of the trio of prices. The relative price flexibilities with respect to "income" were also consistent among the sections. Round and beef loins prices appeared to be the least flexible to "income" changes. The "income" flexibilities for round and beef loin prices appeared to be similar with beef loin price generally being slightly more flexible. The "income" flexibilities for rib and arm chuck prices seemed to be somewhat more flexible with arm chuck price being the more flexible of the two.

Pork/Pork Wholesale Cut Price Ratios

1) Relative to hams

$$\text{Bellies/Hams} = 1.18 \underset{(1.86)}{+.005} Q_C \underset{(7.66)}{-.022} Q_H \underset{(2.13)}{+.118} I \underset{(2.32)}{-.044}$$

BELST/HAMST −.074 Feb −.033 Mar +.075 Apr −.031 May −.088 Jun −.086 Jul −.147 Aug −.081 Sep −.142 Oct −.145 Nov −.143 Dec

$R^2 = .73$

D.W. = .66

$$\text{PLoins/Hams} = 1.24 - .002\, Q_c - .007\, Q_H + .155\, I - .286$$
$$(1.27) \quad (3.13) \quad (3.92) \quad (3.70)$$

LOINST/HAMST −.116 Feb −.200 Mar −.127 Apr

−.095 May −.040 Jun +.004 Jul −.028 Aug

+.023 Sep −.119 Oct −.281 Nov −.268 Dec

$R^2 = .82$

D.W. 1.28

$$\text{Picnics/Hams} = .834 - .003\, Q_c - .006\, Q_H + .123\, I - .237$$
$$(3.20) \quad (5.48) \quad (6.20) \quad (7.30)$$

PICNST/HAMST −.074 Feb −.114 Mar −.059 Apr

−.085 May −.081 Jun −.086 Jul −.111 Aug

−.058 Sep −.077 Oct −.128 Nov −.154 Dec

$R^2 = .80$

D.W. = 1.01

$$\text{Butts/Hams} = 1.05 - .006\, Q_c - .012\, Q_H + .257\, I - .268$$
$$(3.88) \quad (7.38) \quad (8.17) \quad (1.88)$$

BUTTST/HAMST −.061 Feb −.082 Mar −.040 Apr

−.058 May −.020 Jun −.013 Jul −.035 Aug

+.040 Sep −.026 Oct −.109 Nov −.130 Dec

$R^2 = .82$

D.W. = 1.37

Statistically significant inverse relationships were found between pork quantity and the price ratios. The negative coefficients suggested that the price flexibility with respect to quantity for hams was less than the flexibilities for the other four pork prices. The size of the pork quantity coefficients indicated that belly price was the most flexible while the flexibilities of picnic, pork loin, and butt prices appeared to differ only slightly. Referral again to Table 2 points up inconsistencies between these relative flexibilities and the calculated flexibilities of the simultaneous equations discussed in Chapter III. In both cases the flexible position of belly price was consistent.

The relative inflexible position of ham price probably was a function of the multiple uses of hams. Hams are used as a rather distinctive, at least in terms of color and taste, change of pace item to beef cuts, as a cold cut, and in various casserole dishes. Likewise, as speculated previously, the flexible position of belly price may be the result of its rather limited use for bacon only, with bacon becoming less of a standard breakfast item.

Another consistent significant explanatory variable over the four equations was "income". The positive coefficient suggested that the price flexibility with respect to "income" for hams was less than for the other cuts, suggesting a relative shift to other pork cuts when "incomes" increase. The relative "income" flexibility of butts appeared to be the most flexible of the pork cut prices.

This relative flexible position of butt price was consistent with the results for the simultaneous equations (See Table 2, p 48). As previously hypothesized, this flexible position of butt price may be modified somewhat when the increased demand for bacon, which may be picked up by butt price, is considered.

Only the beef quantity coefficients in the Picnics/Hams and Butts/Hams equations were significant, indicating that beef quantity was more relevant in explaining the relative price differences between hams and the two lower-price pork cuts. Beef quantity increases may have caused demand to shift away from these lower-price pork cuts more than they affected the demand for hams.

The beginning storage ratios were inversely related to the price ratios. Under the assumption that wholesale pork prices and their beginning storage levels were inversely related,[1] as was found in Chapter III, a relative increase in stored quantity caused a relative price decrease, as one might expect.

The traditional Thanksgiving and Christmas demand for hams was evidenced by the relatively low intercept levels

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[1] This assumption shall be carried forward for the rest of the chapter.

during November and December. The relatively high intercept levels in January could well be a factor of consumers being somewhat tired of ham after this holiday season.

2) Relative to bellies

$$\text{Hams/Bellies} = .879 \underset{(2.53)}{-.010\, Q_C} \underset{(7.65)}{+.037\, Q_H} \underset{(1.95)}{-.159\, I} \underset{(1.36)}{-.083}$$

HAMST/BELST +.080 Feb +.007 Mar -.106 Apr +.055 May +.157 Jun +.167 Jul +.217 Aug +.096 Sep +.255 Oct +.304 Nov +.230 Dec

$R^2 = .77$

D.W. .71

$$\text{PLoins/Bellies} = 1.17 \underset{(2.21)}{-.012\, Q_C} \underset{(4.07)}{+.025\, Q_H} \underset{(.081)}{+.008\, I} \underset{(2.51)}{-.618}$$

LOINST/BELST -.021 Feb -.194 Mar -.250 Apr -.058 May +.110 Jun +.163 Jul +.219 Aug +.203 Sep +.248 Oct -.002 Nov -.045 Dec

$R^2 = .53$

D.W. = .82

$$\text{Picnics/Bellies} = .708 \underset{(5.14)}{-.013\, Q_C} \underset{(5.55)}{+.015\, Q_H} \underset{(2.32)}{+.117\, I} \underset{(1.65)}{-.270}$$

PICNST/BELST -.019 Feb -.114 Mar -.127 Apr -.052 May +.022 Jun +.022 Jul +.026 Aug +.020 Sep +.082 Oct +.010 Nov -.058 Dec

$R^2 = .68$

D.W. = .84

$$\text{Butts/Bellies} = .960 \underset{(4.53)}{-.016\, Q_C} \underset{(3.47)}{+.014\, Q_H} \underset{(3.02)}{+.215\, I} \underset{(1.03)}{-.361}$$

$$\text{BUTTST/BELST} -.007\ \text{Feb} -.093\ \text{Mar} -.136\ \text{Apr}$$

$$-.031\ \text{May} +.095\ \text{Jun} +.109\ \text{Jul} +.129\ \text{Aug}$$

$$+.133\ \text{Sep} +.147\ \text{Oct} +.026\ \text{Nov} -.015\ \text{Dec}$$

$$R^2 = .48$$

$$\text{D.W.} = .86$$

The relative differences between belly price and the other pork cut prices were consistently related, in terms of statistical significance, to both beef and pork quantities. The positive pork quantity coefficients suggested that belly price was more flexible than the other four pork prices, consistent with the results in section 1). Recall that in the simultaneous equations a significant positive beef quantity coefficient was obtained in the normalized wholesale belly price equation. A possible explanation forwarded was that bellies, in the form of bacon, may be used as a rather consistent complementary variety item in conjunction with beef in menu planning. If in fact this relationship between belly price and beef quantity does hold, it readily would explain the inverse relationships between beef quantity and the price ratios.

The significant "income" coefficients in the Picnics/Bellies and Butts/Bellies equations suggested that the "income" flexibilities of picnic and butt prices were somewhat greater than the "income" flexibility for belly price. The inverse relationship between "income" and ham/belly price ratio suggested that again ham price was more inflexible with respect to "income" than the other pork cut prices.

As expected, inverse relationships were found between the storage ratios and the price ratios over the four equations. Only the storage ratio coefficient in the PLoins/Bellies equation was significantly different from zero.

The patterns of the seasonal intercept changes were similar for pork loins, picnics and butts relative to bellies. The coefficients for the dummy variables were below the January base from February to May. From June to November the intercepts generally were above the January levels.

3) Relative to Pork loins

$$\text{Hams/PLoins} = .963 \underset{(1.05)}{+.002\, Q_C} \underset{(3.00)}{+.006\, Q_H} \underset{(3.46)}{-.124\, I} \underset{(2.66)}{-.019}$$

$$\text{HAMST/LOINST} +.062 \text{ Feb} +.139 \text{ Mar} +.075$$

$$\text{Apr} +.046 \text{ May} -.009 \text{ Jun} -.038 \text{ Jul} -.017 \text{ Aug}$$

$$-.055 \text{ Sep} +.061 \text{ Oct} +.256 \text{ Nov} +.225 \text{ Dec}$$

$$R^2 = .83$$

$$\text{D.W.} = 1.19$$

$$\text{Bellies/PLoins} = 1.11 \underset{(2.82)}{+.007\, Q_c} \underset{(6.12)}{-.017\, Q_H} \underset{(.043)}{+.002\, I} \underset{(3.72)}{-.023}$$

BELST/LOINST +.013 Feb +.135 Mar +.180 Apr

+.053 May -.040 Jun -.077 Jul -.117 Aug

-.101 Sep -.091 Oct +.023 Nov +.033 Dec

$R^2 = .61$

D.W. = .92

$$\text{Picnics/PLoins} = .779 \underset{(1.88)}{-.002\, Q_c} \underset{(1.91)}{-.002\, Q_H} \underset{(1.61)}{+.034\, I} \underset{(7.80)}{-.096}$$

PICNST/LOINST -.010 Feb -.002 Mar +.017 Apr

-.030 May -.058 Jun -.084 Jul -.091 Aug

-.065 Sep -.009 Oct +.038 Nov +.0002 Dec

$R^2 = .73$

D.W. = 1.27

$$\text{Butts/PLoins} = 1.00 \underset{(3.63)}{-.005\, Q_c} \underset{(4.21)}{-.006\, Q_H} \underset{(6.24)}{+.161\, I} \underset{(4.18)}{-.266}$$

BUTTST/LOINST +.001 Feb +.041 Mar +.043 Apr

+.008 May +.008 Jun -.020 Jul -.017 Aug

+.018 Sep +.049 Oct +.080 Nov +.050 Dec

$R^2 = .58$

D.W. = 1.59

Consistent with sections 1) and 2), the size and signs of the beef quantity coefficients suggested that ham price was least flexible and belly price most flexible with respect to pork quantity changes. Pork loin price appeared to be slightly less flexible than picnic and butt prices suggesting that pork loins may have more alternative uses than picnics and butts. Pork loins are used for high quality pork chops and roasts as well as being an item easily substituted for beef roasts. Picnics are usually thought of as a lower quality substitute for hams, while butts usually end up as shoulder roasts or sausages and variety luncheon-type meats.

Significant beef quantity coefficients were found in the Bellies/PLoins and Butts/PLoins equations. The positive beef quantity coefficient in the Bellies/PLoins equation was consistent with the earlier found relationship between beef quantity and belly price.

Similar to the price flexibilities with respect to quantity, the two suggested relative extreme "income" flexibilities were similar to those in sections 1) and 2). The relative "income" flexibility rankings between pork loin and belly prices were not consistent among sections 1) to 3). It may be that the "income" flexibilities for these two pork prices are quite similar.

The coefficients for the storage ratios were significant for all four equations indicating that storage ratios were a consistent relevant variable in explaining the relative ratio between pork loin price and the other pork prices. Pork loins are primarily sold as fresh cuts while the other pork cuts go through some processing. This could lead pork loin prices to be somewhat more sensitive to beginning storage levels because of the ease of moving pork loins from storage into the wholesale market without further processing.

The monthly intercepts were generally lower during the summer and early fall months. Of the pork cuts, loins are better suited for outdoor barbecuing which may account for its increased relative demand during the summer months.

4) Relative to picnics

$$\text{Hams/Picnics} = 1.31 \underset{(3.26)}{+.010\, Q_C} \underset{(4.47)}{+.015\, Q_H} \underset{(5.00)}{-.339\, I} \underset{(5.23)}{-.029}$$

$$\text{HAMST/PICNST} +.164 \text{ Feb} +.300 \text{ Mar} +.115 \text{ Apr}$$

$$+.207 \text{ May} +.166 \text{ Jun} +.169 \text{ Jul} +.235 \text{ Aug}$$

$$+.084 \text{ Sep} +.162 \text{ Oct} +.364 \text{ Nov} +.412 \text{ Dec}$$

$R^2 = .76$

D.W. = .96

$$\text{Bellies/Picnics} = 1.60 \underset{(3.83)}{+.015\, Q_C} \underset{(6.57)}{-.026\, Q_H} \underset{(.626)}{-.056\, I} \underset{(2.80)}{-.010}$$

$$\text{BELST/PICNST} +.012 \text{ Feb} +.172 \text{ Mar} +.194 \text{ Apr}$$

$+.094$ May $-.034$ Jun $-.032$ Jul $-.056$ Aug

$-.051$ Sep $-.105$ Oct $-.010$ Nov $+.065$ Dec

$R^2 = .70$

D.W. = .79

$$\text{PLoins/Picnics} = \underset{}{1.49} \underset{(1.00)}{+.004\ Q_c} \underset{(1.34)}{+.006\ Q_H} \underset{(.532)}{-.050\ I} \underset{(4.57)}{-.099}$$

LOINST/PICNST $+.036$ Feb $+.007$ Mar $-.040$ Apr

$+.109$ May $+.172$ Jun $+.245$ Jul $+.272$ Aug

$+.191$ Sep $+ .020$ Oct $-.128$ Nov $-.019$ Dec

$R^2 = .60$

D.W. = .97

$$\text{Butts/Picnics} = 1.51 \underset{(.257)}{-.001\ Q_c} \underset{(3.89)}{-.010\ Q_H} \underset{(1.97)}{+.111\ I} \underset{(2.83)}{-.070}$$

BUTTST/PICNST $+.004$ Feb $+.055$ Mar $+.018$

Apr $+.036$ May $+.061$ Jun $+.073$ Jul $+.097$

Aug $+ .113$ Sep $+.056$ Oct $+.026$ Nov $+.073$ Dec

$R^2 = .58$

D.W. = 1.21

In explaining the relative differences between picnic price and the other pork prices, the storage ratio was the only specified variable that was statistically significant for all the equations. The storage coefficients were negative, indicating that a relative increase in the storage ratio caused a decrease in the price ratios, as expected.

The significant inverse relationships between pork quantity and the belly/picnic and butt/picnic price ratios suggested that belly and butt prices were more flexible than picnic price with respect to quantity. The positive coefficients in the other two equations suggested that ham and pork loin prices were less flexible relative to picnic price. The fact that picnics are sometimes used as substitutes for hams may give them more potential uses than bellies or butts. As mentioned previously, bellies and butts can both be used as bacon sources but are limited in other uses except for shoulder butt roasts.

Beef quantity was a relevant variable in explaining the relative differences between picnic price and ham and belly prices. This response was expected since a positive relationship was found between beef quantity and the ham and belly prices in Chapter III. The insignificant coefficients for the other two beef quantity variables suggested that beef quantity changes caused similar proportional changes among the pork loin, butt, and picnic prices.

The only "income" coefficient that was significant indicated that as "incomes" increased the consumer shifted to demanding more picnics relative to hams. This finding is somewhat puzzling since picnics and hams are fairly close substitutes for each other. At the same time the negative coefficient was consistent with the other sections in pointing out the relative inflexible position of ham price with respect to "income".

5) Relative to butts

$$\text{Hams/Butts} = .943 + .009\, Q_C + .020\, Q_H - .401\, I - .009$$
$$(4.27) \quad (8.28) \quad (9.10) \quad (1.91)$$
$$\text{HAMST/BUTTST} + .094\ \text{Feb} + .129\ \text{Mar} + .063\ \text{Apr}$$
$$+ .097\ \text{May} + .043\ \text{Jun} + .044\ \text{Jul} + .062\ \text{Aug}$$
$$- .058\ \text{Sep} + .033\ \text{Oct} + .209\ \text{Nov} + .219\ \text{Dec}$$
$$R^2 = .84$$
$$\text{D.W.} = 1.35$$

$$\text{Bellies/Butts} = 1.16 + .014\, Q_C - .014\, Q_H - .178\, I - .005$$
$$(4.65) \quad (4.03) \quad (2.91) \quad (1.41)$$
$$\text{BELST/BUTTST} + .007\ \text{Feb} + .088\ \text{Mar} + .136\ \text{Apr}$$
$$+ .035\ \text{May} - .086\ \text{Jun} - .089\ \text{Jul} - .123\ \text{Aug}$$
$$- .116\ \text{Sep} - .113\ \text{Oct} - .016\ \text{Nov} + .009\ \text{Dec}$$
$$R^2 = .50$$
$$\text{D.W.} = .86$$

$$\text{PLoins/Butts} = 1.41 + .008\, Q_C + .009\, Q_H - .259\, I - .102$$
$$(3.81) \quad (3.58) \quad (6.24) \quad (4.56)$$
$$\text{LOINST/BUTTST} - .014\ \text{Feb} - .084\ \text{Mar} - .095\ \text{Apr}$$
$$- .046\ \text{May} - .047\ \text{Jun} - .005\ \text{Jul} + .002\ \text{Aug}$$
$$- .052\ \text{Sep} - .099\ \text{Oct} - .146\ \text{Nov} - .099\ \text{Dec}$$
$$R^2 = .58$$
$$\text{D.W.} = 1.70$$

$$\text{Picnics/Butts} = .783 + .0005\,Q_C + .005\,Q_H - .065\,I - .034$$
$$(.445) \quad (4.13) \quad (2.98) \quad (6.32)$$

PICNST/BUTTST -.010 Feb -.038 Mar -.016 Apr

-.024 May -.049 Jun -.056 Jul -.070 Aug

-.079 Sep -.041 Oct -.020 Nov -.047 Dec

$R^2 = .70$

D.W. = 1.64

In attempting to explain the relative differences between butt price and the other pork prices, significant coefficients over all four equations were obtained for both pork quantity and "income". Beef quantity coefficients were statistically significant in all but the Picnics/Butts equation. The negative storage ratio coefficients were significant in the PLoins/Butts and Picnics/Butts equations.

In summarizing the relative flexibilities with respect to pork quantity and "income", some variation was found among the five sections. The relative positioning of the price flexibilities with respect to quantity were generally consistent. The general relative price rankings from flexible to less flexible were bellies, butts, picnics, pork loins, and hams. The only possible exception to this pattern might be the possible exchange of positions for picnics and pork loins in section 2). For the "income" flexibilities the extreme positions were consistent with butt price being the most flexible and ham price the least.

Also, picnic price was consistently the second most flexible with respect to "income". The relative rankings of the other two pork cut prices were subject to variation. The relative "income" flexibilities of pork loin and belly prices appeared to be essentially equal.

Beef/Pork Wholesale Cut Price Ratios

The general response of the specified explanatory variables was similar in explaining the differences between beef cut prices relative to pork cut prices. A generalized discussion of the results will be presented first. Then five sections of the specific equations, with one section for the beef cut prices relative to each pork cut price, will be presented. Each section will be followed by a brief discussion of the inconsistencies with the generalized picture, possible highlights of the dummy variables patterns, or other pertinent highlights.

As expected, beef and pork quantities were statistically significant in explaining the relative differences between beef prices relative to pork prices. The inverse relationships between beef cut prices and beef quantity or pork cut prices and pork quantity were more pronounced than any cross relationships between pork prices and beef quantity or beef prices and pork quantity. Consequently, negative coefficients were obtained for beef quantity and, conversely, positive ones for pork quantity in the beef/pork price ratio equations.

Generally the "income" coefficients were positive suggesting that "income" flexibilities for beef prices were higher than for pork prices. A consistent exception to this generalization occurred in the beef cuts/butt price ratio equations. The negative "income" coefficients suggested that butt price was more flexible with respect to "income" than any of the other eight beef and pork prices. In Chapter III, the "income" flexibility of butt price was by far the most flexible of the pork prices but beef rib price was slightly more flexible with respect to "income" than butt price. The relative flexible response to "income" for butt price was also consistent with results in the preceding pork/pork wholesale price ratios section.

In the simultaneous equations an inverse relationship between beginning pork storage levels and normalized wholesale pork prices was obtained. The positive storage coefficients estimated in the beef/pork price ratio equations were consistent with these earlier findings indicating that, as storage levels increase, pork prices decrease, causing the relative price ratios to increase.

The coefficients of determination (R^2's) indicated that generally better fits were obtained for the beef/pork price ratio equations than were obtained for the beef/beef price ratio and pork/pork price ratio equations. The distinction between beef and pork cuts is probably much clearer for a consumer than the distinction among beef cuts or pork cuts. Thus, the specified demand and supply variables in the beef/pork price ratio equations may be more relevant in explaining the differences between beef prices relative to pork prices. Although corresponding demand and supply variables are pertinent in explaining relative differences among beef cut prices or pork cut prices, additional unspecified motivational impulse-consumer reaction factors may play a greater role in explaining the price differences among these less clearly distinguished (by the consumer) cuts.

aa) Relative to hams

$$\text{Rounds/Hams} = .995 \underset{(8.86)}{-.021\,Q_c} \underset{(5.92)}{+.017\,Q_H} \underset{(5.34)}{+.289\,I} \underset{(6.06)}{+.0005}$$

$$\text{HAMST} -.123\ \text{Feb} -.246\ \text{Mar} -.119\ \text{Apr}$$

$$-.101\ \text{May} -.068\ \text{Jun} -.031\ \text{Jul} -.010\ \text{Aug}$$

$$+.037\ \text{Sep} -.080\ \text{Oct} -.312\ \text{Nov} -.355\ \text{Dec}$$

$$R^2 = .82$$

$$\text{D.W.} = .94$$

$$\text{Armchks/Hams} = .983 \underset{(10.01)}{-.020\,Q_c} \underset{(3.30)}{+.008\,Q_H} \underset{(6.47)}{+.297\,I} \underset{(2.75)}{+.0002}$$

$$\text{HAMST} -.083\ \text{Feb} -.156\ \text{Mar} -.109\ \text{Apr}$$

$$-.111\ \text{May} -.101\ \text{Jun} -.071\ \text{Jul} -.065\ \text{Aug} +.016$$

$$\text{Sep} -.047\ \text{Oct} -.189\ \text{Nov} -.266\ \text{Dec}$$

$$R^2 = .77$$

$$\text{D.W.} = .80$$

$$\text{BLoins/Hams} = 1.42 \underset{(6.14)}{-.027\ Q_c} \underset{(3.17)}{+.017\ Q_H} \underset{(4.28)}{+.432\ I} \underset{(3.82)}{+.0005}$$

HAMST −.127 Feb −.227 Mar +.033 Apr

+.110 May +.165 Jun +.213 Jul +.180 Aug

+.258 Sep +.002 Oct −.315 Nov −.347 Dec

$R^2 = .74$

D.W. = .91

$$\text{Ribs/Hams} = .1.17 \underset{(7.50)}{-.027\ Q_c} \underset{(3.10)}{+.013\ Q_H} \underset{(5.66)}{+.460\ I} \underset{(4.26)}{+.0005}$$

HAMST −.205 Feb −.291 Mar −.073 Apr

−.080 May −.062 Jun −.063 Jul −.031

Aug +.049 Sep −.130 Oct −.320 Nov −.238 Dec

$R^2 = .69$

D.W. = .86

The relative seasonal demand for hams was quite pronounced during the traditional holiday seasons of Easter, Thanksgiving, and Christmas. Compared to hams, the intercepts shifted upward during the summer months in the BLoins/Hams equation, probably reflecting the popularity of using the beef loin cut for barbecuing.

bb) Relative to bellies

$$\text{Rounds/Bellies} = 1.05 \underset{(7.48)}{-.044\ Q_c} \underset{(7.28)}{+.054\ Q_H} \underset{(2.47)}{+.315\ I} \underset{(6.50)}{+.0007}$$

BELST −.103 Feb −.379 Mar −.527 Apr

-.390 May -.254 Jun -.143 Jul +.147 Aug

+.258 Sep +.360 Oct +.108 Nov -.088 Dec

$R^2 = .84$

D.W. = .67

Armchks/Bellies = 1.18 -.040 Q_c +.031 Q_H +.388 I +.0004
(8.93) (5.64) (4.04) (4.51)

BELST -.093 Feb -.268 Mar -.387 Apr

-.315 May -.232 Jun -.161 Jul +.001 Aug

+.134 Sep +.201 Oct +.031 Nov -.153 Dec

$R^2 = .81$

D.W. = .66

BLoins/Bellies = 1.57 -.064 Q_c +.058 Q_H +.642 I +.001
(8.67) (6.30) (4.05) (9.15)

BELST -.150 Feb -.475 Mar -.623 Apr

-.446 May -.265 Jun -.092 Jul +.357 Aug

+.671 Sep +.747 Oct +.368 Nov +.092 Dec

$R^2 = .85$

D.W. = .89

Ribs/Bellies = 1.32 -.056 Q_c +.046 Q_H +.638 I +.0009
(9.17) (6.01) (4.83) (8.48)

BELST -.248 Feb -.506 Mar -.596 Apr

-.531 May -.423 Jun -.337 Jul +.068 Aug

+.322 Sep +.393 Oct +.207 Nov +.164 Dec

$R^2 = .85$

D.W. = .98

Given the specified variables, the price for bellies, relative to the beef cut prices, decreased from February to July. From August to November the trend reversed itself with the relative belly price being greater than the beef prices. December was the only month for which a consistent seasonal demand shift was not obtained in all four equations.

cc) Relative to pork loins

$$\text{Rounds/PLoins} = \underset{}{.752} \; \underset{(7.48)}{-.015\, Q_c} \; \underset{(10.46)}{+.028\, Q_H} \; \underset{(.767)}{+.036\, I} \; \underset{(3.27)}{+.001}$$

$$\text{LOINST} +.014\text{ Feb} +.005\text{ Mar} +.038\text{ Apr}$$
$$+.054\text{ May} +.026\text{ Jun} +.023\text{ Jul} +.050\text{ Aug}$$
$$+.005\text{ Sep} +.022\text{ Oct} +.034\text{ Nov} -.035\text{ Dec}$$

$R^2 = .91$

D.W. = 1.19

$$\text{Armchks/PLoins} = .853 \; \underset{(9.63)}{-.017\, Q_c} \; \underset{(6.95)}{+.016\, Q_H} \; \underset{(3.43)}{+.135\, I} \; \underset{(.314)}{.0001}$$

$$\text{LOINST} -.018\text{ Feb} -.026\text{ Mar} -.024\text{ Apr}$$
$$-.029\text{ May} -.051\text{ Jun} -.047\text{ Jul} -.042\text{ Aug}$$
$$-.031\text{ Sep} -.021\text{ Oct} -.015\text{ Nov} -.088\text{ Dec}$$

$R^2 = .88$

D.W. = .78

$$\text{BLoins/PLoins} = 1.12 \; \underset{(5.06)}{-.021\, Q_c} \; \underset{(5.42)}{+.029\, Q_H} \; \underset{(1.42)}{+.131\, I} \; \underset{(2.95)}{+.002}$$

$$\text{LOINST} +.041\text{ Feb} +.098\text{ Mar} +.224\text{ Apr}$$

$$+.259\ \text{May} +.207\ \text{Jun} +.195\ \text{Jul} +.210\ \text{Aug}$$

$$+.198\ \text{Sep} +.162\ \text{Oct} +.171\ \text{Nov} +.093\ \text{Dec}$$

$$R^2 = .76$$

$$\text{D.W. } 1.04$$

$$\text{Ribs/PLoins} = .913 \underset{(5.82)}{-.021\ Q_c} \underset{(5.20)}{+.024\ Q_H} \underset{(2.40)}{+.193\ I} \underset{(2.53)}{.001}$$

$$\text{LOINST} -.057\ \text{Feb} -.018\ \text{Mar} +.095\ \text{Apr}$$

$$+.071\ \text{May} +.015\ \text{Jun} -.024\ \text{Jul} +.027\ \text{Aug}$$

$$+.019\ \text{Sep} -.001\ \text{Oct} +.072\ \text{Nov} +.138\ \text{Dec}$$

$$R^2 = .80$$

$$\text{D.W.} = .96$$

The "income" coefficients in the Rounds/PLoins and BLoins/PLoins equations were not significantly different from zero suggesting that the proportional responses to "income" were similar among these three cuts. Similarity between "income" responses for round and beef loin prices was found previously in the beef/beef price ratio equations. When "incomes" increase, consumers could look to rounds, beef loins, and pork loins rather interchangeably as a source of more steaks or chops, as well as high-quality roasts. The insignificant storage coefficient in the Armchks/PLoins equation indicated that beginning pork loin storage levels were not a relevant explanatory force in distinguishing the relative difference between arm chuck and pork loin prices.

Relative to pork loin price the intercept shifters followed opposite trends for the Armchks/PLoins equation versus the BLoins/PLoins equation. Consumers may shift their demand from the higher-price beef loins to the lower-price arm chucks in January with their Christmas bills coming in.

dd) Relative to picnics

$$\text{Rounds/Picnics} = .923 \underset{(4.69)}{-.023\, Q_c} \underset{(10.51)}{+.052\, Q_H} \underset{(.130)}{+.014\, I} \underset{(7.91)}{+.003}$$

PICNST +.038 Feb +.011 Mar -.011 Apr +.160 May +.207 Jun +.284 Jul +.381 Aug +.242 Sep +.114 Oct -.043 Nov -.069 Dec

$R^2 = .83$

D.W. = .77

$$\text{Armchks/Picnics} = 1.28 \underset{(7.10)}{-.026\, Q_c} \underset{(6.76)}{+.026\, Q_H} \underset{(2.63)}{+.216\, I} \underset{(5.44)}{+.002}$$

PICNST -.022 Feb -.037 Mar -.095 Apr -.041 May -.031 Jun +.031 Jul +.096 Aug +.119 Sep +.058 Oct -.048 Nov -.140 Dec

$R^2 = .79$

D.W. = .67

$$\text{BLoins/Picnics} = 1.37 \underset{(5.34)}{-.040\, Q_c} \underset{(6.79)}{+.052\, Q_H} \underset{(2.55)}{+.423\, I} \underset{(10.37)}{+.007}$$

PICNST +.061 Feb +.139 Mar +.205 Apr +.486 May +.558 Jun +.666 Jul +.777 Aug

$+.717$ Sep $+.418$ Oct $+.156$ Nov $+.105$ Dec

$R^2 = .80$

D.W. = .90

$$\text{Ribs/Picnics} = 1.10 \underset{(6.47)}{-.034\,Q_c} \underset{(6.88)}{+.043\,Q_H} \underset{(3.77)}{+.506\,I} \underset{(10.24)}{+.005}$$

PICNST $-.104$ Feb $-.051$ Mar $+.026$ Apr

$+.142$ May $+.163$ Jun $+.191$ Jul $+.355$ Aug +

$+.324$ Sep $+.117$ Oct $+.025$ Nov $+.194$ Dec

$R^2 = .81$

D.W. = .97

The insignificant "income" coefficient in the Rounds/Picnics equation suggested that the "income" flexibilities of round and picnic prices were similar. In conjunction with the previous section the inference could be drawn that the proportional "income" responses of round, beef loin, pork loin, and picnic prices were similar. Similar "income" flexibilities for pork loin and picnic prices were found both in the pork/pork price ratio equations and the simultaneous equations.

ee) Relative to butts

$$\text{Rounds/Butts} = .751 \underset{(3.35)}{-.010\,Q_c} \underset{(11.80)}{+.047\,Q_H} \underset{(4.01)}{-.258\,I} \underset{(4.34)}{+.003}$$

BUTTST $+.019$ Feb $-.056$ Mar $-.021$ Apr

$+.055$ May $+.025$ Jun $+.066$ Jul $+ .114$ Aug

$-.012$ Sep $-.027$ Oct $-.076$ Nov $-.125$ Dec

$R^2 = .89$

D.W. = 1.25

Armchks/Butts = $.910 - .016\ Q_c + .028\ Q_H - .011\ I + .0007$
(6.59) (8.77) (.211) (1.21)

BUTTST $-.014$ Feb $-.064$ Mar $-.063$ Apr

$-.022$ May $-.041$ Jun $-.009$ Jul $+.004$ Aug

$-.025$ Sep $-.036$ Oct $-.077$ Nov $-.155$ Dec

$R^2 = .86$

D.W. = .94

BLoins/Butts = $1.10 - .012\ Q_c + .055\ Q_H - .295\ I + .004$
(2.21) (7.56) (2.50) (3.54)

BUTTST $+.058$ Feb $+.035$ Mar $+.191$ Apr

$+.332$ May $+.279$ Jun $+.331$ Jul $+.350$ Aug

$+.219$ Sep $+.100$ Oct $+.021$ Nov $-.004$ Dec

$R^2 = .77$

D.W. = .80

Ribs/Butts = $.904 - .015\ Q_c + .045\ Q_H - .116\ I + .003$
(3.27) (7.39) (1.17) (3.12)

BUTTST $-.069$ Feb $-.093$ Mar $+.051$ Apr

$+.093$ May $+.028$ Jun $+.031$ Jul $+.095$ Aug

$-.004$ Sep $-.086$ Oct $-.061$ Nov $+.077$ Dec

$R^2 = .79$

D.W. = .83

The "income" coefficients in the Armchks/Butts and Ribs/Butts equations were insignificant. The implied similar "income" flexibilities for arm chuck and rib prices were substantiated by the suggested relative flexibilities in the beef/beef price ratio equations. The storage coefficient in the Armchks/Butts equation was also insignificant. In looking at all five equations involving arm chuck price relative to the pork cut prices, the influence of the storage variable in explaining relative differences between the prices was less than in the other beef cuts relative to pork cuts equations. Arm chuck price may be more sensitive to pork storage levels and their effects on pork prices because consumers may readily substitute pork for this low-price beef cut when pork prices decrease.

<u>Summary</u>

Model II was concerned with explaining the relative price ratios among the nine wholesale beef and pork prices. In the beef wholesale cut price ratio equations, the suggested relative price flexibilities with respect to quantity and "income" were not consistent with the calculated flexibilities in the simultaneous equations model. The arm chuck price was the most flexible with respect to quantity relative to rib, round, and beef loin prices whose price flexibilities with respect to quantity appeared to be similar. These beef price flexibilities with respect to quantity were closer to prior expectations based on assumed consumer purchasing behavior. The relative "income" flexibilities of arm chuck and rib prices were similar and somewhat more flexible than the "income" flexibilities of beef loin and round prices. Hog quantity, the other specified explanatory variable included in the beef price ratio equations was most relevant in explaining the relative differences between round price and the other beef cut prices. As pork quantity increased, the proportional round price decrease was less than that of the other beef cut prices.

The suggested relative price flexibilities in the pork price ratio equations, likewise, showed some inconsistencies with the calculated flexibilities in Model I. The relatively flexible responses of belly price to pork quantity changes and butt price to "income" changes were consistent with the Model I findings. But, the relative flexibilities with respect to both quantity and "income" suggested that ham price was the least flexible which is clearly inconsistent with calculated price flexibilities of Model I.

Beef quantity was a relevant variable in explaining the relative differences between belly price and the other pork cut prices. This finding was consistent with the positive relationship found between beef quantity and belly price in the simultaneous equations. The beef quantity coefficients were also significant in the equations looking at the relative differences between hams and the two lower-price pork cuts, butts and picnics. Negative coefficients were estimated for the beginning storage ratio variables, indicating that a relative increase in beginning storage levels caused a relative price decrease, as expected.

Consistency between reciprocal equations was also analyzed for the beef and pork price ratio equations. In each case where an explanatory variable's coefficient was statistically significant, it was also significant in the reciprocal equation with the expected sign.

Both beef and pork quantity coefficients were significant in the equations relating beef cut prices to pork cut prices. The "income" coefficients were generally positive suggesting somewhat higher "income" flexibilities for beef relative to pork prices. The exception to this general statement was the suggested "income" flexibility for butt price being the highest of the nine beef and pork cut prices. The calculated "income" flexibilities in Model I were essentially consistent with these relative findings except that the calculated rib "income" flexibility was slightly more than the butt "income" flexibility. The relationships between the beginning pork cut storage level and the price ratios were consistent with the Model I findings. Better fits were obtained for the beef/pork wholesale cut price ratio equations relative to the beef/beef and pork/pork price ratio equations.

CHAPTER V

RELATIONSHIPS BETWEEN WHOLESALE AND LIVE PRICES LEVELS FOR BEEF AND PORK (Model III)

The preceding chapter dealt with the price ratios between different beef and pork wholesale cuts. In this chapter price ratios and differences between wholesale cuts and live animal prices are studied. Since it was unclear whether the prices of wholesale cuts and live prices more nearly moved proportionately or maintained a fairly constant price difference, both price ratios and price differences were estimated as dependent variables for each wholesale cut. In fact the price behavior of the various cuts, relative to the live level, may differ with some maintaining more nearly a percentage differential and others a constant cents per pound differential, depending upon the competitive situation and established industry pricing procedures.

As previously specified in Chapter II, the dependent variables referred to as price differences are simply the difference between wholesale beef cut prices and live steer price or between wholesale pork cut prices and live hog price. The comparable price ratios are simply the beef or pork wholesale cut prices relative to the steer or hog price, similar to the price ratios in Chapter IV. Where possible, consistent results and interpretations will be tied together in the first discussion sections for beef and pork, i.e. rounds and hams.

Wholesale Beef Cut Prices Relative to Live Steer Price

a) Rounds

$$\text{Rounds/SteerP} = \underset{(6.70)^{1}}{1.31 + .013\, Q_c} \; \underset{(5.36)}{+ .017\, Q_H} \; \underset{(3.95)}{- .332\, I} \; \underset{(.184)}{- .0006}$$

$$\text{WAGE} + .033\ \text{Feb} - .030\ \text{Mar} - .029\ \text{Apr}$$

$$+ .038\ \text{May} + .080\ \text{Jun} + .110\ \text{Jul} + .084\ \text{Aug}$$

$$- .012\ \text{Sep} - .039\ \text{Oct} - .041\ \text{Nov} - .003\ \text{Dec}$$

$R^2 = .64$[2]

D.W. = .92[3]

$$\text{Rounds-SteerP} = \underset{(3.36)}{20.00 - .147\, Q_c} \; \underset{(1.66)}{+ .115\, Q_H} \; \underset{(1.82)}{+ 3.33\, I} \; \underset{(.106)}{+ .008}$$

$$\text{WAGE} - 1.73\ \text{Feb} - 3.25\ \text{Mar} - 3.48\ \text{Apr}$$

$$- 2.03\ \text{May} - 1.06\ \text{Jun} - 1.87\ \text{Jul} - 1.19\ \text{Aug}$$

$$- .597\ \text{Sep} - .499\ \text{Oct} - 1.88\ \text{Nov} - 2.62\ \text{Dec}$$

$R^2 = .58$

D.W. = .73

The significant positive beef quantity coefficient in the ratio equation indicated that steer price was relatively more responsive to quantity changes than round price. The negative coefficient for beef quantity in the price difference equation indicated that the difference

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[1] Figures in parentheses refer to calculated "t-values" for testing the hypothesis that the coefficients = 0 where the critical "t-value" at the .05 level of approximately 2.0 with 88 degrees of freedom.

[2] Proportion of variation explained by the coefficients for the endogenous variable.

[3] Durbin-Watson statistic. See footnote 3 on page 47 for further detail.

between round and steer prices decreased when beef quantity increased, i.e. round price decreased more than steer price.

Seemingly, a conflict arose between the results of the two equations. In terms of percentages, steer price responded more than round price to changes in the beef quantity level in the price ratio equation. In the price difference equation, round price changed more, in terms of cents per pound, than steer price in response to beef quantity changes. Mathematically the responses can be shown to be consistent with each other. For example, suppose round price is 50 cents per pound and steer price is 25 cents per pound (nearly equal to their mean values). The price ratio is 2.0 and the difference is 25 cents. Now, suppose beef production increases, decreasing round price 6% to 47 cents and steer price 8% to 23 cents. The new ratio is now slightly greater than 2, at 2.04, while the difference has decreased to 24 cents, and thus, illustrating consistency between the two responses.

If the prices had been increasing, a similar example would result in round price increasing to 53 cents and steer price to 27 cents. The new ratio would be 1.96 while the difference would increase to 26 cents, again consistent with the signs of the estimated coefficients for beef quantity.

Related statistics support the likelihood of these responses occurring. The mean value of the round/steer price ratio was 1.93 with a standard deviation of .05. The mean value of the difference was 23.95 cents with a standard deviation of 1.16. Consequently, under the assumption of a normal distribution, approximately two-thirds (43, p 118) of ratio changes were within ± .05 of the mean value and two-thirds of the changes in the differences were within ± approximately one cent, both of which are very similar to the changes in the preceding example.

Having shown possible consistency, a more important consideration is whether such a response is reasonable. Traditionally retail prices have shown a tendency to react slowly relative to changes in the live price. So, when prices are increasing the live to retail price difference has generally decreased and has increased during periods of falling prices. This same general notion characterized the preconceived hypothesis concerning the changes in the wholesale to live price difference during price fluctuations.

Given the other variables, the negative coefficient for the beef quantity variable in the price difference equation indicated that the wholesale-live price difference actually reacted oppositely to this general notion, i.e., the difference decreased when prices decreased and increased with price increases. Looking somewhat ahead, the directional response to beef quantity was generally consistent in all four price difference equations for beef cuts. Since the results for rounds appeared typical of the beef cuts, and were contrary to the preconceived hypothesis, support from other empirical evidence was sought. A brief look at the monthly live-wholesale beef price spreads published by the U.S. Department of Agriculture showed that in numerous cases when prices were falling the spread did in fact decrease and increase when the general price level for beef was rising. Although this brief look was by no means thorough enough to be conclusive, it did point out that such responses to beef quantity need not be atypical.

The round/steer price ratio was significantly influenced by pork quantity. The positive coefficient indicated that an increase in pork quantity causes a greater proportional decrease in steer price than round price, under the assumption of an inverse relationship between pork quantity and beef prices. On the other hand, the insignificant pork quantity coefficient in the difference equation suggested that the effect of pork quantity, in absolute terms, was similar for both prices.

In comparing the two equations, the "income" coefficient was significant in the ratio equation and insignificant in the difference equation. An overall look at the equations for each beef cut revealed that the signs of the "income" coefficients were opposite the beef quantity coefficients signs. Thus, the question of consistency between the ratio and difference equations again arose. Consistent results are possible and can be shown following the same type of analyses discussed earlier. Actual differences could increase when "incomes" increase while the percentage increase of steer price is more than the round price increase.

The wage coefficients were insignificant, indicating that this proxy for services performed between the live and wholesale price levels was not relevant in explaining the difference or ratio between round and steer prices. Some variations between using ratios versus differences were evidenced in the two patterns of seasonal demand shifts. The intercept was highest in July for the price ratio equation and in January for the price difference equation. The lowest intercept level occurred in November for the price ratio equation and in April for the price difference equation.

b) Arm chucks

$$\begin{aligned}\text{Armchks/SteerP} = 1.51 &\underset{(1.46)}{-.002}\, Q_c \underset{(.898)}{+.002}\, Q_H \underset{(.782)}{+.054}\, I \underset{(.671)}{-.002} \\ &\text{WAGE} -.029\ \text{Feb} -.071\ \text{Mar} -.118\ \text{Apr} \\ &-.132\ \text{May} -.125\ \text{Jun} -.085\ \text{Jul} -.098\ \text{Aug} \\ &-.037\ \text{Sep} -.031\ \text{Oct} -.033\ \text{Nov} -.089\ \text{Dec}\end{aligned}$$

$$R^2 = .58$$

$$\text{D.W.} = 1.07$$

$$\begin{aligned}\text{Armchks} - \text{SteerP} = 17.06 &\underset{(4.68)}{-.222}\, Q_c \underset{(.594)}{-.045}\, Q_H \underset{(2.50)}{+4.96}\, I \underset{(.436)}{-.035} \\ &\text{WAGE} -1.50\ \text{Feb} -2.57\ \text{Mar} -3.84\ \text{Apr}\end{aligned}$$

$$-4.34 \text{ May } -4.34 \text{ Jun } -3.72 \text{ Jul } -3.65 \text{ Aug}$$

$$-1.06 \text{ Sep } -.636 \text{ Oct } -1.11 \text{ Nov } -3.07 \text{ Dec}$$

$$R^2 = .60$$

$$D.W. = .93$$

Of the wholesale beef cuts, arm chuck prices was closest to the steer price level. This was seen from the mean ratio value of 1.29 and by the fact that the mean value of the difference was about one-third that of the next smallest difference.

The relative response to the specified variables of arm chuck and steer prices appeared to be similar because none of the coefficients were significant in the price ratio equation. The difference between the prices was significantly explained by both beef quantity and "income" levels. Although the signs of these two variables were consistent between the two equations it was puzzling why their coefficients were significant in one case and not the other because of the closeness of the two price levels. Both relatively and absolutely, the monthly intercept shifters indicated that the price of arm chucks relative to steer price was highest in the base month of January.

c) Beef loins

$$\text{BLoins/Steer P} = \underset{}{1.61} \underset{(4.51)}{+.019\, Q_C} \underset{(.560)}{-.004\, Q_H} \underset{(3.80)}{-.688\, I} \underset{(1.90)}{+.014}$$

$$\text{WAGE } +.134 \text{ Feb } +.165 \text{ Mar } +.289 \text{ Apr}$$

$$+.359 \text{ May } +.402 \text{ Jun } +.413 \text{ Jul } +.333 \text{ Aug}$$
$$+.252 \text{ Sep } +.157 \text{ Oct } +.098 \text{ Nov } +.187 \text{ Dec}$$
$$R^2 = .68$$
$$D.W. = .77$$

$$\text{BLoins} - \text{SteerP} = \underset{}{37.77} \underset{(4.31)}{-.449\ Q_C} \underset{(4.43)}{-.733\ Q_H} \underset{(1.11)}{+4.84\ I} \underset{(2.39)}{+.425}$$
$$\text{WAGE } -1.36 \text{ Feb } -.268 \text{ Mar } +2.52 \text{ Apr}$$
$$+4.01 \text{ May } +3.61 \text{ Jun } +1.78 \text{ Jul } +2.52 \text{ Aug}$$
$$+6.33 \text{ Sep } +5.18 \text{ Oct } +1.07 \text{ Nov } -.073 \text{ Dec}$$
$$R^2 = .75$$
$$D.W. = 1.01$$

The findings and interpretations for the beef quantity and "income" variables of these equations follow those presented in section a) for rounds. A significant coefficient for wages was obtained in the difference equation. This positive relationship may be attributed to more trimming of beef loins over the last few years. The significant negative pork quantity coefficients showed that the response of the price difference to a closely substitutable commodity was consistent with the response to beef quantity. Demand was higher in the summer months for beef loins relative to the composite demand for all beef cuts as reflected by steer price.

d) Ribs

$$\text{Ribs/SteerP} = 1.19 \underset{(1.89)}{+.007\ Q_c} \underset{(.353)}{-.002\ Q_H} \underset{(3.17)}{-.464\ I} \underset{(2.45)}{+.015}$$

$$\text{WAGE} -.023\ \text{Feb} -.004\ \text{Mar} +.109\ \text{Apr}$$

$$+.064\ \text{May} +.047\ \text{Jun} -.008\ \text{Jul} +.020\ \text{Aug}$$

$$-.041\ \text{Sep} -.081\ \text{Oct} -.038\ \text{Nov} +.227\ \text{Dec}$$

$$R^2 = .57$$

$$\text{D.W.} = .88$$

$$\text{Ribs-SteerP} = 19.48 \underset{(5.21)}{-.449\ Q_c} \underset{(3.29)}{-.450\ Q_H} \underset{(.803)}{+2.90\ I} \underset{(2.77)}{+.408}$$

$$\text{WAGE} -3.81\ \text{Feb} -3.17\ \text{Mar} -.474\ \text{Apr} -1.76\ \text{May}$$

$$-2.99\ \text{Jun} -5.80\ \text{Jul} -3.50\ \text{Aug} -1.27\ \text{Sep}$$

$$-1.46\ \text{Oct} -1.89\ \text{Nov} -2.66\ \text{Dec}$$

$$R^2 = .69$$

$$\text{D.W.} = .92$$

Rib price relative to the more aggregate steer price was not significantly explained by beef quantity levels. For ribs, the coefficient for the wage variable was significant in both equations. Ribs, like beef loins, have been more closely trimmed in recent years to meet the consumers' demand for leaner meat. The response to pork quantity was similar to that found for beef loins.

The demand for ribs was high during the Christmas holiday season. This high demand seemed to carry over into January and was also evidenced in April in the price ratio equation corresponding to Easter.

Wholesale Pork Cut Prices Relative to Live Hog Price

a) Hams

$$\text{Hams/HogP} = 1.47 \underset{(4.58)}{-.012\, Q_c} \underset{(4.78)}{+.020\, Q_H} \underset{(2.13)}{+.0002\, \text{HAMST}} \underset{(4.16)}{-.474\, I} \underset{(3.43)}{+.015\, \text{WAGE}} +.059\, \text{Feb} +.049\, \text{Mar} -.051\, \text{Apr}$$
$$-.076\, \text{May} -.073\, \text{Jun} -.066\, \text{Jul} +.045\, \text{Aug}$$
$$-.033\, \text{Sep} +.081\, \text{Oct} +.098\, \text{Nov} +.118\, \text{Dec}$$
$$R^2 = .92$$
$$\text{D.W.} = .89$$

$$\text{Hams-HogP} = 30.71 \underset{(.263)}{+.017\, Q_c} \underset{(2.45)}{-.249\, Q_H} \underset{(3.21)}{-.007\, \text{HAMST}} \underset{(.175)}{+.483\, I} \underset{(.156)}{+.016\, \text{WAGE}} +.009\, \text{Feb} +1.61\, \text{Mar} -1.80\, \text{Apr}$$
$$-2.03\, \text{May} -2.84\, \text{Jun} -4.06\, \text{Jul} -2.45\, \text{Aug}$$
$$-1.63\, \text{Sep} +1.84\, \text{Oct} +6.00\, \text{Nov} +6.12\, \text{Dec}$$
$$R^2 = .78$$
$$\text{D.W.} = .68$$

A good fit (R^2 = .92) was obtained for the price ratio equation, with the coefficients for all the specified explanatory variables significantly different from zero. In fact, the equation was the only one of the pork price ratio equations where a significant response to "income" was obtained. The negative "income" coefficient suggested that ham price was less flexible to "income" than the more aggregate hog price. The relatively inflexible position of ham price was consistent with the results obtained in the preceding chapter in the pork/pork price ratio equations. Also, possible explanations for this position were discussed in the preceding chapter.

Average wages appeared to be a relevant explanatory variable for explaining only the relative difference between ham and hog prices, with insignificant coefficients obtained in the rest of the ratio equations and all the pork price difference equations. Why wages were found to be relevant in the ham price ratio equation and not in any of the other pork equations was unexplained.

The response to pork quantity in the ratio and difference equations created an interpretation problem similar to the discussion for the beef equations. Again the related statistics indicated that consistency between seemingly inconsistent results was very possible. The average ratio was 2.1 with a standard deviation of .06 while the average difference was 22 cents with a standard deviation of 1.6 cents. So, consistent with the general case for the beef cuts, ham price appeared to be less flexible than its corresponding aggregate live price with respect to quantity, but the absolute changes were such that the wholesale to live difference decreased during falling prices. Again the U.S. Department of Agriculture's spread data showed that such a relationship between price fluctuations and the wholesale to live spread was not uncommon.

The inverse relationships betwen pork quantity and the pork price difference were consistent for all the cuts, except for an insignificant coefficient in the picnic equation. These inverse relationships were reinforced by the negative coefficients found for beginning storage quantities for all the pork cuts.

The monthly intercept patterns showed a strong relative demand for hams during the Thanksgiving-Christmas holiday season. Ham price was the only pork cut price that was higher relative to the live hog price during this holiday season.

b) Bellies

$$\underset{}{\text{Bellies/HogP}} = 2.07 \underset{(4.71)}{+.015\, Q_c} \underset{(.879)}{-.004\, Q_H} \underset{(5.48)}{-.0003\, \text{BELST}}$$

$$\underset{(.089)}{-.014\, I} \underset{(1.45)}{- .008\, \text{WAGE}} -.010\, \text{Feb} + .113$$

$$\text{Mar} +.231\, \text{Apr} +.200\, \text{May} +.140\, \text{Jun}$$

$$+.135\, \text{Jul} -.025\, \text{Aug} -.089\, \text{Sep} -.232\, \text{Oct}$$

$$-.121\, \text{Nov} -.040\, \text{Dec}$$

$$R^2 = .66$$

$$\text{D.W.} = .89$$

$$\text{Bellies- HogP} = 31.84 \underset{(6.72)}{+.478\, Q_c} \underset{(4.63)}{-.516\, Q_H} \underset{(8.72)}{-.012\, \text{BELST}}$$

$$\underset{(.373)}{+1.28\, I} \underset{(1.57)}{-.202\, \text{WAGE}} -.521\, \text{Feb} +3.16\, \text{Mar}$$

$$+6.18 \text{ Apr } +5.41 \text{ May } +3.50 \text{ Jun } +2.24 \text{ Jul}$$
$$-2.56 \text{ Aug } -3.81 \text{ Sep } -6.52 \text{ Oct } -2.94 \text{ Nov } -.427 \text{ Dec}$$
$$R^2 = .86$$
$$D.W. = .96$$

The significant positive coefficients for beef quantity in both equations were consistent with the positive sign found between beef quantity and belly price in the simultaneous equations. Bacon may be used by consumers as a variety item rather than just having more beef meals when beef prices decrease. The monthly intercept shifters showed that the ratios and differences were greatest, given the other variables, from March to July. This may well have resulted from the fact that bellies stored prior to December 1 can not be delivered on the February through August futures contracts.

c) Pork Loins

$$\text{PLoins/HogP} = 1.85 \underset{(4.24)}{-.016\, Q_c} \underset{(1.13)}{+.007\, Q_H} \underset{(2.82)}{+.002\, \text{LOINST}} \underset{(.158)}{-.030}$$
$$\text{I} \underset{(1.18)}{+.008\, \text{WAGE}} -.012 \text{ Feb } -.116 \text{ Mar } -.183 \text{ Apr}$$
$$-.128 \text{ May } -.008 \text{ Jun } +.060 \text{ Jul } +.165 \text{ Aug}$$
$$+.221 \text{ Sep } +.160 \text{ Oct } -.106 \text{ Nov } -.196 \text{ Dec}$$
$$R^2 = .67$$
$$D.W. = .86$$

$$\text{PLoins} - \text{HogP} = \underset{}{34.37} \underset{(1.93)}{-.109\, Q_c} \underset{(5.57)}{-.493\, Q_H} \underset{(1.14)}{-.010\, \text{LOINST}}$$

$$\underset{(2.65)}{+7.37\, I} - \underset{(.015)}{.0015\, \text{WAGE}} -2.56\, \text{Feb} -4.11$$

$$\text{Mar} -5.21\, \text{Apr} -3.84\, \text{May} -2.11\, \text{Jun}$$

$$-1.72\, \text{Jul} -1.14\, \text{Aug} +1.60\, \text{Sep} +.351$$

$$\text{Oct} -2.75\, \text{Nov} -3.18\, \text{Dec}$$

$$R^2 = .86$$

$$\text{D.W.} = 1.69$$

The significant negative coefficients for beef quantity in both equations were also found in the picnics and butts equations. Thus, for these cuts, beef quantity changes appeared to have more of an impact on the whole-sale prices than the live price. This result was anticipated because of the positive relationship found in the belly price equation. On an aggregate basis, such as live hog price which is related to all pork cuts, some of the negative relationship was off-set by the positive relationship between belly price and beef quantity. The demand for pork loins was highest during September and October and lowest from March to Mary relative to the composite demand for all pork cuts reflected by live hog price.

d) Picnics

$$\text{Picnics/HogP} = 1.19 \underset{(6.29)}{-.010\, Q_c} \underset{(4.39)}{+.011\, Q_H} \underset{(7.05)}{-.001\, \text{PICNST}}$$

$$\underset{(.240)}{-.019\, I} \underset{(1.29)}{+.004\, \text{WAGE}} -.015\, \text{Feb} -.088$$

$$\text{Mar} -.059\, \text{Apr} -.046\, \text{May} -.010\, \text{Jun}$$

$$-.017\, \text{Jul} -.040\, \text{Aug} -.052\, \text{Sep} -.046$$

$$\text{Oct} -.099\, \text{Nov} -.143\, \text{Dec}$$

$$R^2 = .82$$

$$\text{D.W.} = .98$$

$$\text{Picnics - Hog P} = 6.84 \underset{(5.55)}{-.156\, Q_c} \underset{(.980)}{+.041\, Q_H} \underset{(8.88)}{-.023\, \text{PICNST}}$$

$$\underset{(1.16)}{+1.59\, I} \underset{(.831)}{+.041\, \text{WAGE}} -.679\, \text{Feb} -1.88\, \text{Mar}$$

$$-1.47\, \text{Apr} -1.56\, \text{May} -1.10\, \text{Jun} -1.40\, \text{Jul}$$

$$-1.84\, \text{Aug} -1.30\, \text{Sep} -.895\, \text{Oct} -1.58\, \text{Nov}$$

$$-2.47\, \text{Dec} \qquad R^2 = .83$$

$$\text{D.W.} = 1.07$$

The response to hog quantity in the ratio equation was similar to that found for hams. But, contrary to hams, a corresponding negative coefficient was not found in the difference equation. The average levels of picnic and hog prices were relatively close together as evidenced by the average ratio of 1.2. Proportional changes from base levels that are closer together are also closer in absolute terms.

In this case the greater proportional change of hog price was enough to offset the picnic price change in absolute terms.

The strongest level of demand for picnics relative to the composite hog carcass products occurred in January. Consumers may have shifted from hams to picnics for a little variety after the holiday season or they may have shifted because of the lower price of picnics.

e) Butts

$$\text{Butts/HogP} = 1.85 \underset{(7.27)}{-.019\, Q_c} \underset{(1.50)}{-.006\, Q_H} \underset{(1.66)}{+.001\, \text{BUTTST}}$$

$$\underset{(1.97)}{+.231\, I} \underset{(1.20)}{+.005\, \text{WAGE}} -.041\, \text{Feb} -.065\, \text{Mar}$$

$$-.116\, \text{Apr} -.158\, \text{May} -.085\, \text{Jun} -.071\, \text{Jul}$$

$$-.015\, \text{Aug} +.086\, \text{Sep} +.071\, \text{Oct} -.040\, \text{Nov}$$

$$-.001\, \text{Dec} \qquad R^2 = .56$$

$$\text{D.W.} = 1.49$$

$$\text{Butts-HogP} = 27.19 \underset{(4.79)}{-.258\, Q_c} \underset{(6.33)}{-.555\, Q_H} \underset{(1.97)}{-.024\, \text{BUTTST}}$$

$$\underset{(3.93)}{+9.61\, I} \underset{(.259)}{+.025\, \text{WAGE}} -1.91\, \text{Feb} -1.80\, \text{Mar}$$

$$-2.71\, \text{Apr} -3.61\, \text{May} -2.34\, \text{Jun} -2.87\, \text{Jul}$$

$$-2.34\, \text{Aug} +.744\, \text{Sep} +.832\, \text{Oct} -.193\, \text{Nov}$$

$$-1.08\, \text{Dec} \qquad R^2 = .79$$

$$\text{D.W.} = 1.49$$

The significant "income" coefficient in the price difference equation was consistent with the relative findings in the pork/pork price ratio equations. The higher intercept levels in September and October may have resulted from consumers shifting to more roasts with the onset of cooler weather prior to the holiday season in November and December.

Summary

In Model III the factors affecting wholesale cuts and live animal price ratios and differences were analyzed. Relative to the wholesale beef cut prices, the response of steer price to beef quantity levels was proportionally more in the price ratio equations but was less in terms of cents per pound in the price difference equations. The signs of the "income" coefficients were opposite the signs found for the beef quantity coefficients, indicating that steer price responded proportionally more to changes in the "income" level than wholesale beef prices but less in terms of cents per pound in the price difference equations.

The wage variable, representing the cost of services performed between the live and wholesale price levels, was found to be a relevant variable in explaining the differences between live steer price and beef loin and rib prices. The positive relationships found probably attests to closer trimming of these cuts in recent years to meet consumers' demand for leaner meat. Pork quantity levels appeared to be most relevant in explaining the ratio between round and steer prices and beef loin and rib price differences relative to steer price.

In the equations relating wholesale pork cut prices to live hog price, the significant responses to the hog quantity variable were similar to the responses between beef quantity and wholesale beef cut prices. Beef quantity levels were a relevant explanatory variable in the pork cut/hog price ratio equations, with a general inverse relationship being found. Consistent with other findings in this study, a positive relationship was found between beef quantity and the belly/hog price ratio. Only the wage coefficient in the ham/hog price ratio equation was found to be significant. The "income" variable was also found to be of limited importance in explaining the differences between wholesale pork cut prices and live hog price. The inverse relationships between pork quantity and the pork cuts-hog price differences were reinforced by the negative coefficients for beginning storage quantities.

CHAPTER VI

FORECASTING EQUATIONS

Participants in the meat industry are interested in both the causes and rationale for the fluctuations in the current price levels and what to expect in the future. Chapters III, IV, and V focused on explaining the factors causing fluctuations in current price levels and relationships among wholesale prices and live price levels. Chapter VI focuses on the short-run forecastibility of monthly beef and pork wholesale cut prices.

Originally, it was planned to compare two types of forecasting equations--reduced-forms and ordinary least squares. The reduced-form equations were envisioned as being derived from the structural coefficients obtained in the simultaneous equations of Model I. Due to an excess of total number of times the predetermined variables appeared in the simultaneous equations, the option for reduced-form equations could not be computed as part of the two-stage least-squares program at Michigan State University. The method of obtaining derived reduced-form equations presented by Goldberger (9, pp364-371) was tried. The resultant reduced-form equations were estimated against actual values with generally poor results. The inaccuracy of the estimates probably resulted from rounding off the structural coefficients because of the limited capacity available on the remote access computer terminal used.

Because of the poor fit of these derived reduced-form equations, comparisons with the ordinary least-squares equations were not justified.

The simultaneous equations normalized on wholesale prices were fitted individually by ordinary least squares for the other type of forecasting equations. As pointed out in Chapter II, the estimated coefficients were biased and inconsistent because there was more than one endogenous variable in each equation. But, more importantly for forecasting, ordinary least-squares techniques yield estimates of the dependent variable that are efficient and unbiased, conditional on the particular values for the "independent" variables. (27; 15, pp 232-234) The least-squares technique has the advantage of being somewhat less costly to use than two-stage least-squares. Thus, it more readily lends itself to possible refinements and to future updating than the derived reduced form procedure. The refinements can be made on individual least-squares equations.

The discussion in this chapter is, thus, based on the least-squares forecasting equations. The regression coefficients and related statistics for the nine least-squares equations are presented in Table 5. The estimated wholesale prices were checked against their actual values over the data period included in the equations, March 1963-May 1969. The equations were used to forecast the wholesale cut prices from June 1969-December 1969. The forecasts were obtained

TABLE 5. ORDINARY LEAST-SQUARES ESTIMATED COEFFICIENTS AND RELATED STATISTICS FOR THE BEEF AND PORK FORECASTING EQUATIONS

Explanatory Variables	Dependent Price Variables								
	Rounds	Armchks	BLoins	Ribs	Hams	Bellies	PLoins	Picnics	Butts
Intercept	36.95	19.25	55.33	37.71	66.58	69.97	68.86	46.39	68.04
Q_C	-.447 (4.51)[1]	-.407 (4.36)	-.133 (7.67)	-1.03 (7.43)	.138 (1.07)	.441 (3.91)	.022 (.208)	.014 (.174)	-.295 (2.34)
Q_H	-.017 (.168)	-.093 (.983)	-.166 (1.12)	.067 (.480)	-1.15 (9.07)	-1.83 (15.02)	-1.03 (8.85)	-.832 (13.03)	-1.33 (10.19)
Change in storage					.015 (2.72)	.026 (6.00)	-.055 (2.81)	*	.016 (.481)
Storage					-.013 (3.66)	-.014 (8.48)	-.074 (5.25)	-.047 (9.36)	-.088 (3.48)
I	14.54 (7.98)	13.07 (7.60)	31.50 (11.65)	29.12 (11.47)	4.74 (1.71)	2.62 (1.16)	8.07 (3.90)	4.67 (2.84)	15.42 (6.42)
PERCOW	.273 (1.99)	.464 (3.58)	1.06 (5.17)	.939 (4.90)					
MPORT	.003 (.328)	.012 (1.38)	-.015 (1.09)	-.013 (1.02)					
CKPD	-.004 (.372)	-.001 (.156)	-.028 (2.00)	-.038 (2.84)	.013 (1.04)	.028 (2.45)	.015 (1.33)	.016 (2.10)	.014 (1.07)
TKPD	-.012 (.823)	-.009 (.633)	.056 (2.63)	.044 (2.22)	.011 (.586)	.006 (.346)	-.004 (.259)	-.007 (.583)	.006 (.284)

* Less than .001

TABLE 5 <u>continued</u>

Explanatory Variables	Dependent Price Variables								
	Rounds	Armchks	BLoins	Ribs	Hams	Bellies	BLoins	Picnics	Butts
Dummy Variables[2]									
Feb	-3.11	-1.83	-4.50	-6.88	.46	-2.65	-3.06	-1.62	-2.97
Mar	-4.19	-2.39	-3.15	-5.25	5.32	.03	-4.28	-2.63	-2.94
Apr	-4.09	-3.09	1.18	-1.22	-3.62	2.60	-4.83	-2.88	-4.32
May	-1.98	-2.84	7.30	2.29	-2.26	1.92	-4.42	-5.46	-5.74
Jun	-2.05	-3.69	7.33	2.14	-4.60	1.41	-4.17	-6.41	-5.10
Jul	-2.68	-3.41	1.25	-4.34	-8.58	1.05	-5.46	-7.76	-7.79
Aug	- .33	-2.76	-2.62	-5.17	-7.26	-5.49	-6.38	-7.90	-8.41
Sep	2.06	.44	-2.01	-6.80	-4.80	-3.80	-2.36	-2.98	-2.37
Oct	2.20	.27	-7.98	+11.34	-1.18	-9.36	-3.20	-1.31	-1.95
Nov	- .71	-1.90	-17.93	-17.92	9.23	-4.78	-2.01	1.15	-1.10
Dec	-3.53	-4.67	-12.35	- 7.28	11.07	-4.29	-1.06	- .50	-1.22
R^2 [3]	.826	.827	.894	.868	.889	.958	.943	.929	.906
Stand. error of the estimate	1.63	1.54	2.42	2.27	2.16	1.92	1.81	1.28	2.20
Stand. error as a % of mean price	3.3	4.7	3.3	4.1	5.0	5.8	4.1	5.0	6.3

[1] t-value

[2] Only operative during the particular month in question with January as the base.

[3] Proportion of variation explained by the coefficients for the endogenous variable.

under ideal conditions of using actual data for the explanatory variables. The accuracy of the forecasting equations is relevant only if reasonably accurate estimates of the explanatory variables are obtainable. The earlier stydy by Hayenga and Hacklander (12) discussed possible ways of forecasting most relevant explanatory variables.

The accuracy of the forecast prices, versus actual prices, can be seen by the actual and percentage errors presented in Tables 6-14. The mean absolute percentage error was calculated for each cut and is presented as part of Table 15.

Other than the magnitude of the error, another criterion was the actual diagnosis of the direction of change in the price. An estimate was judged correct if the forecast direction of change from period "t" to "t + 1" was in the same direction as the observed change.

The number of correct forecasts may be evaluated by a binomial probability function.[1] The probability of obtaining a specific number or more of the correct directional change by chance alone was used in evaluating the forecasting ability of each of the wholesale price equations.

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[1] This discussion follows closely that presented by Myers, Havlicek, and Henderson (21). The specific distribution under consideration was $C^7_r\ (1/2)^r\ (1/2)^{7-r}$ where 7 was the number of forecast monthly values for each price, r was the number of correct forecasts ($0 \le r \le 7$), and an equal probability of occurrence by chance alone of a correct and incorrect change was assumed.

The number of correct forecasts and probabilities of obtaining as many or more correct forecasts by chance alone are presented in Table 15 for each of the wholesale prices.

Brief paragraphs discussing the forecasts of each wholesale price follow in which the various findings presented in the tables are summarized.

a) Rounds

The fit (R^2 = .83) of the round price forecasting equation for the estimation period was fairly good, as seen in Table 5. The standard error of the estimate was 1.6 cents per pound or 3.3% of the mean value for round prices. The forecast versus the actual round prices are presented in Table 6. The forecast prices were quite close to the observed prices, being off 2.2% on the average as seen in Table 15. The mean absolute percentage error for forecast round prices was the smallest of the beef and pork forecast prices. By the other criterion of accuracy, the forecast prices also performed fairly well with the directional change being correct five out of the seven mobths. The probability of forecasting the correct change five or more times out of seven by chance alone is only .227 (Table 15).

b) Arm chucks

Similar to rounds, a R^2 of .83 was obtained for the arm chuck forecasting equation. The standard error of the

TABLE 6. FORECAST AND ACTUAL ROUND PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price Forecast ¢/lb.	Price Actual ¢/lb.	Error ¢/lb.	Percentage Error
June	56.605	59.137	-2.532	-4.3
July	56.035	59.130	-3.095	-5.2
Aug	57.312	58.275	-.963	-1.7
Sep	56.926	57.287	-.361	-.6
Oct	56.356	57.030	-.674	+1.2
Nov	56.770	56.891	-.121	-.2
Dec	55.192	56.327	-1.135	-2.0

TABLE 7. FORECAST AND ACTUAL ARM CHUCK PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price Forecast ¢/lb.	Price Actual ¢/lb.	Error ¢/lb.	Percentage Error
June	38.694	43.712	-5.018	-11.5
July	39.590	42.425	-2.835	-6.7
Aug	39.624	40.663	-1.039	-2.6
Sep	39.700	41.369	-1.669	-4.0
Oct	38.910	40.480	-1.570	-3.9
Nov	38.719	39.184	-.465	-1.2
Dec	37.215	38.290	-1.075	-2.8

estimate was 1.5 cents which as a per cent of the mean value was 4.7. The deviations presented in Table 7 showed a greater degree of error than was found for the round price forecasts. Generally the errors were somewhat more than the standard error of the estimate over the data period included in the equation. Reference to Table 15 shows that the accuracy of directional price changes was poor for arm chucks. The probability that by chance alone more accurate forecasts of direction of change could have been obtained was .5.

c) Beef loins

Over the data period included in the beef cut equations the best fit (R^2 = .89) was obtained for the loin equation. The standard error of the estimate was 2.4 cents per pound and 3.3% of the mean value. Less than half of the sharp 7 cents per pound increase in beef loin price from May to June was picked up by the May to June forecast loin price change. After June to the end of the year, actual beef loin price decreased quite sharply. The forecast loin price also generally followed a decreasing pattern but at a slower rate which resulted in rather large positive errors. The tendency of the forecast prices to move in the same direction as the actual prices was reinforced in Table 15 where the correct directional change was found 6 out of 7 times.

d) Ribs

The rib price forecasting equation and forecasts were very similar to the beef loin results. The fit of the rib forecasting equation was nearly the same as for loins with a standard error of the estimate as a per cent of the mean value of 4.1%. The same general sharp increase in price from May to June occurred for ribs before the price level decreased. The forecast rib prices picked up less than half of the increase but they did not decrease to as low a level as the actual prices resulting in positive errors. Contrary to beef loin prices both the actual and forecast rib prices increased in November and December. The direction of change of the forecast prices corresponded to the observed change for all seven months.

e) Hams

Table 5 shows that the fits of the pork forecasting equations were usually better than the fits obtained for the beef forecasting equations, in terms of R^2. But, on a more standardized comparison, taking into account the average price levels, the standard errors of the estimate as a per cent of the mean price were usually higher for pork than beef.

The standard error of the estimate for hams was 2.2 cents per pound or 5.0% of the mean ham price. Starting with a sharp increase in actual ham price from May to June, the actual ham prices increased fairly rapidly over the

TABLE 8. FORECAST AND ACTUAL BEEF LOIN PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price Forecast	Price Actual	Error	Percentage Error
	¢/lb.	¢/lb.	¢/lb.	
Jun	93.760	99.312	-5.552	-5.6
Jul	92.787	86.395	6.392	7.4
Aug	88.202	81.250	6.952	8.6
Sep	84.861	81.057	3.804	4.7
Oct	80.270	77.000	3.270	4.2
Nov	80.564	75.200	5.364	7.1
Dec	79.460	74.630	4.830	6/5

TABLE 9. FORECAST AND ACTUAL RIB PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price Forecast	Price Actual	Error	Percentage Error
	¢/lb.	¢/lb.	¢/lb.	
Jun	70.441	75.412	-4.971	-6.6
Jul	67.832	67.658	.174	.3
Aug	66.209	61.525	4.684	7.6
Sep	61.758	57.428	4.330	7.5
Oct	58.089	55.940	2.149	3.8
Nov	62.739	58.725	4.014	6.8
Dec	66.553	63.300	3.253	5.1

entire seven month period, except for September. The forecast ham prices did not pick up the sharp increase from May to June, when in fact they decreased. After June, the forecast prices responded quite well to the generally rising ham price trend but at a lower level resulting in the underestimation for the forecast period seen in Table 10. The fact that the forecast ham prices did in fact respond to the actual price pattern, after June, was emphasized in Table 15, where it was found that the direction of change was correct for six out of the seven months.

f) Bellies

The fits for the belly, pork loin, and picnic equations were good with R^2's of .93 to .96. The standard error of the estimates for these pork prices were all less than two cents per pound.

Like forecast ham prices, the forecast belly prices were below the actual prices during the forecast period. The mean absolute percentage error for forecast belly prices was the smallest of the pork cut prices at 4.5%. Chances were 50:50 that by chance alone four or more correct forecasts of the direction of price change could have been obtained.

g) Pork loins

Of the pork forecasting equations, the pork loin forecasting equation had the smallest standard error of the estimate on a percentage basis of 4.1 (Table 5). Again, the

TABLE 10. FORECAST AND ACTUAL HAM PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price		Error	Percentage Error
	Forecast	Actual		
	¢/lb.	¢/lb.	¢/lb.	¢/lb.
Jun	43.385	46.325	-2.940	-6.3
Jul	45.852	46.863	-1.011	-2.2
Aug	47.253	49.300	-2.047	-4.2
Sep	46.704	48.863	-2.159	-4.4
Oct	48.353	51.500	-3.147	-6.1
Nov	52.948	55.994	-3.046	-5.4
Dec	54.675	58.937	-4.262	-7.2

TABLE 11. FORECAST AND ACTUAL BELLY PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price		Error	Percentage Error
	Forecast	Actual		
	¢/lb.	¢/lb.	¢/lb.	¢/lb.
Jun	35.729	36.125	- .396	-1.1
Jul	34.872	36.540	-1.668	-4.6
Aug	36.866	40.737	-3.871	-9.5
Sep	38.792	40.013	-1.221	-3.1
Oct	37.258	37.310	- .052	- .1
Nov	36.606	40.488	-3.882	-9.6
Dec	41.114	42.635	-1.521	-3.6

forecast prices were less than actual prices for the seven forecast months. The forecast prices did do a good job, 6 out of 7 times, of correctly identifying the direction of price change. The probability by chance alone of correctly forecasting the directional change 6 or more times is only .062 (Table 15).

h) Picnics

Actual picnic prices rose five cents per pound from May to July. Over the same period the forecast picnic prices rose by less than one cent per pound resulting in the forecast picnic price for July being 15.6% low, as seen in Table 13. The largest mean absolute percentage error, 8.1%, of the forecast cut prices resulted for picnics (Table 15). The directional price change was correctly forecast four out of the seven times.

i) Butts

The standard error of the estimate as a per cent of the mean price for the butt forecasting equation was the largest of the nine forecasting equations. The mean absolute percentage error of the forecast butt prices was also large, being nearly as large as the percentage error for picnics. Like picnics, the directional price change was correctly identified only four out of seven times. The forecast prices for both picnics and butts for November and December were the only monthly pork prices that overestimated the actual prices.

TABLE 12. FORECAST AND ACTUAL PORK LOIN PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price Forecast ¢/lb.	Price Actual ¢/lb.	Error ¢/lb.	Percentage Error
Jun	52.872	54.375	-1.503	-2.8
Jul	55.374	56.777	-1.403	-2.5
Aug	54.357	56.025	-1.668	-3.0
Sep	52.634	56.531	-3.897	-6.9
Oct	51.449	55.780	-4.331	-7.8
Nov	51.310	55.325	-4.015	-7.3
Dec	53.565	55.677	-2.112	-3.8

TABLE 13. FORECAST AND ACTUAL PICNIC PRICES, ACTUAL AND PERCENTAGE ERRORS, JUNE - DECEMBER, 1969

Month	Price Forecast ¢/lb.	Price Actual ¢/lb.	Error ¢/lb.	Percentage Error
Jun	30.102	34.075	-3.973	-11.7
Jul	30.336	35.928	-5.592	-15.6
Aug	29.485	33.712	-4.227	-12.5
Sep	29.901	32.813	-2.912	-8.9
Oct	30.343	32.225	-1.882	-5.8
Nov	31.413	30.760	.653	2.1
Dec	32.074	32.027	.047	.1

TABLE 14. FORECAST AND ACTUAL BUTT PRICES, ACTUAL AND PERCENTAGE ERROR, JUNE - DECEMBER, 1969

Month	Price Forecast	Price Actual	Error	Percentage Error
	¢/lb.	¢/lb.	¢/lb.	
Jun	44.152	47.087	-2.935	-6.2
Jul	47.253	49.630	-2.377	-4.8
Aug	45.994	50.050	-4.056	-8.1
Sep	43.758	51.960	-8.202	-15.8
Oct	39.202	46.760	-7.558	-16.2
Nov	42.792	42.583	.209	.5
Dec	44.785	42.830	1.955	4.6

TABLE 15. Number of correct forecasts of direction of change for the wholesale price estimates, the probability of getting as many or more correct forecasts by change alone, and the mean absolute percentage errors, June 1969 - December 1969.

Dependent Variable	Number of correct forecasts[1]	Probability of getting as many or more correct forecasts by chance alone	Mean absolute percentage error
Rounds	5	.227	2.2
Arm chucks	4	.500	4.7
Beef loins	6	.062	6.3
Ribs	7	.008	5.4
Hams	6	.062	5.1
Bellies	4	.500	4.5
Pork loins	6	.062	4.9
Picnics	4	.500	8.1
Butts	4	.500	8.0

[1]Seven values were forecast for each wholesale price and a correct forecast occurred when both the forecast and the actual price changes from month t to month t +1 were in the same direction.

Summary

The seven month trial period provides a very tentative evaluation of the forecasting usefulness of these equations. The usefulness may have been further obscured by the fact that somewhat atypical sharp price fluctuations occurred during 1969 for both beef and pork wholesale prices. The sharp price fluctuations may have resulted in larger forecasting errors than one might expect under more typical conditions of less drastic price changes.

The mean absolute percentage error ranged from a low of 2.2% for round prices to highs of 8.1% and 8.0% for picnic and butt prices. The direction of price change was forecast correctly all seven months for rib prices and only missed one month for beef loin, ham and pork loin prices. The forecast prices for arm chucks, bellies, picnics and butts identified the directional price change correctly only four out of the seven months.

CHAPTER VII

CONCLUSIONS

The general findings of this study were summarized after each chapter reporting the estimation results of Models I-III and the forecasting equations. Direct comparative conclusions are not possible because of the lack of other known studies of monthly wholesale beef and pork cut behavioral demand and supply relationships.

Differences in the relative price flexibilities, when the calculated flexibilities from the simultaneous equations are compared to the relative suggested flexibilities from Model II, suggests further research clarification is needed. The calculated price flexibilities with respect to quantity for three of the wholesale beef cuts were less than the price flexibility with respect to quantity for Choice grade steers (-1.1) calculated in an earlier study which used essentially the same explanatory variables over a somewhat shorter time period.(11).[1] Similar findings for wholesale pork price flexibilities relative to the price flexibility with respect to quantity for live hogs were obtained, with only the price flexibility for bellies being substantially greater. To further test the reasonableness of the wholesale price flexibilities, price flexi-

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[1] Langemeier and Thompson provide a good summary of retail and farm price flexibilities using annual data (16).

bilities for retail cuts, using the same time period, should be analyzed. Whether the calculated wholesale cut price flexibilities are somewhat more flexible than comparable retail cut price flexibilities, assuming less than a constant percentage mark-up between wholesale and retail, could then be seen.

Myers, Havlicek, and Henderson did calculate price flexibilities with respect to quantity at mean values for monthly farm and retail prices for pork and beef (21). But, the farm flexibilities calculated in their study were substantially more flexible than the farm flexibilities calculated in the study by Hayenga and Hacklander (11). Some of the differences probably resulted from the fact that one study used deflated prices and per capita income, and per capita consumption variables while the other study used current prices and per capita income, and commercial production per workday variables. Also, the studies covered different time periods. Because of the differences in farm flexibilities no comparative conclusions about the wholesale price flexibilities in this study relative to Myers', etc. farm and retail price flexibilities were made.

A clearer insight into what changes occurred at the wholesale level, given a behavioral change, was gained by analyzing cut prices instead of a more aggregate composite beef or pork price. The differences in the price flexibilities among the cuts and the estimated positive relationship between belly price and beef quantity levels are cases in point. These findings suggested possible different groupings of wholesale cuts when analyzing the resultant effect of behavioral changes. In some cases, such as analyzing the responses among cuts to income changes, these groupings would include both beef and pork cuts instead of dividing along the traditional beef versus pork boundaries.

The inverse relationships between the price spread and own quantity level for wholesale beef and pork cuts suggested that wholesale prices were more responsive to quantity changes than live prices. This is contrary to the general price behavior between retail and live price changes. Retail price changes usually lag somewhat behind live price changes and the magnitude of the retail price change is usually less than the live price change.

Further research areas were indicated by this study. Different forecasting equations should be experimented with. This may simply be a re-estimation of the forecasting equations using a different time period. Also the present forecasting equations should be tested over a more typical, less sharply fluctuating, price period.

Integrating this research into a further, more inclusive, behavioral study should provide even greater insights into the factors affecting wholesale price behavior and some of the tentative findings in this study. More wholesale cuts, division of cattle into fed and non-fed groups, different grades and classes of cattle and hogs, and the retail demand level are possible areas that could be included in further research.

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