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Accounting for recent changes in beef and pork marketing margins

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CHAPTER 1. INTRODUCTION

The purpose of this study is to test some possible explanations of the changes observed in the beef and pork marketing margins in about 1978. This study also outlines a method by which changes in the marketing margins can be decomposed into component parts. The decomposition is useful since simply identifying changes in the levels of exogenous variables or identifying changes in coefficients does not, by itself, indicate the magnitude of the effects of these changes on the marketing margins. Finding explanations for and identifying the magnitude of their impact on increased marketing margins may pave the way for more accurate predictions of marketing margins and therefore of retail and live animal prices.

Before the late 1970s, farm-retail margins were fairly stable. Since about 1978, however, monthly margins for beef and pork have increased and have become more volatile. The mean farm-retail beef margin increased more than 45 percent from the period 1974-1977 to the period 1978-1981. The mean farm-retail pork margin increased more than 30 percent in this time. The standard deviation of the farm-retail beef margin increased from 5.6 to 12.7 while the standard deviation of the farm-retail pork margin increased from 7.1 to 7.5 between the two time periods. The seasonal patterns of the two time series also seem to have changed. The jump in the level of the two margins observed in 1978 is not the first but seems to be significantly larger than previous jumps. The previous jumps also do not appear to be accompanied by a sizable change in volatility as the 1978 jump does.

Consideration of the characteristics of the beef and pork processing and marketing sector and the characteristics of the final consumer may be important in trying to identify the causes of the observed changes in margin level and seasonal pattern.

The demands for live cattle and hogs are derived demands--derived from the consumers' demand for meat at the retail level. Even though retail prices may remain relatively stable, predictions of live animal prices could be significantly in error due to the changing marketing margin.

Consumer, retailer, and processor behavior may have changed enough during the 1970s to cause previous prediction equations to be in error. Consumer tastes and habits may have changed the coefficients of the demand equations. Retailer and processor behavior may have changed due to technological advances and changes in market structure. The increased usage of boxed beef, for example, may have changed the level in the marketing channel where certain processing tasks and costs are located. This may affect the markup behavior of processors and retailers. In addition, the multiproduct nature of the processing and retailing firms may have changed also. These changes may show up as changes in coefficients of prediction equations.

Not only the static behavior of consumers, retailers, and processors, but also the dynamic behavior of these market participants may have changed in the 1970s.

There have been numerous papers on margins and on price determination in the food industry. With some exceptions, previous studies of the beef and pork marketing margins have assumed that parameters have not changed over their respective sample periods. Previous studies have also often assumed that the retail level is composed of single-product firms, which implies margins on different products are independent.

Two important hypotheses of this study are from Holdren's (1960) theory on multiproduct firms. By Holdren's theory, margins on different products are not independent. Also from Holdren's model, changes in the own-price and the cross-price slopes of consumer demand functions will change the optimal margin charged by retailers. This study treats the retail and the wholesale levels as if composed of multiproduct firms. This study also tests for structural change in the consumer demand equations and identifies the extent to which these changes have influenced the margin levels. A third hypothesis investigated in this study is that structural change in the margin equations has contributed to the higher margin level.

The second chapter of this work reviews previous work in the area of marketing margins while the third chapter outlines the hypotheses and model of this study. The fourth chapter reviews relevant statistical considerations and the fifth chapter describes the decomposition techniques used in this study. The sixth chapter presents the data descriptions and sources. Chapter 7 and Chapter 8 present the estimated demand equations and margin equations. Chapter 9 presents the effects of structural change in the margin equations on the margins. The next two chapters present the effects that demand-equation structural-change has had on the farm-retail, the wholesale-retail, and the farm-wholesale margins.

CHAPTER 2. LITERATURE REVIEW

Previous work in the area of marketing margins has taken into account various aspects of the meat processing and marketing sector. The process of price determination for marketing margins, as well as other aspects considered important, differs among studies. This chapter reviews some studies of marketing margins and discusses important characteristics of the meat processing and marketing sector.

John Ikerd (1983) developed an econometric model to predict the monthly average farm-retail marketing margin for beef. His approach was to estimate the supply of and demand for marketing services. He assumed the quantity of marketing services was proportional to the quantity of meat. The interaction of the supply and demand for marketing services determined the price of marketing services (i.e., the marketing margin). The demand for marketing services was defined as the excess retail beef demand minus excess live cattle supply, with respect to the price axis. His model consisted of four simultaneous equations: two equations to arrive at an estimate of excess retail beef demand, one equation to estimate the excess live cattle supply, and one equation to estimate the supply of marketing services. The model also contained four identities.

Ikerd's study also included the estimation of a single equation: the beef marketing margin as a function of the quantity of marketing services, a processing and marketing cost estimate, and the seasonal dummies. Commercial beef production was again used as the quantity of marketing services for this equation. Residual analysis indicated cyclical patterns similar to the original marketing margin series.

Dale Heien (1980) took a different tack than Ikerd. Heien presented a dynamic theory of price determination in the food processing industry that was consistent with the static model Gardner (1975) described. Heien's model did not require the supply and demand at a particular level in the marketing channel to be equal at every point in time. Heien pointed out that disequilibrium becomes more important in this sector as the time period of analysis becomes shorter.

Although the theory was general enough to include the retail, wholesale, and farm levels, a six equation model of the retail and farm levels was used as an example in his paper. The six equation model consisted of retail level supply and demand equations, a change-in-farm-price equation, and a retail markup pricing equation. Heien showed that for a single product firm with constant returns to scale and time-fixity of production coefficients, markup pricing was the optimal pricing rule. Heien dedicated part of his paper to empirically testing one component of his theory: the markup pricing rule. Following Sim's use of a Granger test for direction of causality, Heien tested whether wholesale price changes 'cause' retail price changes, which was implied if the markup pricing rule held. For 23 food items he tested, 13 items showed unidirectional-upward causality, two items showed unidirectional-downward causality, three items showed bidirectional causality, and five items showed independence. The tests for beef and pork showed unidirectional-upward causality, which, on the basis of this test, implied the markup pricing rule held. Although not explicit in the model, Heien included both current and lagged wholesale prices in the markup equation when testing for causality. This was yet another source of dynamics in the model.

Heien also tested for symmetrical pricing on the part of retailers-- a test of whether retailers passed on decreases in wholesale prices as fully as they passed on increases. The hypothesis of symmetrical pricing was not rejected for beef but was rejected for pork.

A structural stability test was performed to see if some parameters in the markup pricing equations had changed significantly over the period January, 1975 through December, 1976. The hypothesis of structural change was rejected in 15 of 22 cases. From this, Heien concluded there was support for the time-fixity of production coefficients assumption which lent support for markup pricing in the marketing channel.

Lamm and Westcott (1981) also tested the markup hypothesis, or more specifically, that farm-level price changes 'cause' retail food price changes. Results were very similar to those reported in Heien. For many food items, there was unidirectional causality from the farm level to the retail level.

Lamm and Westcott investigated reasons for food prices rising faster than nonfood prices during the 1970s. They developed an econometric model of price determination that was based on Popkin's 'stage of processing' model. The explicitly multiproduct model had prices written as functions of current and lagged output and input prices and excess demand variables. The model was a markup model and allowed them to consider the relationships between changes in farm prices and changes in retail food prices. For their study, farm to retail was considered as one stage. The model consisted of 15 food price equations, two behavioral equations, and three aggregation equations. Quarterly data were used and variables, except seasonal dummies and time trends, were expressed as quarterly percent changes.

From the reduced form of the econometric model, multipliers were generated to examine how input price changes were passed on through the system and over time. The maximum lag required in the equations was one quarter. Results indicated that the bulk of the impact from changing input prices occurred within the current quarter and one quarter ahead with smaller impacts two and three quarters ahead. Lamm and Westcott noted that the food sector had a much simpler lag structure than the nonfood sector.

Results from the model indicated that the rise in the prices of both farm and nonfarm inputs caused the higher retail food prices relative to nonfood prices in the 1970s.

Markup pricing in the marketing channel was incorporated into a quarterly econometric model of the beef and pork marketing sector by Ladd and Karg (1973). The model consisted of 12 stochastic equations: two retailer demand equations, two inventory equations, two consumer demand equations, two wholesale-retail margin equations, two farm-wholesale equations, and two farm price equations. There were also 18 identities in the model. Markup pricing was introduced into the wholesale-retail margins by specifying the margins as functions of the change in the wholesale value of that meat. The farm-wholesale margin for pork was a function of the change in the farm price of pork.

The marketing margins estimated in the Ladd and Karg study included variables that allowed them to determine the effects of marketing input prices as well as labor productivity on margins at both the farm-wholesale and the wholesale-retail levels. Ladd and Karg also allowed for multiproduct effects by including interrelationships between the beef and pork margins. Results indicated that beef and pork margins were not independent. They found that the pork margin at the farm-wholesale level influenced the farm-wholesale beef margin but that the influence did not run in the other direction. At the wholesale-retail level, the pork margin influenced the beef margin and the beef margin influenced the pork margin. The system of equations was dynamic since each margin equation contained its own one period lag.

Both linear and logarithmic quarterly consumer demand equations, where price was the dependent variable, were estimated. Various hypotheses were tested concerning equality of quarterly slope coefficients and equality of the quarterly intercepts for beef, pork, lamb, and broilers. Results for beef and pork, for both the linear and the logarithmic versions, indicated that quarterly intercepts were different but that quarterly slopes were not significantly different. The Ladd and Karg study ranked the quarterly intercepts for beef (highest to lowest) as III, IV, II, and I. For pork, their ranking was

IV, III, I, and II. Their rankings of quarterly intercepts differed somewhat from rankings in previous works, which were cited in their study.

Quarterly intercepts were also ranked for the two inventory equations, for the two farm-wholesale margins, and for the two wholesale-retail margins. Ladd and Karg concluded from the comparison of their quarterly intercept rankings with those of other studies that seasonal patterns in consumption and margin behavior had changed over a period of years.

The multiproduct effect that was introduced into the Ladd and Karg model was consistent with the retail firm multiproduct theory described by Holdren (1960). Holdren conducted an industry study of the retail market. The study identified decision variables of the retail sector and developed a model of retail firms. The relationships among firms were also established.

Demand functions facing a retail unit in Holdren's model were of the form:

$$Q_i = f_i(P_1, \ldots, P_n, a_1, \ldots, a_m), \quad i = 1, \ldots, n$$

The quantity of a good demanded from a retail unit was a function of the price of that good as well as prices of other goods (the P_is) and the nonprice offer variants (the a_js).

The total cost function for a retail unit took the form:

$$C = c(Q_1, \ldots, Q_n, a_1, \ldots, a_m)$$

The nonprice offer variants represented fixed or discretionary cost inputs or variable cost inputs (such as a stamp program). Costs of providing a product for sale were not independent of quantities of other items in the product line. Clearly, the retail units were treated as multiproduct firms.

The profit function was

$$\Pi = \sum_{i=1}^{n} P_i Q_i - C$$

Maximizing profit over the decision variables, which were the prices and nonprice offer variants, Holdren obtained

$$\partial\Pi/\partial P_j = Q_j + \sum_{i=1}^{n} (P_i - \partial C/\partial Q_i)(\partial Q_i/\partial P_j) = 0, \; j = 1,\ldots,n.$$

$$\partial\Pi/\partial a_j = \sum_{i=1}^{n} (P_i - \partial C/\partial Q_i)(\partial Q_i/\partial a_j) - \partial C/\partial a_j = 0, \; j=1,\ldots,m$$

In equilibrium, the profit margin on the nth good, for example, equaled price offer variation cost. Mathematically,

$$(P_n - \partial C/\partial Q_n) = [-Q_n - \sum_{i=1}^{n-1} (P_i - \partial C/\partial Q_i)(\partial Q_i/\partial P_n)]\,(\partial Q_n/\partial P_n)^{-1}$$

where the right-hand side was the profit margin on the nth good and the left-hand side was the price offer variation cost. With certain complementary relationships, the profit margin on the nth good could be negative.

Two interesting implications of Holdren's model are that (1) the profit margins on goods sold by the retailer are not determined independently and (2) the profit margins are functions of slope coefficients of the demand functions.

Heien provided some theoretical basis for markup pricing on the part of retailers. Holdren also provided some theoretical basis for interrelated margins due to the multiproduct nature of the sector.

Some of the previous works described have common characteristics. The markup pricing by retailers has been tested in some studies and assumed true in some others. Two of the studies explicitly included the multiproduct nature of the industry in their models. The Holdren study indicated there was some justification to model the industry as consisting of multiproduct firms.

Some of the studies have also tried to capture dynamics of the industry. A justification for including dynamics can be found in articles by Parham and Duewer (USDA Report No. AGESS8012215 1980f) and Ross (1984). Ross described how dynamic retailer behavior could cause 'step' patterns and short term cycles in marketing margin series. Consumers may tend to resist frequent price changes or steadily rising prices. Retailers, then, may be willing to accept losses for relatively long periods of time as costs or wholesale prices rise in order to keep retail prices constant. When losses become overwhelming, retailers then step their margins up to a higher level. On wholesale price or cost declines, retailers delay lowering margins 1) in order to recoup losses incurred on wholesale price increases, and/or 2) on the expectation that wholesale prices or costs will soon rebound. Wholesale prices and farm prices, then, tend to be more variable than retail prices. The seasonal patterns in farm and wholesale prices do not always find their way to retail prices as retailers absorb the price changes by expanding and contracting margins. Short term cycles then appear in margin data.

This type of dynamic retailer behavior implies relatively stable retail prices in the short run. Three of the studies cited previously included dynamics of this type in their models.

An alternative explanation of these retail price dynamics may be found in Wohlgenant and Hahn (1982). They found that the difference between the short and long run price elasticities of demand for beef and pork may also have accounted for relatively stable retail prices in the short run. The short run own-price elasticities for beef and pork were greater than the long run elasticities since in the short run, consumers could vary their demand for stocks as well as consumption.

Heien's model included yet another source of dynamics. He allowed demand and supply to differ at a point in time.

Although the approach differs among studies, some overall conclusions may be drawn. Several studies supported the hypothesis that the meat processing sector was characterized by markup pricing. Also, some found evidence of behavior consistent with a sector made up of multiproduct firms. Other aspects of the Holdren multiproduct theory were untested. Dynamics in the meat processing and marketing sector were also important.

CHAPTER 3. MODEL FORMULATION

Several different approaches have been taken in previous studies to examine issues involving marketing margins. Some of these approaches have been outlined in the Literature Review Chapter. This study contains some characteristics similar to those of previous work but differs on some important points. The purpose of this study is to test possible explanations of the changes observed in the beef and pork marketing margins in the late 1970s. In about 1978, both marketing margin series appeared to step to a higher level and although this was not the first jump for either time series, this jump seemed to be greater than earlier such jumps. Also, unlike previous increases, this recent jump was accompanied by an increase in volatility in both monthly time series and an apparent change in seasonality. This study tests three possible explanations of the changes observed in these margins.

This chapter outlines the three hypotheses of this study and describes the econometric model that allows tests of these hypotheses. The statistical methods and formulations of the tests of the hypotheses for both the static and dynamic versions are outlined in the next two chapters. Descriptions of data are saved for discussion in Chapter 6.

Hypotheses

Two of the hypotheses of this study are derived from work by Holdren (1960) on multiproduct retail firms. According to Holdren's model, the margin charged on one good is not independent of the margins charged on other goods. The model also implies that the margin charged on a good changes as the own-price slope or the cross-price slopes change.

One first-order condition for profit maximization for a two-good case of Holdren's model is

$$3.1. \qquad \partial \Pi / \partial P_1 = Q_1 + (P_1 - \partial C/\partial Q_1) \frac{\partial Q_1}{\partial P_1} + (P_2 - \partial C/\partial Q_2) \frac{\partial Q_2}{\partial P_1} = 0$$

Rearranged, this becomes

$$3.2. \qquad (P_1 - \partial C/\partial Q_1) = - (\partial Q_1/\partial P_1) - [(P_2 - \partial C/\partial Q_2)(\partial Q_2/\partial P_1)/(\partial Q_1/\partial P_1)]$$

where P_i and Q_i are the retail price and quantity of the ith good, and $(P_i - \partial C/\partial Q_i)$ is the profit margin on the ith good. A more detailed discussion of Holdren's model can be found in the Literature Review Chapter. From equation (3.2), it is clear that the profit margin on good 1 is not independent of the profit margin on good 2; this generalizes to an n-good case. The first hypothesis then is that of interdependent margins. The pork margin is not isolated from beef sector changes and vice versa. To incorporate this multiproduct effect into the econometric model of this study, the margin on beef (pork) is a function of the margin on pork (beef).

Changes in demand also affect the margins in Holdren's model. One can differentiate (3.2) with respect to the own-price slope, $\partial Q_1/\partial P_1$, and with respect to the cross-price slope, $\partial Q_2/\partial P_1$, to obtain

$$3.3. \qquad \frac{\partial (P_1 - \partial C/\partial Q_1)}{\partial(\partial Q_1/\partial P_1)} = [Q_1 + (\partial Q_2/\partial P_1)(P_2 - \partial C/\partial Q_2)](\partial Q_1/\partial P_1)^{-2}$$

$$= \frac{-(P_1 - \partial C/\partial Q_1)}{(\partial Q_1/\partial P_1)}$$

and

$$3.4. \qquad \frac{\partial (P_1 - \partial C/\partial Q_1)}{\partial (\partial Q_2/\partial P_1)} = \frac{-(P_2 - \partial C/\partial Q_2)}{(\partial Q_1/\partial P_1)}$$

Similar results are obtained from the derivatives of the (rearranged) first-order condition, $\partial \Pi/\partial P_2 = 0$, with respect to $\partial Q_2/\partial P_2$ and $\partial Q_1/\partial P_2$. Equation (3.3) is positive as long as $(P_1 - \partial C/\partial Q_1) > 0$ and $(\partial Q_1/\partial P_1) < 0$. Equation (3.4) is positive as long as $(P_2 - \partial C/\partial Q_2) > 0$ and $(\partial Q_1/\partial P_1) < 0$.

A USDA publication (USDA Report No. 509 1984) indicates that gross margins for meat are slightly less than those for the store as a whole-- possibly due to the extensive use of meat advertisements to draw customers-- but are still positive. Although gross margins and profit margins are not equal, one may expect profit margins on beef and pork to be positive also. Furthermore, it is expected that the demands for beef and pork are typical downward-sloping curves. Therefore, the signs of (3.3) and (3.4) are expected to be positive. As the own-price slope increases (becomes flatter) or as the cross-price slope increases, the margin on good 1 is expected to rise. The own-price and cross-price impacts discussed here generalize to the case of n goods.

The second hypothesis of this study then is that structural changes in the demands for beef and pork have affected margin behavior in the late 1970s via the Holdren demand impacts. Structural change in the late 1970s in the two demands is hypothesized mainly because of the increased health concerns over red meat consumption. The 1970s saw relative price changes among beef, pork, and poultry. Slowly changing consumption habits toward poultry and the increased concern about fat and cholesteral in the 1970s may show up as structural change in the slope coefficients of the beef and pork demands. Placement of the structural change differs among studies. Chavas (1983) placed the change in the mid-1970s while Ikerd (1984) placed the change in the early 1980s. This study searches for structural change in 1977/1978. This coincides with the approximate time when the beef and pork margins increased sharply and became more volatile.

The third hypothesis of this study is that of structural change in the margin equations themselves. The beef and pork processing sector saw important changes over the past two decades and especially in the 1970s. Perhaps the biggest change came in the way meat was marketed to the retail stores. The shift from carcass to boxed beef had important implications as far as retail marketing and costs were concerned. With boxed beef, retailers are better able to control the proportions of certain cuts they purchase from packers, which allows them to better target certain customer groups. Furthermore, costs are relocated within the marketing channel. Less cutting at the retail level (where wages tend to be higher) is required and cutting is instead shifted to the packer or wholesale level where lower wages and assembly line efficiency can reduce costs. Although this marketing phenomenon has been largely in beef, pork marketing has seen similar changes.

Another possible source of structural change in the marketing sector has been the unit product codes (UPC) which allow the retailers to better control meat inventory. The sales information that the UPCs provide gives the store managers a better idea of the effectiveness of specialling and the interactions among the various departments of the store.

Yet another area of change in the sector was the beef grading change that occurred in the mid-1970s. Costs of grading may have changed and pricing efficiency may have increased (Purcell and Nelson 1976).

Although these changes in the beef and pork marketing sector have not occurred overnight, this study searches for evidence of structural change in 1977/1978. Again, this coincides with the observed increase in the level and with the increase in volatility after the late 1970s for the beef and pork margins.

The attempt to explain changes in recent margin behavior leads this study to investigate the three hypotheses described. The first hypothesis is that margins on beef and pork are not determined independently of one another. As a result, changes in one sector impact both the beef and pork sector. The second hypothesis is that structural change in the demands for beef and pork have influenced margins for the two goods via the Holdren demand impact. And finally, the third hypothesis is that margin behavior changed due to the important changes that have taken place in the beef and pork marketing sector in the 1970s.

Model

An econometric model has been developed to test the hypotheses of this study. Appropriate variables that are included in the model are based on economic theory, previous studies, characteristics of the beef and pork marketing sector, and changes that have taken place in this sector within the past decade.

The economic model used in this study is derived from a more general specification of the beef and pork marketing sector. When certain maintained hypotheses are introduced, a complex, general specification of the sector may be reduced to a small yet powerful economic model that permits the hypotheses of this study to be tested.

One can begin with a somewhat simplified model of the meat marketing sector that consists of supply and demand at the retail level and supply and demand at the farm level.

3.5. $Q_r^d = g_1(P_r, z_1)$

3.6. $Q_r^s = g_2(P_r, w_x)$

3.7. $Q_f^d = g_3(P_f, w_x)$

3.8. $Q_f^s = g_4(P_f, z_2)$

Superscripts on quantities identify whether it is the quantity demanded or supplied. Subscripts on quantities and prices identify whether it is at the retail or farm level. The zs are simply other exogenous variables. The w_x is the price of the marketing input x. Inventories are not dealt with explicitly since it is assumed that there is no change in inventories from one period to another or $Q_r^s = Q_f^d$. Equation

(3.5) is the primary or consumer demand at the retail level for the good. Equation (3.6) is the supply to the retail level. The derived demand, equation (3.7), is the retailers' demand for the farm product. Finally, equation (3.8) is the primary or farmers' supply of the farm product. In equilibrium,

$$Q_r^d = Q_r^s$$
$$Q_f^d = Q_f^s$$

A description of a simple model such as this can be found in Tomek and Robinson (1977).

Dale Heien (1980) demonstrated that with the assumptions of time-fixity of coefficients in the production of the retail good and constant returns to scale that retailers' pricing behavior is characterized by a markup over the farm value. Consider the fixed-coefficient production function

$$Q_r = \min (Q_f/a_1, x/a_2)$$

The addition of constant returns to scale yields a cost function of the form

$$C = (a_1 P_f + a_2 w_x) Q_r$$

Then under competitive conditions (price equals marginal cost)

$$P_r = a_1 P_f + a_2 w_x$$

Substituting the identity

3.9. $$P_r = P_f + M$$

where M is the farm-retail margin, yields

3.10. $$M = (a_1 - 1) P_f + a_2 w_x$$

The coefficient a_1 is the farm equivalent and for livestock is typically greater than one. Therefore $(a_1 - 1)$ is positive. The retailer's margin here is a function of the farm price and the price of other inputs. With fixed-coefficient production and constant returns to scale, one can replace equations (3.6) and (3.7) with (3.10).

In Heien's 1980 article, he tested the time-fixity of production coefficients hypothesis and found that it was a reasonable assumption to make for the meat industry. Both Heien and Gardner (1975) assumed that the meat marketing sector had constant returns to scale production.

Two maintained hypotheses concerning the quantity supplied at the farm level may be considered to simplify the general model further. Suppose that farm-level supply is not a function of current price or other endogenous variables. There is a vertical supply curve in contemporaneous price/quantity space and the quantity supplied in a particular period is predetermined. If, in addition to predetermined supply, changes in inventory are small relative to changes in consumption, then consumption may be treated as predetermined also.

A second maintained hypothesis concerning supply helps to identify the retail demand. The supply curve must be subtantially more variable in price-quantity space than the demand curve. Shifts in the supply curve, then, map out the demand curve from equilibrium price-quantity data. In addition to the relative variability in demand and supply curves, shifts in the supply curve must be independent of shifts in the demand curve. If this condition is violated, the estimated demand curve will be either steeper or flatter than the true demand curve, depending on the correlation in supply and demand shifts.

Predetermined supply is a reasonable assumption for the livestock sector with monthly data. For beef, it may be more than a year after a price change before significant changes in supply are felt. Although some contraction or expansion takes place within a year, relatively little supply change comes within a one or two month period. The situation is not as clear-cut for hogs, but the assumption of predetermined supply is still reasonable.

It is also reasonable to assume that supply shifts substantially more than demand. Income is probably the major shifter in meat consumption, but income or changes in income remain relatively stable over time. Among weather, rapid input price changes, and herd liquidation phases, supply shifts are expected to be more variable. Furthermore, returns to the livestock producers from sales are small relative to consumers' total income. Therefore, the correlation between demand and supply shifts is expected to be quite low.

Given the two maintained hypotheses of supply, one may simply set $Q_f^s = \bar{Q}$ and include an equilibrium condition $Q_r^d = Q_f^s$. Since quantity is predetermined, the retail demand may be inverted to yield (after substituting in the equilibrium condition)

3.11. $P_r = g_5(\bar{Q}, z)$

A complete but much simplified economic model of the meat marketing sector is made up of equations (3.9), (3.10), and (3.11). This model is static and only includes a single good, which is meat in the above example.

The monthly econometric model postulated in this study is an extension of the above model. The economic model in this study takes into account the multiproduct nature of the beef and pork marketing sector as well as the possible dynamics considered important. There are two forms of the model-- Form I contains farm-retail margins while Form II contains farm-wholesale and wholesale-retail margins. For each form of the model, both a static and a dynamic version are estimated.

Form I of the model in general form then is

3.12. $P_{Bt}/CPI_t = f_1(RQ_{Bt}, RQ_{Pt}, DI_t, Z_{1t})$

3.13. $P_{Pt}/CPI_t = f_2(RQ_{Bt}, RQ_{Pt}, DI_t, Z_{2t})$

3.14. $M_{Bt} = f_3(FV_{Bt}, M_{Pt}, Z_{3t})$

3.15. $M_{Pt} = f_4(FV_{Pt}, M_{Bt}, Z_{4t})$

3.16. $FV_{Bt} = P_{Bt} - M_{Bt}$

3.17. $FV_{Pt} = P_{Pt} - M_{Pt}$

Form II breaks the farm-retail margins into farm-wholesale and wholesale-retail margins. The demand equations of Form II are identical to those of Form I. Form II of the model then is

3.12. $P_{Bt}/CPI_t = f_1(RQ_{Bt}, RQ_{Pt}, DI_t, Z_{1t})$

3.13. $P_{Pt}/CPI_t = f_2(RQ_{Bt}, RQ_{Bt}, DI_t, Z_{2t})$

3.18. $RM_{Bt} = g_1(WV_{Bt}, RM_{Pt}, Z_{5t})$

3.19. $RM_{Pt} = g_2(WV_{Pt}, RM_{Bt}, Z_{6t})$

3.20. $WM_{Bt} = g_3(FV_{Bt}, WM_{Pt}, Z_{7t})$

3.21. $WM_{Pt} = g_4(FV_{Pt}, WM_{Bt}, Z_{8t})$

3.22. $WV_{Bt} = P_{Bt} - RM_{Bt}$

3.23. $WV_{Pt} = P_{Pt} - RM_{Pt}$

3.24. $FV_{Bt} = P_{Bt} - RM_{Bt} - WM_{Bt}$

3.25. $FV_{Pt} = P_{Pt} - RM_{Pt} - WM_{Pt}$

Table 3.1 defines and classifies the variables of the two forms.

The two demand functions of this model are price dependent since, as discussed previously, the quantity consumed is predetermined. Prices and income of the two demands are deflated by the the Consumer Price Index for all goods. Deflating prices and income may aid in reducing multicollinearity in the estimation stage. Income and quantities of beef and pork are divided by population in order to obtain the demands of a representative consumer. The other exogenous variables, Z_{1t} and Z_{2t} are lagged exogenous variables and/or dummy variables. The dummy variables are seasonal dummies and may also represent an event in the sample period that has shifted the intercept.

In a static framework, all variables in the demand functions are current exogenous and endogenous variables. In a more dynamic framework where habits may influence purchases, lagged exogenous variables such as retail quantities may be included. Including lagged retail quantities does not conflict with the maintained hypothesis of predetermined supply since within one month, supply is still reasonably fixed.

The margin equations of this study are consistent with the markup-type margins described earlier. The farm-retail margins (equations (3.14) and (3.15)) and the farm-wholesale margins (equations (3.20) and (3.21)) are functions of the farm value of the particular meat. The

Table 3.1. Definitions and classifications of monthly variables

Variable	Definition/Classification
P_{Bt}	Composite retail price of beef in period t; endogenous.
P_{Pt}	Composite retail price of pork in period t; endogenous.
RQ_{Bt}	Percapita retail quantity of beef in period t; exogenous.
RQ_{Pt}	Percapita retail quantity of pork in period t; exogenous.
DI_t	Real percapita disposable personal income in period t; exogenous.
CPI_t	Consumer Price Index for all goods in period t; exogenous.
M_{Bt}	Farm-retail margin on beef in period t; endogenous.
M_{Pt}	Farm-retail margin on pork in period t; endogenous.
FV_{Bt}	Net farm value of beef in period t; endogenous.
FV_{Pt}	Net farm value of pork in period t; endogenous.
Z_{1t}, Z_{2t}, Z_{3t}, Z_{4t}	Other exogenous and/or lagged endogenous variables in period t.
RM_{Bt}	Wholesale-retail margin for beef in period t; endogenous.
RM_{Pt}	Wholesale-retail margin for pork in period t; endogenous.
WM_{Bt}	Farm-wholesale margin for beef in period t; endogenous.
WM_{Pt}	Farm-wholesale margin for pork in period t; endogenous.
WV_{Bt}	Net wholesale value of beef in period t; endogenous.
WV_{Pt}	Wholesale value of pork in period t; endogenous.
Z_{5t}, Z_{6t}, Z_{7t}, Z_{8t}	Other exogenous and/or lagged endogenous variables.

wholesale-retail margins (equations (3.18) and (3.19)) are functions of the wholesale value of the particular meat. Both wholesalers and retailers are hypothesized to determine a margin at a level as a markup over the price at the previous level in the marketing channel.

The margin equations also take into account the multiproduct nature of the meat marketing sector. This multiproduct effect is introduced into the model by writing the margin on pork, for example, as a function of the margin on beef. The coefficients on the other margins are expected to be positive.

The model of this study may either be a static or a dynamic model, depending on whether certain other variables are included in the margin equations. The model is static when only current exogenous variables are included. The addition of lagged endogenous variables in the margin equations makes the model dynamic. With the dynamic specification, the coefficient on current farm or wholesale value is expected to be negative while the coefficient on lagged farm or wholesale value is expected to be positive. These signs are expected since it is supposed that retailers or wholesalers absorb a change in price within the first month but pass that cost on in the second month.

The other exogenous variables of the margin equations, Z_{3t} through Z_{8t}, represent input costs and dummy variables. The important input costs are for labor, packaging materials, processing equipment, and energy. Labor costs make up a large portion of the marketing costs in meat processing and retailing. Changes that have taken place in the meat marketing sector may influence the size and behavior of the margins studied here. For example, the trend toward boxed beef has shifted much of the labor associated with breaking and cutting from the retail store to the wholesale or slaughter levels. Wage rates differ among these levels and this perhaps has had an impact on the marketing margins. The coefficients on input costs are expected to be positive. The dummy variables consist of 11 seasonal dummy variables.

CHAPTER 4. STATISTICAL METHODS

The inappropriateness of certain assumptions in this study complicates the estimation stage. Ordinary Least Squares assumptions concerning the X, or independent variable, matrix and assumptions concerning the errors are violated in the econometric model outlined in the Model Formulation Chapter. This chapter outlines the procedure used to correct the data for these violations. The first section describes the use of Generalized Least Squares for correcting heteroscedasticity and autocorrelated errors in a single equation. The second section provides tests for autocorrelation and heteroscedasticity. The third section outlines the procedure that is used to estimate equations of a system where both heteroscedasticity and autocorrelation are present. The fourth section describes the procedure and tests for identifying structural change. The last section of this chapter outlines the necessary conditions for identification of an equation in a system of equations.

Generalized Least Squares

Typically with time series data, the assumption of a scalor diagonal variance-covariance matrix of the errors is not met. The Ordinary Least Squares (OLS) estimator is then inappropriate. The Generalized Least Squares (GLS) estimator may be applied in such cases (see Johnston 1984). GLS begins with the same linear equation as with OLS, or

$$Y = XB + u$$

where Y is an (nx1) vector of observations on the dependent variable; X is an (nxk) matrix of observations on the independent variables; B is a (kx1) vector of coefficients; and u is an (nx1) vector of errors with $Eu = \underline{\emptyset}$. There are n observations and k exogenous variables. The variance-covariance matrix is

$$E(uu') = \sigma^2 V \neq \sigma^2 I_n$$

A standard assumption of OLS is violated. OLS estimates of B will be unbiased but will no longer have minimum variance in the class of linear unbiased estimators. The OLS estimator for B,

$$\hat{B} = (X'X)^{-1}X'Y$$

is unbiased. Furthermore, the distribution of the u_i's are not generally independent, which violates an important assumption of hypothesis testing. Hypothesis testing with t, F, or χ^2 distributions require independence of the u_i's.

The GLS procedure finds a matrix H to transform the model such that

$$H'H = V^{-1}$$

$$u_{\star} = Hu$$

$$X_{\star} = HX$$

$$Y_{\star} = HY$$

One then applies OLS to the transformed model

$$\tilde{B} = (X'V^{-1}X)^{-1}X'V^{-1}Y$$

The GLS estimator is unbiased

$$E(\tilde{B}) = B + (X'V^{-1}X)^{-1}X'V^{-1}Eu$$

$$= B$$

since $Eu = \underline{\emptyset}$. The variance-covariance matrix for $\tilde{B}$ is

$$\begin{aligned} var(\tilde{B}) &= E(X'V^{-1}X)^{-1}X'V^{-1}uu'V^{-1}X(X'V^{-1}X)^{-1} \\ &= \sigma^2(X'V^{-1}X)^{-1}X'V^{-1}VV^{-1}X(X'V^{-1}X)^{-1} \\ &= \sigma^2(X'V^{-1}X)^{-1} \\ &= \sigma^2(X_*'X_*)^{-1} \end{aligned}$$

Also

$$s^2 = \frac{\tilde{u}_*'\tilde{u}_*}{(n - k)}$$

is an unbiased estimator for σ^2.

If V is unknown, then one may replace V with the estimated matrix $\hat{V}$. The small sample properties of Estimated Generalized Least Squares (EGLS) is unknown but the approximation improves as the sample size increases. Two types of deviations from standard OLS assumptions are examined in this study. One is autocorrelated errors and the other is heteroscedasticity. In both cases, V is unknown and must be estimated. The first-order autocorrelation is corrected within the sample periods before the presence of heteroscedasticity is tested for.

An area where OLS assumptions about the errors are possibly violated is autocorrelated errors. Here, the error in one period is correlated with of the error in at least one previous period. The errors are assumed to follow a first-order autoregressive process in this study. The equations for the two sample periods then are

$$y_{1t} = X_{1t}B_1 + e_{1t}, \quad e_{1t} = \rho_1 e_{1t-1} + u_{1t}$$
$$y_{2t} = X_{2t}B_2 + e_{2t}, \quad e_{2t} = \rho_2 e_{2t-1} + u_{2t}$$

where the first subscript is the sample period and the second subscript is the observation. Assume that $Eu_i = \underline{0}$ and

$$Eu_i u_i' = \sigma^2_{u_i} I_{n_i} \quad \text{for } i = 1, 2$$

where u_i is an $(n_i \times 1)$ vector of errors for period i. Also assume $Ee_i = 0$ for i=1,2. It can be shown (Johnston 1984) that

$$\sigma^2_{e_i} = \sigma^2_{u_i}(1 - \rho^2_i)$$

The variance-covariance matrix for the errors in period i then is

$$Ee_i e_i' = \sigma^2_{u_i} V_i$$

See Johnston (1984, 310) for V_i. Define the transformation matrix H as T when correcting for autocorrelation. The transformation matrix T_i such that $T_i'T_i = V_i^{-1}$ for period i then is

$$4.1. \qquad T_i = \begin{bmatrix} 1-\rho^2_i & 0 & 0 & \dots & 0 & 0 \\ -\rho_i & 1 & 0 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & 1 & 0 \\ 0 & 0 & 0 & \dots & -\rho_i & 1 \end{bmatrix}$$

If ρ_i is known, then the GLS estimator for autocorrelated errors is

$$\tilde{B}_i = (X_i'T_i'T_iX_i)^{-1}X_i'T_i'T_iY_i$$

This estimator is unbiased since $Ee_i = 0$. The variance-covariance matrix for $\tilde{B}_i$ is

$$\text{var}(\tilde{B}_i) = \sigma^2_{u_i}(X_i'V_i^{-1}X_i)^{-1}$$

If ρ_i is unknown, as it is in this study, it is estimated with OLS residuals, $\hat{e}_i$, 4.2. $$\hat{\rho}_i = \frac{\sum_{t=2}^{n_i}(\hat{e}_{it-1}\hat{e}_{it})}{\sum_{t=2}^{n_i}(\hat{e}_{it}^2)}$$

The equations for the two sample periods transformed for first-order autocorrelation can be written as

$$T_iY_i = T_iX_iB_i + T_ie_i$$

for sample period i (i=1,2). Then say that n_i is the sample size in period i and that $N = n_1 + n_2$. Also say there are k variables including the intercept. Then the transformed data for the two sample periods can be stacked to yield

$$TY = TXB + Te$$

where T is (NxN), Y is (Nx1), X is (Nx2k), B is (2kx1), and e is (Nx1). The transformed data here are then used to test for heteroscedasticity.

The assumed structure of the heteroscedasticity may be written as

$$ETee'T' = \begin{bmatrix} \sigma_1^2 I_{n_1} & \emptyset \\ \emptyset & \sigma_2^2 I_{n_2} \end{bmatrix} = \sigma^2 V$$

Further assume that $\sigma^2 = \sigma_1^2$ and $\sigma_2^2 = w\sigma_1^2$. This states that there is homoscedasticity within each sample period but that the variance differs between sample periods. Covariances are assumed to be zero. Then

$$ETee'T' = \sigma^2 \begin{bmatrix} I_{n_1} & \emptyset \\ \emptyset & wI_{n_2} \end{bmatrix}$$

and the transformation matrix

$$H = \begin{bmatrix} I_{n_1} & \emptyset \\ \emptyset & 1/\sqrt{w}\ I_{n_2} \end{bmatrix}$$

The ratio $w = \sigma_2^2/\sigma_1^2$ is estimated from the OLS residuals from each period. The estimate of w then equals s_2^2/s_1^2 where

$$s_1^2 = \frac{\hat{u}_1'\hat{u}_1}{(n_1-k_1)}$$

$$s_2^2 = \frac{\hat{u}_2'\hat{u}_2}{(n_2-k_2)}$$

The H-matrix used to transform the data in sample period i then can be written as

4.3. $$H_i = 1/\sqrt{w_i}\ I_{n_i}$$

where $w_1 = 1$, $w_2 = w$, and H_i is $(n_i x n_i)$. An equation after transformation for first-order autocorrelation and heteroscedasticity can be written as

$$H_iT_iY_i = H_iT_iX_iB_i + H_iT_ie_i$$

for sample period i.

If there is heteroscedasticity within a sample period, a similar structure is assumed. Heteroscedasticity is corrected for within a sample period before it is corrected for between sample periods.

Autocorrelated Errors and Heteroscedasticity Tests

The presence of (first-order) autocorrelated errors is tested with the Durbin-Watson d-statistic

$$d = \sum_{t=2}^{n}(\hat{e}_t - \hat{e}_{t-1})^2 / \sum_{t=1}^{n}\hat{e}_t^2$$

where e = Y - XB (i.e., the OLS residuals). This statistic is closely related to the first-order autocorrelation coefficient defined by equation (4.2)

$$d \cong 2(1 - \hat{\rho})$$

The null hypothesis of the Durbin-Watson test is that of no first order autocorrelation. Reject the null hypothesis in favor of the alternative hypothesis (positive first-order autocorrelation) if the calculated d is less than the published lower bound. Fail to reject the null hypothesis if the calculated d is greater than the published upper bound. The test is inconclusive for calculated d between the lower and upper bound.

One can also calculate a standard error of $\hat{\rho}$ to test the null hypothesis that there is no autocorrelation (i.e., $\hat{\rho} = \emptyset$). If $\hat{\rho}$ is thought of as a regression coefficient in the regression

$$e_t = \hat{\rho} e_{t-1} + u_t$$

then the standard error of the estimate for $\hat{\rho}$ can be used in the hypothesis test.

An F-test is used to test for heteroscedasticity within a period and between periods. The null and alternative hypotheses for this test are

$$H_\emptyset: \sigma_1^2 = \sigma_2^2$$

$$H_A: \sigma_1^2 \neq \sigma_2^2$$

It can be shown (Judge et al. 1982, p. 167) that

$$s_i^2/\sigma_i^2 \sim \chi^2_{n_i-k}/(n_i-k), \quad i=1,2$$

Since there is no overlap in the two sample periods, the χ^2's are independent and their ratio is distributed as F under H_0.

$$F = s_2^2/s_1^2 \sim F_{n_2-k,\, n_1-k,\, \alpha/2}$$

This is a two tailed test but setting the larger sample variance in the numerator allows one to reject H_0 for large calculated values.

Autoregressive Two-Stage Least Squares

A standard assumption of OLS is violated if endogenous variables appear as regressors in an equation. A standard assumption of OLS is that the regressors are fixed, or if stochastic are independent of the errors. The margin equations violate this assumption. The endogenous variables on the right-hand side are correlated with the errors. The Two-Stage Least Squares (2SLS) procedure purges the endogenous regressors of their correlation with the errors thus allowing unbiased estimation of the coefficients. Three further complications are added in this estimation procedure: 1) the presence of autocorrelated errors, 2) the presence of heteroscedasticity, and 3) the presence of lagged endogenous variables as regressors. Some margin equations estimated in this study do not contain lagged endogenous variables as regressors. A five step procedure is used to estimate the margin equations.

There are two sample periods (i=1,2), J equations in the system, and n_i observations in each sample period. For the ith sample period, the jth equation for observation t can be written as

$$4.4. \quad y_{ijt} = Y'_{ijt}B_{ij} + Y'_{ijt-1}\delta_{ij} + X'_{ijt}\gamma_{ij} + e_{ijt}$$

where y_{ijt} is the value of the dependent variable for period i, equation j, and observation t. Y'_{ijt} is the vector of endogenous variables in the current period on the right-hand side and is $(1xG_j)$. Y'_{ijt-1} is the vector of endogenous variables for observation t-1 and is $(1xg_j)$. X'_{ijt} is the vector of exogenous variables and is $(1xk_j)$. The coefficient vectors B_{ij}, δ_{ij}, and γ_{ij} are (G_jx1), (g_jx1), and (k_jx1), respectively. First-order autocorrelated errors are assumed

$$e_{ijt} = \rho_{ij}e_{ijt-1} + u_{ijt}$$

where

$$Eu_{ij}u'_{ij} = \sigma^2_{ij}I_{n_i}$$

and $Eu_{ijt}=\emptyset$. The correlation ρ_{ij} is allowed to differ over sample periods and equations. The Autoressive 2SLS procedure used in this study is as follows:

Step 1) Obtain $\hat{Y}'_{ijt}$ and $\hat{Y}'_{ijt-1}$ by OLS using the exogenous variables and lagged exogenous variables as regressors.

Step 2) Substitute $\hat{Y}'_{ijt}$ and $\hat{Y}'_{ijt-1}$ for Y'_{ijt} and Y'_{ijt-1}, respectively, in equation (4.4) and estimate the coefficients by OLS to arrive at

$$4.5. \quad y_{ijt} = \hat{Y}'_{ijt}\hat{B}_{ij} + \hat{Y}'_{ijt-1}\hat{\delta}_{ij} + X'_{ijt}\hat{\gamma}_{ij} + \hat{e}_{ijt}$$

Step 3) Calculate the coefficient ρ_{ij} with the residuals from equation (4.5)

$$\hat{\rho}_{ij} = \frac{\sum_{t=2}^{n_i}(\hat{e}_{ijt-1}\hat{e}_{ijt})}{\sum_{t=2}^{n_i}(\hat{e}^2_{ijt})}$$

Tests of the significance of ρ_{ij} are discussed in the second section of this chapter. If $\hat{\rho}_{ij}$ is statistically significant, transform the data by the EGLS method outlined in the first section. Re-estimate equation (4.5) with transformed data to arrive at new coefficient and error estimates. In matrix notation,

4.6. $$T_{ij}y_{ij} = T_{ij}\hat{Y}_{ij}\hat{B}_{ij} + T_{ij}\hat{Y}_{ijL}\hat{\delta}_{ij} + T_{ij}X_{ij}\hat{\gamma}_{ij} + T_{ij}\hat{e}_{ij}$$

where y_{ij} is $(n_i x1)$, $\hat{Y}_{ij}$ is $(n_i xG_j)$, X_{ij} is $(n_i xk_j)$, and $\hat{e}_{ij}$ is $(n_i x1)$. $\hat{Y}_{ijL}$ is the matrix of predicted lagged endogenous variables and is $(n_i xg_j)$. T_{ij} is the transformation matrix discussed in the previous section. Calculate a $\hat{\rho}_{ij}$ from these residuals and test for significance. If $\hat{\rho}_{ij}$ is significant here, transform the data again. Otherwise procede with step 4.

Step 4) Use the new residuals from equation (4.6), the $T_{ij}\hat{e}_{ij}$s, to calculate

$$w = \sigma^2_{2j}/\sigma^2_{1j}$$

where

$$\sigma^2_{ij} = (T_{ij}\hat{e}_{ij}\hat{e}'_{ij}T'_{ij})/(n_i - k_j)$$

Testing $H_{\emptyset}$: $w = 1$ is discussed in the second section of this chapter. If w is statistically significantly different from one, then transform the second period data by the procedure outlined in first section of this chapter with the matrix

$$H_2 = (1/\sqrt{w})I_{n_2}$$

Step 5) The first period data has been transformed by T_{ij} and the second period data has been transformed by T_{2j} and by H_2. The final estimate of the coefficients are obtained by estimating

$$4.7.\quad \begin{bmatrix} T_{1j}Y_{1j} \\ HT_{2j}Y_{2j} \end{bmatrix} = \begin{bmatrix} T_{1j}\hat{Y}_{1j} & \emptyset & T_{1j}\hat{Y}_{ijL} & \emptyset & T_{1j}X_{1j} & \emptyset \\ \emptyset & HT_{2j}\hat{Y}_{2j} & \emptyset & HT_{2j}\hat{Y}_{2jL} & \emptyset & HT_{2j}X_{2j} \end{bmatrix} \begin{bmatrix} B_{1j} \\ B_{2j} \\ \delta_{1j} \\ \delta_{2j} \\ \gamma_{1j} \\ \gamma_{2j} \end{bmatrix} + \begin{bmatrix} T_{1j}e_{1j} \\ HT_{2j}e_{2j} \end{bmatrix}$$

This regression is corrected for autocorrelation and heteroscedasticity and can therefore be used to test for equality of coefficients.

Structural Change

Testing for structural change is a special case of testing a set of linear constraints (see Johnston 1984). The general form of the linear constraint is RB = r where the fixed R matrix is (qxk) and embodies the hypothesized linear combinations of the elements in the (kxl) vector B, and the (qxl) vector r contains the constants in the linear combinations. There are k independent variables and q constraints.

For this study, to be more specific, the linear constraints are used to test whether coefficients have changed from the first sample period to the second. The constraints state that the difference between the first and second period coefficients for the ith independent variable equals zero ($B_{i1} - B_{i2} = \emptyset$). Define B_1 as the (kxl) vector of first period parameters and B_2 as the (kx1) vector of second period parameters. Stack these two vectors to form the (2kx1) vector

$$B = \begin{bmatrix} B_1 \\ B_2 \end{bmatrix}$$

The constraint matrix R to restrict all coefficients to remain unchanged between the two periods is

$$R = \begin{bmatrix} I_k & -I_k \end{bmatrix}$$

where I_k is the (kxk) identity matrix. The vector of constants of the linear constraints, r, would be a (kx1) vector of zeros. By eliminating some rows of R, one could test that only a subset of coefficients changed.

The common test of linear constraints is an F-test. The statistic is based on some OLS assumptions and results. Two important assumptions are

4.8. $\epsilon \sim N(0, \sigma^2 I)$

where ϵ is the vector of errors, and X is nonstochastic with rank k. Three important results from OLS are that

4.9. $b \sim N(B, \sigma^2 (X'X)^{-1})$,

4.10. $(1/\sigma^2)(e'e) \sim \chi^2_{n-k}$

and that b is distributed independently of $s^2 = (e'e)/(n-k)$. The coefficient b is the unrestricted OLS estimator for the parameters B, and e is the unrestricted estimator for ϵ. The sample size is n. These results are sufficient to set up inference tests for elements in b.

Using equation (4.9) and E(Rb) = RB, one finds

$$R(b - B) \sim N(\emptyset, \sigma^2 R(X'X)^{-1}R')$$

If RB = r,

$$(Rb - r) \sim N(\emptyset, \sigma^2 R(X'X)^{-1}R')$$

It can be shown that

$$C = (Rb - r)'[\sigma^2 R(X'X)^{-1}R']^{-1}(Rb - r) \sim \chi^2_q$$

Noting the independence of b and $e'e/\sigma^2$ in equation (4.1Ø), one can form the statistic

$$\frac{C/q}{\dfrac{(e'e)/\sigma^2}{(n-k)}} = \frac{C/q}{s^2/\sigma^2} \sim F_{q,n-k,\alpha}$$

Another statistic useful in testing linear constraints is derived from a Lagrange multiplier. Maximizing (over B and λ), the Lagrange expression of the form

$$\mathfrak{L} = L + \lambda'(RB - r),$$

where L is the log-likelihood function, will yield the restricted parameters and the estimated Lagrange multipliers. If indeed the restriction contained in RB = r are valid, the Lagrange multipliers should not be significantly different from zero. If, on the other hand, the restrictions are not valid, the multipliers will be significantly different from zero. Therefore, testing $\lambda = \underline{\emptyset}$ is a test of the validity of the restrictions. Aitchison and Silvey (Dhrymes et al. 1972) have shown that the test statistic for the hypothesis $H_\emptyset$: $\lambda = \underline{\emptyset}$ for the linear model framework (i.e., y = XB + ϵ) is

$$A = \sigma^2 \hat{\lambda}'(R(X'X)^{-1}R')\hat{\lambda}$$

and

$$\hat{\lambda} = (1/\hat{\sigma}^2)(R(X'X)^{-1}R')^{-1}(r - Rb)$$

A is asymptotically distributed chi-square with q degrees-of-freedom under the null hypothesis. The consistent estimator

$$\hat{\sigma}^2 = \hat{\epsilon}\hat{\epsilon}'/n$$

can be substituted for σ^2 if it is unknown. $\hat{\epsilon}$ is the restricted estimator residual vector and $b=(X'X)^{-1}X'Y$ is, as before, the unrestricted least squares estimator. The test statistic

$$\hat{A} = \hat{\sigma}^2 \hat{\lambda}'(R(X'X)\ R')\hat{\lambda}$$

converges to the asymptotic distribution of A.

In Dhrymes et al. (1972), comparisons of the F-test and the Aitchison-Silvey test were made. If σ^2 was known, they concluded A and C are Mathematically equivalent, and A was a valid small sample test, as long as the ϵ were distributed normally. If, on the other hand, σ^2 was unknown, then A and F were asymptotically equivalent. The F-test however had more desirable small sample properties, again assuming the normality of the ϵ.

In the case of stochastic regressors, the Aitchison-Silvey test is completely unaffected as long as the regressors are independent of ϵ.

In a simultaneous equations model where the equations are estimated by 2SLS, the Aitchison-Silvey test is still applicable with unchanged asymptotic justification. The structural errors must be serially independent and the predicted variables must be either non-stochastic or be independent of the structural errors.

If the regressors include lagged dependent variables, one needs a

Central Limit Theorem for the dependent random variables in order to establish the asymptotic distribution of the Aitchison-Silvey statistic.

Clearly, in this study, σ^2 is unknown. The normality of ϵ (or the lack thereof) determines whether the F-test or the Aitchison-Silvey test is appropriate. The ϵ are assumed normal in this study. Other assumptions of the F-test are met by transforming the data to correct for heteroscedasticity and autocorrelated errors. Inference testing is performed on the transformed model.

The F-test is used to test for equality of coefficients between time periods. The full model where all coefficients are allowed to differ between the two periods yields a sum of squared errors (SSE_F). The reduced model where a set of q coefficients are restricted to equal their period two values yields a sum of squared errors (SSE_R). The F-test then is

$$F_C = \frac{(SSE_R - SSE_F)/q}{SSE_F/(n-k)} \sim F_{q,\ n-k,\ \alpha}$$

where α is the significance level and n-k is defined previously.

This study is interested in whether the seasonal dummy variable coefficients have changed between the two sample periods and whether the economic variable coefficients have changed also. A structural change hypothesis that the eleven non-economic seasonal dummy variable coefficients have not changed between the two sample periods is tested first with an α =.05. Given the result of this first test, the second hypothesis that the economic variable coefficients in the equation have not changed between the two sample periods is tested with a nominal

α=.05. The significance level on the second hypothesis test is not strictly at the five percent level, however, since it is the second of the two hypotheses. This procedure is applied consistently to all equations that are estimated.

Identification

A system of simultaneous equations as in this study can be written as

$$AY_t + BX_t = u_t$$

where Y_t is the (Dx1) vector of current endogenous variables, X_t is the (Kx1) vector of predetermined variables, and u_t is the (Dx1) vector of structural errors. The total number of endogenous variables in the model is D, and K is the total number of exogenous variables in the model. The coefficient matrices A and B are (DxD) and (DxK), respectively. The model can alternatively be written as

$$Y_t = - A^{-1}BX_t + A^{-1}u_t$$
$$= CX_t + v_t$$

Then C is the source of information on the coefficients in A and B (see Johnston 1984).

It is likely that the ith structural equation of the model contains only a subset of the current endogenous and predetermined variables. There are likely exclusion restrictions which states that particular elements of A and B are zero. Given these restrictions, a necessary condition for the identification of the ith equation can be formulated. Define d as the number of current endogenous variables in the ith equation and k as the number of predetermined variables in the ith equation. Since the only restictions in this study are exclusion restrictions, the necessary condition for the ith equation to be identified is

$$(D - d) + (K - k) \geq D - 1$$

or

$$K - k \geq d - 1$$

In words, the number of endogenous variables included in the equation less one must be less than or equal to the number of predetermined variables excluded from the equation.

CHAPTER 5. DECOMPOSITION METHODS

The three hypotheses of this study are tested with the econometric model described in Chapter 3. The hypotheses are that 1) firms behaved as multiproduct firms, 2) slope coefficient changes in the demand equations affected margins, and 3) structural change within the margin equations affected margins. The last two hypotheses of course require that structural change indeed occurred, the first in the demand equations, the second in the margin equations. The structural change and therefore the impacts are hypothesized to have taken place between 1977 and 1978. This chapter outlines how the three hypotheses are tested in this study. The total change in each margin is decomposed into various components that have affected the margins.

The test of the multiproduct hypothesis is straight forward. The multiproduct effect, noted in Holdren's model of multiproduct retail firms, is introduced into the econometric model by specifying the margin on one meat as a function of the margin on the other meat. The test of this hypothesis then is simply a test of the significance of the particular regression coefficient in each margin equation. Any change in the coefficient from one sample period to the other can be considered with other structural change in the margin equations.

The Holdren demand impact and the impact that structural change in the margin equations had on levels of margins are tested much the same. Tests of these two hypotheses first require tests of structural change in the demand equations and the margin equations. Tests of structural change are tests of equality of selected coefficients. The procedure for testing for structural change is outlined in the Statistical Methods Chapter. Identifying structural change is the first step in isolating the impact on margins. The next step is decomposing the margins into components of change. The decomposition is necessary since simply identifying structural change does not indicate the magnitude of the affect on the retail prices or the margins. This magnitude depends on the values of the variables to which the coefficients are attached. The decomposition is the main topic of this chapter.

Static Model Decompositions

With a simple decomposition, one can identify the amount of the change in a margin from sample period one (January, 1968 through December, 1977) to sample period two (January, 1978 through June, 1984) that is due to a change in a coefficient or a subset of coefficients in the demand equations or the margin equations. A special property of the econometric model allows this decomosition. The model is block recursive in the two retail prices. Retail prices affect margins but are not themselves a function of the margins. Therefore, the demands can be estimated seperately from the remaining equations of the model. The reduced form then in a particular margin is a function of retail prices and exogenous variables. Coefficient changes that affect retail prices affect the margins.

Consider a simple decomposition where $\bar{y}_{im} = \hat{b}_i\bar{x}_{im}$ and $\bar{y}_{im}$ and $\bar{x}_{im}$

are vectors of means for period i and calendar month m, and $\hat{b}_i$ is a coefficient matrix for period i. The change in $\bar{y}_m$ from period 1 to period 2 can be exactly decomposed as follows:

$$5.1. \quad (\bar{y}_{2m} - \bar{y}_{1m}) = (\hat{b}_2 - \hat{b}_1)\bar{x}_{1m} + \hat{b}_1(\bar{x}_{2m} - \bar{x}_{1m}) + (\hat{b}_2 - \hat{b}_1)(\bar{x}_{2m} - \bar{x}_{1m})$$

In other words, the change in $\bar{y}_m$ can be decomposed into 1) the change due to changing coefficients, 2) the change due to changing means of $\bar{x}_{1m}$ and 3) the change due to the interaction of the first two. This simple decomposition can be used to identify the effect on retail prices of demand coefficient changes and the effect of these retail price changes on margins. This same general decomposition can also be used to identify the impact on margins of changing margin coefficients. Of course numerous other decompositions are possible with this technique.

This general decomposition is applied to both the static and the dynamic versions of the model. Although the details of the application differ between the two versions, the interpretation is much the same. First, the general decomposition is applied to the static version, then ways of applying the decomposition to the dynamic version are outlined.

Since the model is block recursive, the static econometric model can be written as

$$AM_t = CZ_t + FP_t + u_t$$
$$D_t = \pi_t^{-1} P_t = BQ_t + e_t$$

where, for Form I,

$$A = \begin{bmatrix} 1 & -a_{12} & -a_{11} & 0 \\ -a_{22} & 1 & 0 & -a_{21} \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix} \qquad M_t = \begin{bmatrix} M_{Bt} \\ M_{Pt} \\ FV_{Bt} \\ FV_{Pt} \end{bmatrix}$$

$$C = \begin{bmatrix} a_{10} & a_{13} & 0 \\ a_{20} & 0 & a_{23} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad Z_t = \begin{bmatrix} Z_{0t} \\ Z_{3t} \\ Z_{4t} \end{bmatrix}$$

$$F = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \qquad P_t = \begin{bmatrix} P_{Bt} \\ P_{Pt} \end{bmatrix}$$

$$B_t = \begin{bmatrix} b_{10} & b_{11} & b_{12} & b_{13} & b_{14} & 0 \\ b_{20} & b_{21} & b_{22} & b_{23} & 0 & b_{24} \end{bmatrix}$$

$$Q_t = \begin{bmatrix} Z_{0t} \\ RQ_{Bt} \\ RQ_{Pt} \\ DI_t \\ Z_{1t} \\ Z_{2t} \end{bmatrix}$$

π_t = CPI_t (a scalar), and u_t and e_t are vectors of random errors. The a_{ij}s and b_{ij}s are regression coefficients. All other variables are as defined in the economic model with the exception of Z_{0t} which equals 1 to bring in the intercept. The reduced form in the two margins and the two farm values is

$$M_t = \hat{A}^{-1}(\hat{C}Z_t + FP_t) + \hat{A}^{-1}\hat{u}_t$$

and the reduced form in nominal retail prices is

$$P_t = \pi_t\hat{B}Q_t + \pi_t\hat{e}_t$$

The notation used here applies equally well to Form II of the model. The only difference is the size of the matrices. This application of the decomposition is the same for both Form I and Form II of the model.

The methods used to estimate the model are described in the Statistical Methods Chapter. Once estimated, however, one knows that

5.2. $$\bar{M}_{im} = \hat{A}_i^{-1}(\hat{C}_i\bar{Z}_{im} + F\bar{P}_{im})$$

in period i (i = 1, 2) for some calendar month m (m = 1,..., 12) if the mean of the residuals for month m in sample period i equals zero. $\bar{M}_{im}$ is the vector of mean margins and farm values in sample period i and calendar month m. Similarly, $\bar{Z}_{im}$ and $\bar{P}_{im}$ are vectors of mean exogenous variables and nominal prices, respectively, in sample period i and calendar month m. Coefficient matrices $\hat{A}_i$ and $\hat{C}_i$ are now the estimated matrices for sample period i. Similarly,

5.3. $$\bar{P}_{im} = \hat{B}_i\overline{\pi Q}_{im}$$

where $\overline{\pi Q}_{im}$ is the mean of the product in sample period i and calendar month m. This assumes the residual mean for month m in sample period i is zero.

Applying the general decomposition technique,

5.4. $$(\bar{P}_{2m} - \bar{P}_{1m}) = (\hat{B}_2 - \hat{B}_1)\overline{\pi Q}_{1m} + \hat{B}_1(\overline{\pi Q}_{2m} - \overline{\pi Q}_{1m})$$

$$+ (\hat{B}_2 - \hat{B}_1)(\overline{\pi Q}_{2m} - \overline{\pi Q}_{1m})$$

The total change in the monthly mean retail prices from period 1 to period 2 is the sum of three components. The first component on the right hand side is the change in the means of retail prices due to a change in the demand coefficients only. The second component is the change due to a change in the mean of the exogenous variables given that the coefficients remain unchanged. Finally, the third component is the interaction of the first two sources of change.

Using the first component in equation (5.4) and allowing only certain coefficients within $\hat{B}$ to change, one can identify the change in the monthly mean retail prices due to those selected coefficient changes. By decomposing the margin and farm value changes in the same way and setting selected elements of $\overline{\pi Q}_{2m} - \overline{\pi Q}_{1m} = \emptyset$, one can identify the impact on monthly mean margins from a change in a subset of demand coefficients.

One can decompose the change in the monthly mean margins and farm values into

$$(\bar{M}_{2m} - \bar{M}_{1m}) = (\bar{M}^{*}_{2m} - \bar{M}_{1m}) + (\bar{M}^{**}_{2m} - \bar{M}_{1m}) + (\bar{M}^{***}_{2m} - \bar{M}_{1m})$$

where

5.5. $$(\bar{M}^{*}_{2m} - \bar{M}_{1m}) = (\hat{A}_2^{-1}\hat{C}_2 - \hat{A}_1^{-1}\hat{C}_1)\bar{Z}_{1m} + (\hat{A}_2^{-1}F - \hat{A}_1^{-1}F)\bar{P}_{1m}$$

5.6. $$(\bar{M}^{**}_{2m} - \bar{M}_{1m}) = \hat{A}_1^{-1}\hat{C}_1(\bar{Z}_{2m} - \bar{Z}_{1m}) + \hat{A}_1^{-1}F(\bar{P}_{2m} - \bar{P}_{1m})$$

5.7. $$(\bar{M}^{***}_{2m} - \bar{M}_{1m}) = (\hat{A}_2^{-1}\hat{C}_2 - \hat{A}_1^{-1}\hat{C}_1)(\bar{Z}_{2m} - \bar{Z}_{1m}) + (\hat{A}_2^{-1}F - \hat{A}_1^{-1}F)(\bar{P}_{2m} - \bar{P}_{1m})$$

The interpretation is much the same as for the retail price decomposition. Equation (5.5) is the change in monthly mean margins and farm values due to the change in the coefficients in $\hat{A}$ and $\hat{C}$ only. Equation (5.6) is the change due to a change in the means of the exogenous variables and retail prices, $\bar{Z}$ and $\bar{P}$ respectively, given the coefficients remain unchanged. The third equation, (5.7), is the interaction of the first two components and is calculated as a residual in this study.

By altering equation (5.6), $(\bar{M}^{**}_{2m} - \bar{M}_{1m})$ can yield the change in monthly mean margins due to a change in a subset of demand coefficients. Simply set the change in monthly mean exogenous variables, $\bar{Z}$, equal to zero and substitute the change in monthly mean retail prices due to the change in a subset of demand coefficients in for $(\bar{P}_{2m} - \bar{P}_{1m})$. In this way, the effects of actual demand coefficient changes on margins can be isolated.

The decomposition outlined here can be used for testing more than just the Holdren demand impact. This decomposition can also be used to isolate the impact on margins due to structural change within the margin equations. Equation (5.5) is the impact on monthly mean margins allowing all margin coefficients to change but keeping monthly means of exogenous variables and retail prices constant. One can also allow just a subset of margin coefficients to change in equation (5.5) and find the impact on margins from this subset. The effects of individual margin coefficients are not additive, however, as they are with demand coefficients. This is the case since individual coefficient changes within the $\hat{A}$ matrix affect all elements of $\hat{A}^{-1}$. Therefore the effects of coefficient changes within $\hat{A}$ on margin levels can not be examined individually.

The decomposition of the static econometric model then can be used to isolate the impacts on margins due to actual changes in selected demand coefficients. The decomposition is also used to isolate the impact on margins from structural change that is hypothesized to have taken place in the beef and pork marketing sector.

Dynamic Model Decompositions

The demand and margin structural change effects can also be isolated with the dynamic version of the model. The dynamic model can be written with much the same notation as with the static version.

$$AM_t = GM_{t-1} + CZ_t + FP_t + u_t$$

$$D_t = \pi_t^{-1}P_t = BQ_t + e_t$$

The vector M_{t-1} contains the variables of M_t but lagged one month. G is a matrix of coefficients. The demand equations change little since the addition of lagged exogenous variables (quantities) merely increases the size of B and Q_t. Although similar notation is used, elements of the coefficient matrices are not the same for the static version and the dynamic version.

The reduced form in margins and farm and wholesale values of the dynamic version is

5.8. $$M_{it} = A_i^{-1}G_iM_{it-1} + A_i^{-1}C_iZ_{it} + A_i^{-1}FP_{it}$$

and the reduced form in nominal retail prices is (again)

$$P_{it} = \pi_{it}B_iQ_{it}$$

for sample period i (i = 1, 2) and time period t (in months).

There are several ways to apply the general decomposition to the dynamic model, but only two are considered in this study. For one application to the dynamic model, define $\bar{M}_{10}$ as the vector of annual means of the endogenous variables in the first year in sample period one and $\bar{M}_{20}$ as the vector of annual means of endogenous variables in the last year of sample period one. $\bar{M}_{10}$ and $\bar{M}_{20}$ are initial conditions of the model. Let $\bar{Z}_i$ be the sample period i means of the Z's and $\bar{P}_i$ be the sample period i means of the P's. Then define

5.9. $$\bar{M}_{it} = (\hat{A}_i^{-1}\hat{G}_i)^t\bar{M}_{i0} + \sum_{s=0}^{t-1}[(\hat{A}_i^{-1}\hat{G}_i)^s(\hat{A}_i^{-1}\hat{C}_i)]\bar{Z}_i + \sum_{s=0}^{t-1}[(\hat{A}_i^{-1}\hat{G}_i)^s(\hat{A}_i^{-1}F)]\bar{P}_i$$

for i = 1,2 and t=1,...,T (where T could equal, say, 50). $\bar{M}_{it}$ then is the time path the endogenous variables follow given the initial conditions $\bar{M}_{i0}$, and given that Z_{it} and P_{it} remain at their sample period means, $\bar{Z}_i$ and $\bar{P}_i$, respectively. Applying the general decomposition then yields

$$(\bar{M}_{2t} - \bar{M}_{1t}) = (\bar{M}_{2t}^{*} - \bar{M}_{1t}) + (\bar{M}_{2t}^{**} - \bar{M}_{1t}) + (\bar{M}_{2t}^{***} - \bar{M}_{1t})$$

where

5.10. $$(\bar{M}_{2t}^{*} - \bar{M}_{1t}) = [(\hat{A}_2^{-1}\hat{G}_2)^t - (\hat{A}_1^{-1}\hat{G}_1)^t]\bar{M}_{10} + \sum_{s=0}^{t-1}[(\hat{A}_2^{-1}\hat{G}_2)^s(\hat{A}_2^{-1}\hat{C}_2) - (\hat{A}_1^{-1}\hat{G}_1)^s(\hat{A}_1^{-1}\hat{C}_1)]\bar{Z}_1 + \sum_{s=0}^{t-1}[(\hat{A}_2^{-1}\hat{G}_2)^s(\hat{A}_2^{-1}F) - (\hat{A}_1^{-1}\hat{G}_1)^s(\hat{A}_1^{-1}F)]\bar{P}_1$$

5.11. $$(\bar{M}_{2t}^{**} - \bar{M}_{1t}) = (\hat{A}_1^{-1}\hat{G}_1)^t(\bar{M}_{20} - \bar{M}_{10})$$

$$+ \sum_{s=0}^{t-1} (\hat{A}_1^{-1}\hat{G}_1)^s (\hat{A}_1^{-1}\hat{C}_1)(\bar{Z}_2 - \bar{Z}_1)$$

$$+ \sum_{s=0}^{t-1} (\hat{A}_1^{-1}\hat{G}_1)^s (\hat{A}_1^{-1}F)(\bar{P}_2 - \bar{P}_1)$$

5.12. $(\bar{M}_{2t}^{***} - \bar{M}_{1t}) = (\bar{M}_{2t} - \bar{M}_{1t}) - (\bar{M}_{2t}^{*} - \bar{M}_{1t}) - (\bar{M}_{2t}^{**} - \bar{M}_{1t})$

Modifying equation (5.11) yields the change in the time path of the endogenous variables given that only the means of nominal retail prices have changed-- simply set $\bar{M}_{20} = \bar{M}_{10}$ and $\bar{Z}_2 = \bar{Z}_1$. Then, to break this total retail price (or demand) effect into effects of subsets of coefficients, simply substitute in the value $(\bar{P}_2^* - \bar{P}_1)$ for $(\bar{P}_2 - \bar{P}_1)$ in equation (5.11). Define $\bar{P}_2^*$ as the mean of retail prices given that only a subset of coefficients have changed between the two periods. The impact on margins of a change in a subset of demand coefficients can be isolated with the dynamic model.

Computation of the impact on margins of structural change in the margin equations is also possible. Equation (5.10) is the impact on margins with a change in all margin equation coefficients. Again, the effects of individual margin equation coefficients are not additive as they are for demand coefficients.

A second way of isolating demand and structural change effects in the dynamic version is also considered in this study. This decomoposition uses actual intial conditions and actual exogenous variables instead of their means. It is essentially a sample period forecast. Notation changes only slightly. Now M_{10} is the values of endogenous variables in the last month before sample period one and M_{20}

is the values in the last month in sample period one. The exogenous variables are the actual sample period values, Z_{it} and P_{it} (for i=1,2 and t, the months). Applying the general decomposition here yields

$$(M_{2t} - M_{1t}) = (M_{2t}^{*} - M_{1t}) + (M_{2t}^{**} - M_{1t}) + (M_{2t}^{***} - M_{1t})$$

where

5.13. $$(M_{2t}^{*} - M_{1t}) = [(\hat{A}_2^{-1}\hat{G}_2)^t - (\hat{A}_1^{-1}\hat{G}_1)^t]M_{10}$$
$$+ \sum_{s=0}^{t-1}[(\hat{A}_2^{-1}\hat{G}_2)^s(\hat{A}_2^{-1}\hat{C}_2) - (\hat{A}_1^{-1}\hat{G}_1)^s(\hat{A}_1^{-1}\hat{C}_1)]Z_{1t-s}$$
$$+ \sum_{s=0}^{t-1}[(\hat{A}_2^{-1}\hat{G}_2)^s(\hat{A}_2^{-1}F) - (\hat{A}_1^{-1}\hat{G}_1)^s(\hat{A}_1^{-1}F)]P_{1t-s}$$

5.14. $$(M_{2t}^{**} - M_{1t}) = (\hat{A}_1^{-1}\hat{G}_1)^t(M_{20} - M_{10})$$
$$+ \sum_{s=0}^{t-1}(\hat{A}_1^{-1}\hat{G}_1)^s(\hat{A}_1^{-1}\hat{C}_1)(Z_{2t-s} - Z_{1t-s})$$
$$+ \sum_{s=0}^{t-1}(\hat{A}_1^{-1}\hat{G}_1)^s(\hat{A}_1^{-1}F)(P_{2t-s} - P_{1t-s})$$

5.15. $$(M_{2t}^{***} - M_{1t}) = (M_{2t} - M_{1t}) - (M_{2t}^{*} - M_{1t}) - (M_{2t}^{**} - M_{1t})$$

The interpretation of these three components is similar to that of the other dynamic decomposition.

The impact on margins from structural change in the margin equations is found in equation (5.13). The effect of selected margin coefficient changes can be isolated but again these effects are not additive.

The dynamic econometric model then can also be used to isolate the effect of demand coefficient changes and margin equation coefficient changes on margins. Two ways of applying the general decomposition to the dynamic model are outlined above. The dynamic model yields meaningful results if the system of equations are stable. Dynamic stability is discussed in the next section of this chapter.

Dynamics and Stability

Equation (5.8) of the Decomposition Chapter represents the dynamic version of the model in matrix notation. If A^{-1} exists, then

$$M_t = A^{-1}GM_{t-1} + A^{-1}CZ_t + A^{-1}FP_t + A^{-1}u_t$$

or

$$M_t = BM_{t-1} + KX_t + e_t$$

where, for simplicity, the sample period subscripts are left off. For the next period,

$$M_{t+1} = BM_t + KX_{t+1} + e_{t+1}$$

By recursive substitution, the general solution is

$$M_t = B^tM_\emptyset + \sum_{s=\emptyset}^{t-1} B^sKX_{t-s} + \sum_{s=\emptyset}^{t-1} B^se_{t-s}$$

where $M_\emptyset$ is the vector of initial values of the endogenous variables. Note that if the deterministic system of equations, which sets $e_t = \emptyset$, is stable, the system is stochastically stable also.

To check for stability in this system of equations, redefine the equation as (see Ladd lecture notes).

$$M_t = BM_{t-1} + N_\emptyset$$

where $N_\emptyset$ is a vector of constants representing the effect of the initial conditions of the exogenous variables. The coefficient matrix B is assumed to have distinct characteristic roots λ_i. The coefficient matrix can be diagonalized as

$$V^{-1}BV = L$$

giving

$$B = VLV^{-1}$$

where V is the matrix of column characteristic vectors of B and L is the diagonalized matrix of characteristic roots of B satisfying BV = VL. The general solution then is

$$M_t = B^t M_\emptyset + (I - B^t)(I - B)^{-1} N_\emptyset$$

where $M_\emptyset$ is again the vector of initial values of the endogenous variables and $B^t = VL^tV^{-1}$.

If all of the characteristic roots of B are less than one in absolute value, then L^t approaches $\underline{\emptyset}$ as t aproaches infinity and B^t also approaches $\underline{\emptyset}$ as t aproaches infinity. The system of equations is then deterministically and stochastically stable and

$$\lim_{t \to \infty} M_t = (I - B)^{-1} N_\emptyset = M^*$$

In other words, given some initial conditions $N_\emptyset$ and $M_\emptyset$, the vector of endogenous variables, M_t, converges on the constant vector M^*. Characteristic roots greater than one in absolute value imply the system of equations is unstable and that M_t does not converge to M^*.

In this study, characteristic roots are calculated for four matrices since there are two forms of the model, Form I and Form II, and two sample periods.

CHAPTER 6. DATA SOURCES AND DESCRIPTIONS

The retail prices of beef (PB) and pork (PP) that are used in this study are average-for-the-month retail prices paid by consumers. The averages are calculated from survey data and are adjusted by the USDA for the effect of meat specials. Both price series are in cents per retail pound.

The net farm value of either beef (FVB) or pork (FVP) is equal to gross farm value less a byproduct allowance. Gross farm value is a weighted average farm-gate price multiplied by a factor to yield a price in retail pounds. The net carcass value of beef (WVB) is calculated as the gross carcass value less the carcass byproduct allowance. In this study, the carcass level is refered to as the wholesale level for beef. The net carcass value is also in cents per retail pound. The wholesale value for pork (WVP) is calculated as an average wholesale pork price multiplied by a factor to yield a price in retail pounds.

Marketing margins, or price spreads, are the difference between prices at different marketing levels. The farm-retail margin (FRMB and FRMP) is retail price less net farm value. The farm-wholesale margin (FWMB and FWMP) is wholesale value less net farm value. The wholesale-retail margin (WRMB and WRMP) is retail price less wholesale value.

Retail price, farm and wholesale value, byproduct allowance, and margin data are published by USDA. Data for October, 1980 through June, 1984 are found in the Livestock and Poultry Outlook and Situation Report (USDA 1983c-1984c). Data for January, 1976 through September, 1980 are found in Livestock and Meat Situation (USDA 1976a-1980a) and revised data for January, 1968 through December, 1975 are available from USDA upon request.

There may be data quality concerns with the retail price, farm and wholesale value, byproduct, and margin data. Some specific issues concerning the data quality have been discussed in previous studies. The calculation of some of these variables has changed within the sample period and the USDA has updated the historical series. There were changes in the method of calculation of some variables in 1969 and 1978 (USDA 1978a). The biggest change in 1978 was in the live and wholesale conversion factors that are used to convert quantities to retail weight. The changes were made to reflect the changes in both industry practices and animal type. The industry has changed some trimming procedures and tends to sell more boneless, retail cuts than has been the case in the past. During the 1970s, animals slaughtered have tended to be meatier also.

The adjustment for the affect that specialing meat has on the average retail price of that meat was changed in 1978 also. The previous study of the effect of specialing on price was a 1967 study.

The source of live cattle prices and retail prices has changed also due to the discontinuation of certain price surveys in the late 1970s. Furthermore, the calculation of some of the values has changed.

Other studies raise concern about other issues of data quality. Parham and Duewer (USDA Report No. AGESS8012215 1980f) investigated whether price spreads should be calculated as the difference in prices at two levels in the marketing channel at the same point in time. The concern was that it takes between two and four weeks for meat to move through the processing stage. Parham and Duewer found that somewhat less variable price spreads resulted when there was a two-week lag between the retail and farm levels for beef and a four-week lag between the retail and farm levels for pork. Additional concerns were addressed in a study for the American Agricultural Economics Association (Barrowman et al., 1976).

Some measures of processor and retailer costs are needed in the margin equations. A USDA Technical Bulletin (USDA No. 1633 1980e) identified the relative importance of various inputs in the USDA Marketing Cost Index. Wages and salaries at 38.8 percent was by far the largest cost followed by transportation cost at 9.9 percent. Fuel and power accounted for about 7.9 percent. Consistent time series for many of the costs for the entire sample period are unavailable. Therefore, the Producer Price Index (PPI) for Intermediate materials is used to represent non-labor costs of processors. The PPI is found in the Monthly Labor Review (USDL 1968-1985). The entire series is converted to the base 1967=100. Two wage rates are used in this study. Average hourly earnings for meat packing plants is used as the labor cost variable for packers. Average hourly earnings for food stores is used as the labor cost variable for retailers. Both wage rates are found in Employment and Earnings (USDC 1968c-1985c).

The two wage rates and the PPI are combined in various proportions to yield three simple cost indexes. The two wage rates are converted to indexes with base 1967=100. The ratio of 100 over the 1967 mean of the wage rate is multiplied by the wage rate series in the sample period to give the index. The ratio for the meat packing plant wage rate is 30.9 and the ratio for the food store wage rate is 44.78. The meat packing plant wage rate index is denoted MPWRI and the food store wage rate index is denoted FSWRI. The three cost indexes then weight the two wage rate indexes and the PPI as

CI1 = 0.25*MPWRI + 0.25*FSWRI + 0.50*PPI

CI2 = 0.50*MPWRI + 0.50*PPI

CI3 = 0.50*FSWRI + 0.50*PPI

Cost index CI1 is used in the farm-retail margins while CI2 and CI3 are used in the farm-wholesale margins and wholesale-retail margins, respectively.

Monthly data on quantity of beef and pork consumed by the civilian population in million pounds are published by the USDA up through February, 1982. After that time, only quarterly consumption data are available. Civilian consumption plus military takings can be calculated from the identity: commercial production less the change in inventory, plus imports, less exports and shipments. Therefore, the quantity consumed in this study is civilian consumption plus military takings. An additional problem is caused by the lack of monthly data on the production and the change in inventories for the period March, 1982 through December, 1982. Quarterly data is available and is used to estimate missing data.

The pattern in federally inspected slaughter of the particular meat is used to estimate monthly production from quarterly data for April, 1982 through December, 1982. Weekly slaughter figures are summed to give monthly and quarterly slaughter figures. Then the proportion that slaughter in month i of quarter j is of slaughter in quarter j is assumed to be the same proportion that production in month i quarter j is of production in quarter j.

The missing monthly beginning and ending inventory figures for April, 1982 through December, 1982 are estimated by using a rough typical pattern of inventory changes. Typical patterns are from 1978 through 1984 data of inventory changes. Estimated monthly inventory changes are calculated to sum to the published quarterly inventory change.

Monthly shipments of beef and pork for April and May, 1982 are missing also. Since the second quarter figure and the June figure are available, the difference is simply split in two to give estimates for April and May, 1982.

Beef and pork civilian consumption and military takings data are published in Livestock and Meat Situation (USDA 1969a-1980a) for January, 1968 through June, 1980 and in Livestock and Meat Outlook and Situation (USDA 1981d-1982d) for July, 1980 through February, 1982. All other quarterly data for the period after February is published in Livestock and Poultry Outlook and Situation (USDA 1981b-1983b).

Percapita consumption is used in the demand equations. The population data are civilian population. The population data are published in Current Population Reports (USDC 1968d-1985d). The per capita quantity of beef and pork are denoted QB and QP, respectively.

The income variable that is used in the consumer demand equations is real per capita disposable personal income (RY). Disposable personal income for January, 1968 through October, 1979 is available from the November, 1979 issue of Survey of Current Business (USDC 1979b). For the remainder of the sample period, disposable personal income is found in various issues of Survey of Current Business (USDC 1979b-1985b). Disposable personal income is divided by both the civilian population and the Consumer Price Index to yield the income variable that is used in this study. The Consumer Price Index for all items (1967=100) for 1968 through 1981 is available from the May, 1982 issue of Business Conditions Digest (USDC 1982a). More current data are found in various issues of Business Conditions Digest (USDC 1982a-1985a).

In order to account for unusual price behavior during the beef price ceilings imposed in 1973, a dummy variable, PR73, is used. This variable equals one for the months March through September of 1973, which are the months the price ceilings are in effect. The variable PR73 equals zero for all other months.

If indeed the measurement error in some of these variables is large, the coefficients estimated from Ordinary Least Squares are inconsistent. To formalize this (Johnston 1984, p. 428), suppose the true equation is

$$y = XB + u$$

where X is the true but unobserved matrix of explanatory variables. Let $Z = X + V$ be the observed matrix of explanatory variables where V is the matrix of measurement errors. Then

$$y = ZB + (u - VB)$$

and

$$\hat{B} = B + (Z'Z)^{-1}Z'(u - VB)$$

Given the two conditions 1) the measurement errors are uncorrelated in the limit with the true values, X, and 2) the disturbance, u, plus any measurement error in y is uncorrelated in the limit with X and V, then the Ordinary Least Squares estimate of B is inconsistent. The estimate is inconsistent since the matrix Z is correlated with $(u - VB)$.

CHAPTER 7. ESTIMATED DEMAND EQUATIONS

The procedures that are described in the Statistical Methods Chapter were used to estimate the model outlined in the Model Formulation Chapter. Both Form I, which included farm and retail levels, and Form II, which included farm, wholesale, and retail levels, were estimated. In addition, a static and a dynamic version of both model forms were estimated. The estimated demand equations and tests for structural change are presented in this chapter. The margin equations are presented in the following chapter.

The static demand equations contain only current period variables and a linear income specification, all of which are considered exogenous. The dynamic demand equations contain both current and lagged variables. Alternative income specifications are also investigated in the dynamic demand equations. Only exogenous variables are lagged in the dynamic demand equations so the equations are still essentially static. This study identifies the second set of demand equations as dynamic for ease of reference.

Beef Demand Equations

Static beef demand equation

The static beef demand equation contains the current percapita quantities of beef (QB) and pork (QP), real (per capita) disposable income (RY), and 11 seasonal dummy variables. In addition, a dummy variable (PR73) that equals one for March, 1973 through September, 1973 and zero otherwise is included to account for price distortions due to the beef price ceilings of that time. The results are summarized in Table 7.1 and Table 7.2.

The static beef demand equation required corrections for both autocorrelated errors and heteroscedasticity. The Generalized Least Squares procedures that are outlined in the Statistical Methods Chapter were followed. After the first sample period data were corrected for autocorrelated errors, a plot of the residuals by time indicated the possible presence of heteroscedastic errors. The scatter of residuals in the second half of sample period one appeared to be greater than in the first half. The first period data were then split at the end of 1972.

The autocorrelation coefficients ρ_{1j}, j=1,2, (where the estimate is from the jth half of sample period one) are presented in Table 7.1. Both ρs were significant at the five percent level so the data in each half were corrected for autocorrelated errors. The estimates of error variances s_{11}^2 and s_{12}^2 (where s_{1j}^2 is the estimate from the jth half of sample period one) are presented in Table 7.1. The F-test of the null hypothesis that there was no structural change in variance within the first period (see Chapter 4) is presented as F_{c1} in Table 7.1 along with the scalar by which the data in the second half of sample period one were divided, $(w_{12})^{1/2}$. There was a significant difference in the variances between the first and second halves of the first sample period.

The same procedure was then used to calculate the test of the null

Table 7.1. Results of tests for autocorrelated errors, heteroscedasticity, and structural change in the demand equations

Statistic	Static beef demand	Dynamic beef demand	Static pork demand	Dynamic pork demand
ρ_{11}	0.81**	0.86**	0.12	0.42**
ρ_{12}	0.51**	0.63**	0.56**	0.44**
s_{11}^2	1.913	2.086	3.222	1.482
s_{12}^2	9.548	11.601	13.698	13.146
F_{c1}	4.991**	5.561**	4.251**	8.870**
$(w_{12})^{1/2}$	2.234	2.358	2.062	2.978
ρ_2	0.87**	0.94**	0.81**	0.83**
s_1^2	1.548	1.494	2.172	1.234
s_2^2	2.739	2.372	1.517	1.294
F_{c2}	1.769**	1.588**	1.432	1.049
$(w_2)^{1/2}$	1.330	1.260		
F_{c3}	0.825	0.839	0.583	1.109
F_{c4}	1.448	0.332	3.508**	6.606**

** $\alpha < .05$.

hypothesis that there was no significant difference in the variances of sample periods one and two. The autocorrelation coefficient for period two was significant at the $\alpha = .05$ level so the sample period two data were corrected for autocorrelated errors. Then the F-test for differences in variances, where the s_i^2 is the estimated error variance for sample period i is presented in Table 7.1 as F_{c2} along with the scalar by which the second sample period data were divided.

Table 7.2. Estimated static and dynamic beef demand equations

Variables	Static: Periods 1 and 2	Dynamic: Period 1	Dynamic: Period 2
Intercept	74.453** (7.63)	66.387** (6.07)	-1160.46** (-2.21)
QB	-0.674** (-2.52)	-0.853** (-4.08)	
QP	0.318 (0.79)		
LQB		-0.417** (-2.03)	
RY	6.289** (1.99)	11.612** (3.27)	754.168** (2.20)
RYS		0	-112.896** (-2.41)
PR73	4.057** (2.07)	3.990** (1.96)	
Seasonal[a]	yes	yes	
DW[b]	1.95	1.90	

[a]Seasonal dummy variables included.

[b]Durbin-Watson d-statistic.

** $\alpha < .05$.

Tests for structural change were conducted on the full model, which allowed all coefficients to differ between the two sample periods. The first hypothesis that was tested had the null hypothesis that the 11 seasonal coefficients remained unchanged between the two sample periods; see F_{c3}. This null hypothesis was not rejected at the five percent level and the 11 restrictions were imposed. A second hypothesis was tested and although the nominal significance level α was set at 0.05, the actual significance level was higher. This was the case since the second test depended on the results of the first test. The second test tested whether the coefficients on the economic variables had changed between the two sample periods given that the seasonal pattern had remained unchanged; see F_{C4}. This null hypothesis was also not rejected at α =.05.

Since no structural change in the coefficients is identified, period one and period two coefficients are the same. The coefficients are entered in Table 7.2 under the heading 'Periods 1 and 2'. The t-ratios are in parentheses beneath the coefficients. This beef demand equation has seasonal dummy variables, as is indicated in the table, but their coefficients are not included in this table. These coefficients are, however, included in the Appendix.

The DW in Table 7.2 is the Durbin-Watson d-statistic (see Chapter 4). The d-statistic here is greater than the published upper bound equal to 1.836 with 15 variables, α =.05, and sample size 198. Therefore, this study failed to reject the null hypothesis of no autocorrelation in the errors.

Only one nondummy variable was nonsignificant at the α =.05 level of significance and that was the per capita pork quantity. The expectation was that the quantity of pork consumed would influence the price of beef. A possible explanation is that multicollinearity among the variables in the equation masked the true coefficient value and/or the significance of the estimate.

The price restriction dummy variable was positive and significant. This indicated that the real price of beef was higher during those months than would have been predicted by the quantity and income levels and the seasonal pattern.

The income coefficient was positive and significant. In the full model (not presented here), where no coefficients were restricted to be equal in the two periods, the first period income coefficient was positive and significant while the second period income coefficient was negative and nonsignificant. One possible explanation was that the income specification was incorrect. The linear income specification forced the price response to income changes to be constant over the range of income levels in the two sample periods. It was possible that either a lagged or a nonlinear income variable would provide better results. This possibility was investigated for the dynamic beef demand equation.

<u>Dynamic beef demand equation</u>

In addition to the lagged quantities in the dynamic beef demand equation, an alternative income specification was also included. Since the addition of a lagged income variable proved to be nonsignificant, a squared income variable was added. The coefficient of the squared income variable in period one was nonsignificant at the $\alpha = .05$ level of significance and so a linear income specification for sample period one was maintained. The addition of the lagged quantities (LQB and LQP) and the squared income variable (RYS) did not alter the nonsignificance of the current percapita quantity of pork. The two lagged quantities were also nonsignificant. The current and lagged pork quantities were dropped from the equation. The dynamic beef demand equation was estimated with the current and lagged quantities of beef, the price ceiling dummy, the seasonal dummies, the real income level, and for period two, the square of real income. Some results for this equation are presented in Table 7.1 and Table 7.2.

Corrections were made for both autocorrelated errors and heteroscedasticity for the final dynamic beef demand equation and for the preliminary equations that were used to arrive at the final equation. The Generalized Least Squares procedures of Chapter 4 were used. The discussion that follows presents results for the final form of the dynamic beef demand equation.

The first sample period data were split after 1972. Both halves were corrected for autocorrelated errors since the autocorrelation coefficients were both significant at $\alpha = .05$. The estimate of s_{1j}^2 ($j=1,2$) and the F-test for equality of variances between the two halves of the first sample period are presented in Table 7.1. This study rejected the null hypothesis that the variances in the two halves of sample period one were equal. The scalar by which the data in the second half of sample period one were divided is also presented in Table 7.1.

The $\hat{\rho}$ for sample period two was significant at the five percent level so sample period two data were corrected for autocorrelated errors. The test of the null hypothesis of equality of variances between period one and period two is presented in Table 7.1 along with the scalar by which the period two data were divided.

Again, the transformed data were used to test for structural change in the coefficients. The full model allowed all coefficients to differ between the two sample periods. The first structural change test conducted tested whether the seasonal coefficients remained unchanged between the two sample periods. The null hypothesis was not rejected at the five percent level.

The second structural change test tested whether the coefficients on the current and lagged quantities of beef had changed. The intercept and the coefficient on the level of real income were allowed to differ since the income specification differed between the two periods. This null hypothesis was not rejected at α=.05. Again, note that this second F-test was conducted with a nominal α=.05. The two structural change F-ratios are presented in Table 7.1.

All nonbinary variables were significant at the α =.05 level of significance in Table 7.2. Coefficients on seasonal dummies are not presented in this table but are presented in the Appendix.

The Durbin-Watson d-statistic was between the lower and the upper published bounds for 17 variables, α =.05, and sample size 198. The test was therefore inconclusive. No further transformations were performed, however.

Figure 7.1 presents the dynamic beef demand equation for sample period one and two in real-beef-price/real-income space. Other

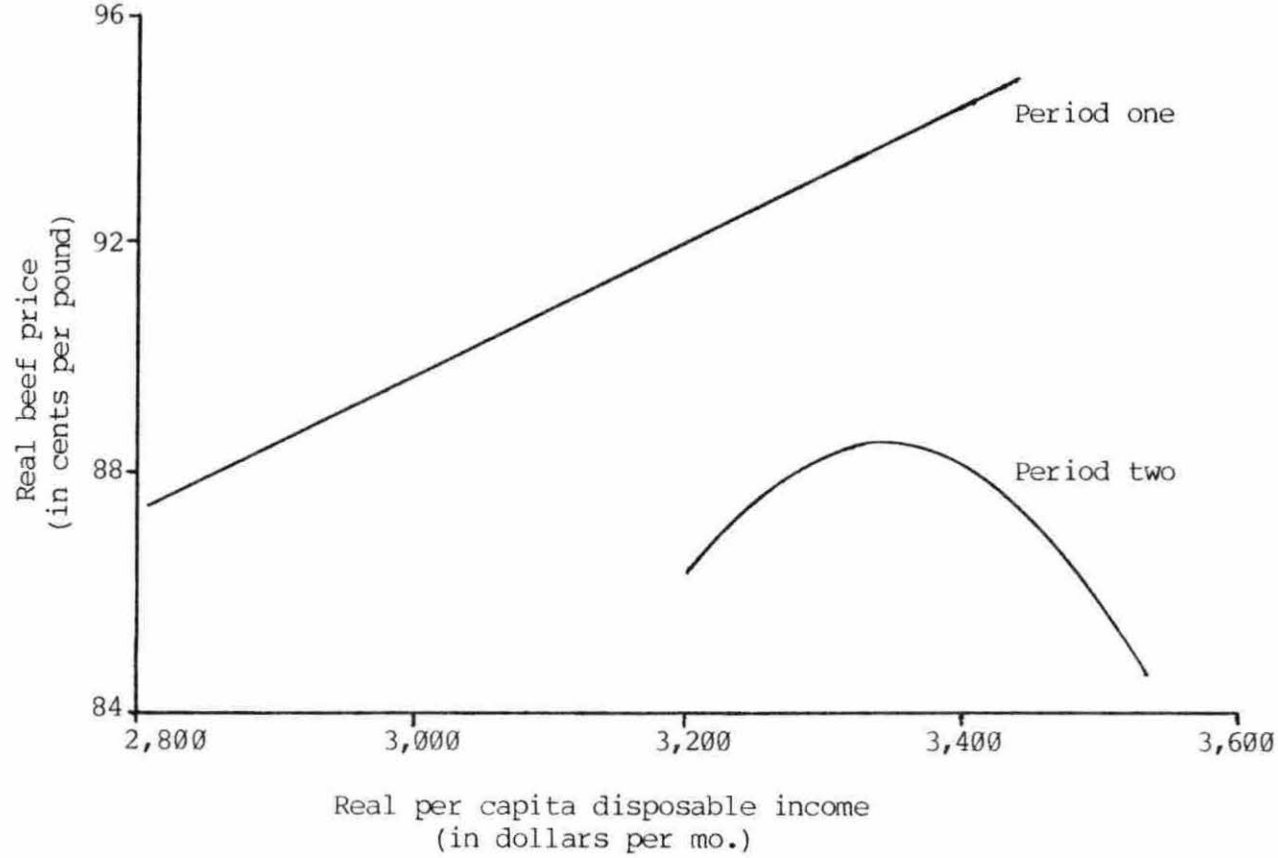

Figure 7.1. Beef demand in price/income space

variables have been set to their sample period means. The horizontal length of each line represents the range of real income during that sample period. The mean of real income in period one was $3,100 while the mean of real income in period two was $3,340. The plot for period two indicates that there are some values of real income for which the real price response to real income changes is negative. Increases in real income over $3,340, which is the maximum of this parabola, tends to decrease the real price of beef, holding all else constant. Extrapolating the effect on the real price of beef from changes in real income differs markedly, depending on the income specification. Projections of the real beef price using a linear income specification may tend to be overstated.

At a given level of real income, the real beef price predicted for the two periods differs. This difference is related to coefficient changes and variable mean changes. The demand decompositions in Chapter 10 break the change in the mean retail beef price into the individual coefficient and the individual mean effects and the coefficient/variable mean interaction. Therefore, one can identify the effect that structural change has played and the effect that changing variable means have played in the total change in the beef price.

Pork Demand Equations

Static pork demand equation

The list of explanatory variables in the static pork demand equation was the same as for the static beef demand equation. The variables were the current per capita quantities of beef and pork, the real per capita disposable income, the price ceiling dummy variable, and the 11 seasonal dummy variables. The static pork demand equation is summarized in Table 7.1 and Table 7.3.

Corrections for autocorrelated errors were made in both sample periods for the static pork demand equation. Refer to Chapter 4 for the Generalized Least Squares procedure. A plot of the first period residuals by time revealed possible heteroscedasticity. Just as for the beef demand equation, the data were split after 1972 and each half of the first period was estimated separately. The autocorrelation coefficient for the first half of sample period one was not significantly different from zero and the autocorrelation coefficient for the second half was significantly different from zero at $\alpha = .05$. Therefore, the estimate s_{11}^2 was from the untransformed first half data and the estimate s_{12}^2 was from transformed data. The estimates of the s_{1j}^2's were used to test the null hypothesis that the error variances in the two halves were equal. The variances and the F-ratios are presented in Table 7.1.

This study rejected the null hypothesis in favor of the alternative that the variances were different and the data in the second half of sample period one were then divided by the square root of w_{12}.

The second period data were corrected for autocorrelated errors since $\rho_2 = 0.81$ and was significant at $\alpha = .05$. The F-ratio of the test of the null hypothesis that the variances of the two sample periods were

Table 7.3. Estimated static and dynamic pork demand equations

Variables	Static		Dynamic	
	Period 1	Period 2	Period 1	Period 2
Intercept	44.050**	11.291	61.227**	-1277.31**
	(4.39)	(0.40)	(6.35)	(-3.18)
QB	1.027**	0.329	2.016**	0.690**
	(2.80)	(1.12)	(5.62)	(2.47)
QP	-2.103**	-0.863**	-4.332**	-1.876**
	(-3.67)	(-1.99)	(-7.51)	(-4.77)
LQB			1.487**	0.831**
			(3.76)	(2.94)
LQP			-3.802**	-1.812**
			(-7.04)	(-4.58)
RY	8.112**	15.946*	5.912**	791.395**
	(2.45)	(1.91)	(1.99)	(3.30)
RYS			0	-116.159**
				(-3.25)
PR73	4.284**		6.852**	
	(2.19)		(2.87)	
Seasonal[a]	yes		yes	
DW[b]	1.76		1.61	

[a]Seasonal dummy variables included.

[b]Durbin-Watson d-statistic.

* $\alpha < .10$.

** $\alpha < .05$.

equal is presented in Table 7.1. This study failed to reject the null hypothesis that the variances were equal.

The first hypothesis of structural change that was tested was that the coefficients on the seasonal dummy variables were unchanged between the two sample periods. This null hypothesis was not rejected and the 11 restrictions were imposed. The second null hypothesis tested was that the coefficients of the intercept, the percapita quantities, and the real income level were unchanged between the two sample periods. This study rejected this null hypothesis in favor of the alternative hypothesis that the set of coefficients differed between the two periods. Again this second test was conducted at nominal α =.05.

In Table 7.3, the t-ratios are in parentheses beneath the coefficients. Excluding the intercept and seasonal coefficients, two coefficients were individually nonsignificant at the five percent level of significance: the period two beef quantity coefficient and the period two real income coefficient. Both quantity coefficients fell in absolute value between periods one and two, which indicated that a given change in percapita quantity of beef or pork had less impact on real pork price in period two than in period one. The real income coefficient had nearly doubled between the two periods but the intercept coefficient declined by more than half.

The Durbin-Watson d-statistic fell between the published lower and upper bounds for 18 variables, α =.05, and sample size 198. Therefore, the Durbin-Watson test of no autocorrelation in the errors was inconclusive. No additional transformations were performed, however.

Dynamic pork demand equation

The dynamic pork demand equation variables included the current and lagged percapita quantities of beef and pork, the price ceiling dummy variable, and the 11 seasonal dummy variables. A nonlinear income specification was also included. The large change in the static pork demand income coefficient accompanying the large decrease in the intercept of that equation may indicate the presence of a nonlinear income affect. The level as well as the square of real income were included in the dynamic pork demand equation.

The coefficient of the square of real income was nonsignificant in the first sample period at the α =.05 level of significance and so was dropped. The coefficient of the squared income variable was significant in the second period and so was retained. No other variables needed to be dropped because of nonsignificance.

The first sample period data were split after 1972. The Generalized Least Squares procedures of Chapter 4 were followed. Data in both halves of sample period one were transformed to correct for autocorrelated errors since both autocorrelation coefficients were significant at α =.05. Each half of the first period then yielded an estimate of the error variance for that half that was used to test for the presence of heteroscedasticity. The F-ratio for the null hypothesis of equal variances is presented in Table 7.1. This study rejected the null hypothesis in favor of the alternative hypothesis that the variances differed. The data in the second half of sample period one were then divided by the scalor presented in Table 7.1.

Data in sample period two were transformed by the appropriate T-matrix of Chapter 4 since ρ_2 was significant at α=.05. Estimates of the error variances for the two sample periods using transformed data were used to test the null hypothesis that the error variances of the two sample periods are equal. This F-ratio is presented in Table 7.1. This study failed to reject the null hypothesis and pooled the period one and period two data without transforming the period two data for heteroscedasticity.

The first structural change test tested whether the seasonal coefficients had remained unchanged between the two sample periods. This study failed to reject the null hypothesis and imposed the 11 restrictions. The second test had the null hypothesis that the coefficients on the current and lagged per capita quantities of beef and pork had remained unchanged between the two periods. This study rejected this null hypothesis in favor of the alternative that there was structural change in the coefficients of these four variables. Both structural change F-ratios are presented in Table 7.1.

All nonseasonal coefficients were significant at the α =.05 level of significance (refer to Table 7.3). The absolute value of the coefficients on the current and lagged per capita quantities fell between the two sample periods. A given change in any of the per capita quantity variables had less impact on the real pork price in period two than in period one. The coefficients on the current per capita quantities of beef and pork were all close to twice their values in the static pork demand equation. The signs on the lagged per capita quantity coefficients had the same sign as the current per capita quantity coefficient for both beef and pork. The coefficients on the lagged per capita quantity variables were smaller in absolute value than those of the current quantity variables, except for the beef quantity in period two.

The Durbin-Watson d-statistic fell between the published lower and upper bounds with 23 variables, α =.05, and sample size 198. The test of the null hypothesis that there were no autocorrelated errors then was inconclusive. No additional transformations were used, however.

Figure 7.2 plots the dynamic pork demand equation for period one and period two in real-price/real-income space. All other variables are held at their sample period means. The horizontal length of each line is the range of real income for that period. The mean real income in period one and period two was \$3,100 and \$3,340, respectively. This graph is very similar to Figure 7.1 since the income specification is similar for the beef and pork demand equations. The response in real pork price in period one to a given change in real income is constant. For period two, however, this response depends on the level of real income. Increasing real income over \$3,410 for period two tends to decrease the real price of pork, holding all else constant.

At a given level of real income, the difference between the real pork price predicted for the two periods is related to coefficient and

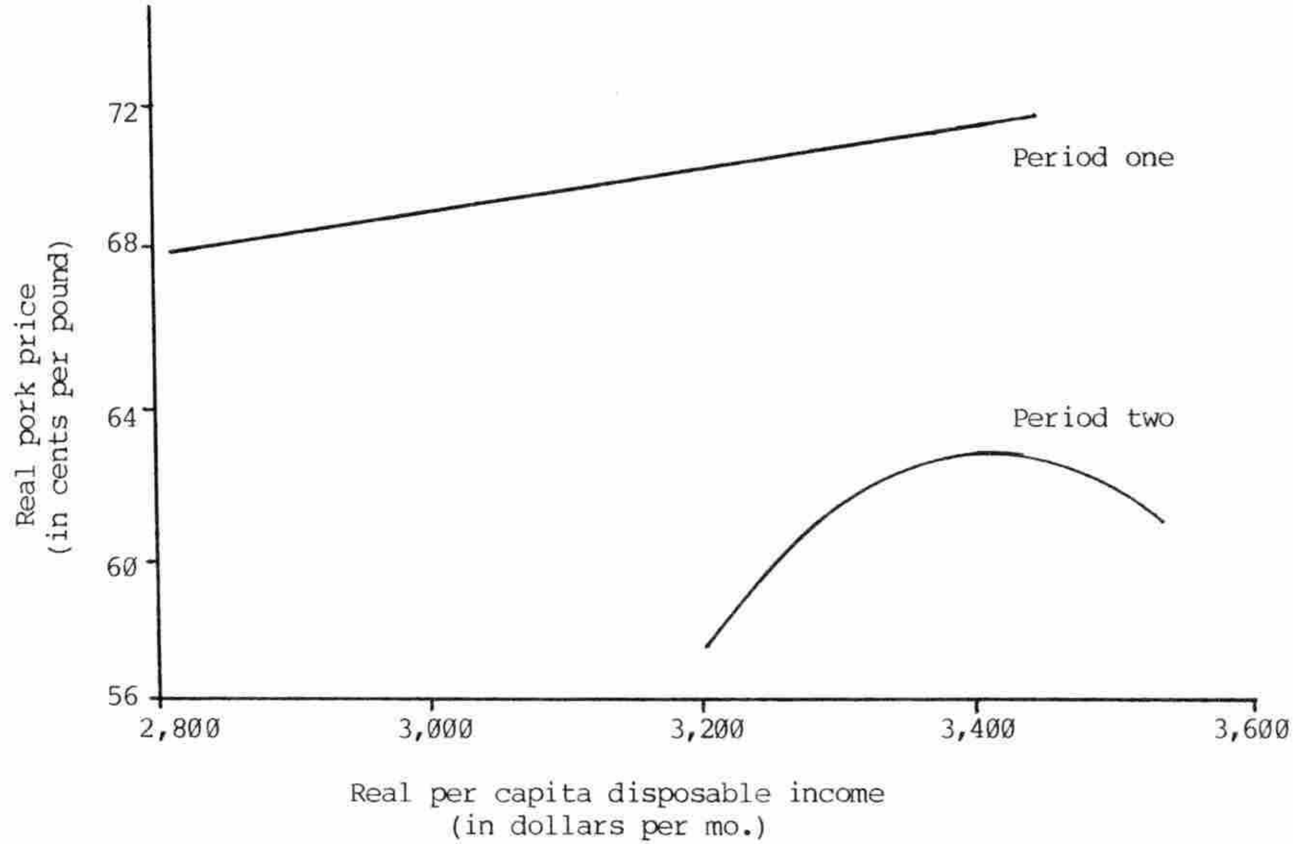

Figure 7.2. Pork demand in price/income space

variable mean changes. Decomposing this difference into its component parts is discussed in Chapter 10.

CHAPTER 8. ESTIMATED MARGIN EQUATIONS

The margin equations were estimated by the procedures outlined in the Statistical Methods Chapter. This chapter presents the estimated static and dynamic margin equations of both Form I and Form II. Tests for structural change are also presented. The margin equations are presented in the following order: farm-retail, wholesale-retail, and farm-wholesale.

Farm-Retail Beef Margin Equations

Static farm-retail beef margin equation

The list of explanatory variables in the static farm-retail beef margin equation included the farm-retail pork margin (FRMP), the farm value of beef (FVB), and a cost index (CI1). The coefficients on the seasonal dummy variables were, as a group, nonsignificant and so were not included. This is not to say that there was no seasonal pattern in this margin. Other explanatory variables in this equation produced what seasonal pattern there was in the data. The cost index variable that was used in this margin equation, CI1, included the producer price index, the meat packing wage rate index, and the food store wage rate index. More detailed explanations of this variable are provided in the Data Sources and Descriptions Chapter. The static farm-retail beef margin equation was estimated with the Autoregressive Two-Stage Least Squares (A2SLS) procedure outlined in the Statistical Methods Chapter. The results are presented in Table 8.1 and Table 8.2.

An examination of the first and second sample period residuals

Table 8.1. Results of tests for autocorrelated errors, heteroscedasticity, and structural change in the farm-retail margin equations

Statistic	Static FRMB	Dynamic FRMB	Static FRMP	Dynamic FRMP
ρ_1	0.50**	0.59**	0.64**	0.48**
ρ_2	0.61**	0.51**	0.69**	0.61**
s_1^2	11.856	9.371	9.935	6.555
s_2^2	21.086	15.649	11.935	7.979
F_{c2}	1.779**	1.670**	1.201	1.217
$(w_2)^{1/2}$	1.334	1.292		
F_{c3}			1.645	0.641
F_{c4}	0.915	0.854	4.195**	2.850**

** $\alpha < .05$.

revealed significant autocorrelation in the errors at the $\alpha = .05$ (see Table 8.1). Both sample periods were transformed to correct for the autocorrelation. An F-test was then conducted to test the null hypothesis that the error variance of the two periods were equal (see F_{c2}). This study rejected the null hypothesis in favor of the alternative hypothesis that the variances differed. The period two data were then divided by the scalor $(w_2)^{1/2}$.

The null hypothesis of the structural change test was that the coefficients of the intercept, the farm-retail pork margin, the farm value of beef, and the cost index were unchanged between the two sample periods. This study failed to reject the null hypothesis (see F_{c4}) and imposed the four restrictions.

Table 8.2. Estimated static and dynamic farm-retail beef margin equations

Variable	Static Periods 1 and 2	Dynamic Periods 1 and 2
Intercept	-4.238** (-2.13)	-4.891** (-2.71)
FRMP	0.277** (3.34)	0.190** (2.56)
FVB	0.027 (0.65)	-0.564** (-6.30)
LFVB		0.638** (7.08)
CI1	0.253** (7.98)	0.260** (9.40)
Seasonal[a]	no	no
DW[b]	1.77	1.76

[a]Seasonal dummy variables included.

[b]Durbin-Watson d-statistic.

** $\alpha < .05$.

Only one coefficient, the coefficient of the farm value of beef, was individually nonsignificant at the five percent significance level (see Table 8.2). This coefficient measures the markup effect and was positive, as expected. Very little confidence could be placed on the value of this coefficient, however. The coefficient of the farm-retail pork margin, the margin interaction, was also positive. This was the expected sign from Holdren's model of multiproduct firms. The cost index coefficient was positive and significant, again as was expected from theory.

The Durbin-Watson d-statistic fell between the published lower and upper bounds with three variables, α =.05 and sample size 198. The test of the null hypothesis that there was no autocorrelation in the errors was inconclusive. No additional transformations were conducted, however.

Dynamic farm-retail beef margin equation

The dynamic equation differed from the static version of the farm-retail beef margin equation by the addition of the lagged farm value of beef (LFVB). Again, there were no seasonal dummy variables included. The dynamic farm-retail beef margin equation was estimated with Autoregressive Two-Stage Least Squares and the results are presented in Table 8.1 and Table 8.2.

Regressions in both sample periods had significant autocorrelation at α =.05. Once the data for both periods were corrected for autocorrelated errors, the F-test for equal error variances was conducted. The estimated error variances and the F-ratio are presented in Table 8.1. This study rejected the null hypothesis at the five percent level of significance. The second period data were divided by the scalor $(w_2)^{1/2}$.

The structural change F-test had the null hypothesis that the coefficients of the intercept, the farm-retail pork margin, the cost index, and the current and lagged farm value of beef remained unchanged between the two sample periods. This study failed to reject the null hypothesis and imposed the five restrictions. The dynamic farm-retail beef margin equation is presented in Table 8.2. All coefficients were significant at the α =.05 level and signs were as expected. The margin interaction--the farm-retail pork margin coefficient--was positive, as it was in the static equation.

The coefficient of the cost index was also positive, as it was in the static version of this equation. The coefficient of the current farm value of beef changed sign. The coefficient of the lagged farm value of beef was positive. An intuitive explanation of these two signs may be found in the hypothesized retailer behavior. In this study, retailers are expected to have a dynamic response to farm value changes. In order to keep retail prices steady in the short-run, retailers absorb some of the increase in farm value, thus there is a negative coefficient of the current farm value. The longer run response of retailers is to increase the margin and thus let retail prices rise. Therefore, the coefficient of the lagged farm value is positive.

The Durbin-Watson d-statistic fell between the lower and upper published bounds. The test of the null hypothesis that the errors were not autocorrelated was inconclusive. However, no additional transformations were performed.

Farm-Retail Pork Margin Equations

Static farm-retail pork margin equation

Explanatory variables in the static farm-retail pork margin equation included the farm-retail beef margin (FRMB), the farm value of pork (FVP), a cost index, and 11 seasonal dummy variables. The cost index variable that was used in this equation was the same index that was used in the two versions of the farm-retail beef margin equation. A preliminary static and the final static farm-retail pork margin equations are presented in Table 8.3. Other results of the final static farm-retail pork margin equation are presented in Table 8.1. The farm-retail pork margin equations were estimated with A2SLS.

Both sample periods for the preliminary static equation required corrections for autocorrelated errors since $\hat{\rho}$ for period one and period two were Ø.59 and Ø.62, respectively, and both were significant at the five percent level. The null hypothesis that the error variances of the two periods were equal was not rejected at the five percent level of significance. The test of the null hypothesis that the seasonal coefficients were unchanged between the two periods was not rejected at the five percent level of significance. The second structural change hypothesis test that the other coefficients in the equation were unchanged was rejected. The results of this equation are presented in Table 8.3 under the heading 'Preliminary static'. The first period coefficient of the farm-retail beef margin was nonsignificant at α=.Ø5. The coefficients of the farm value of pork were nonsignificant at α =.Ø5 in both periods. The sign change between the two periods of the farm value coefficient was unexpected. It was difficult to draw conclusions, since the coefficients were nonsignificant. However, one possible explanation was that the variable was picking up some dynamic effects like those discussed for the dynamic farm-retail beef margin.

Table 8.3. Estimated static and dynamic farm-retail pork margin equations

	Preliminary static		Static		Dynamic	
Variable	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2
Intercept	-1.992	24.306**	-2.102	20.335**	-0.383	19.022**
	(-0.58)	(2.72)	(-0.58)	(2.14)	(-0.18)	(2.71)
FRMB	0.090	0.514**	0.065	0.510**		
	(0.60)	(4.54)	(0.43)	(4.57)		
FVP	0.033	-0.078			-1.013**	-0.866**
	(0.59)	(-1.06)			(-8.86)	(-9.52)
LFVP					1.096**	0.871**
					(9.46)	(9.99)
CI1	0.276**	0.051	0.297**	0.046	0.288**	0.225**
	(4.78)	(1.05)	(5.35)	(0.89)	(13.94)	(9.82)
Seasonal[a]		yes		yes		yes
DW[b]		1.73		1.85		1.58

[a]Seasonal dummy variables included.

[b]Durbin-Watson d-statistic.

** $\alpha < .05$.

Another static farm-retail pork margin equation was estimated without the current farm value of pork. Both sample periods required corrections for autocorrelated errors with this new static margin equation also (see Table 8.1). The test of the null hypothesis that the error variances of the two periods were equal is presented in Table 8.1. This study failed to reject the null hypothesis at the α =.05 level. This study concluded that the error variances were equal and that no transformations of the data were necessary to correct for heteroscedasticity.

The first structural change test had the null hypothesis that the seasonal coefficients remained unchanged between the two sample periods (see F_{c3}). This study failed to reject the null hypothesis and imposed the 11 restrictions. The second null hypothesis was that the coefficients of the intercept, the farm-retail beef margin and the cost index were unchanged between the two periods. This study rejected this null hypothesis. Again, this second test was conducted at a nominal five percent significance level. The actual significance level was higher because it was the second of two related hypotheses.

The final static farm-retail pork margin equation is presented in Table 8.3 under the heading 'static'. Two nonseasonal coefficients were nonsignificant at the five percent level: the first period farm-retail beef margin coefficient and the second period cost index coefficient. The first period coefficient on the farm-retail beef margin was nonsignificant at $\alpha = .05$ and differed widely from the period two coefficient. The second coefficient on the cost index was nonsignificant at $\alpha = .05$ and differed widely from the period one coefficient. The degree of structural change may be overstated for these two variables but the changes appear to be offsetting.

The Durbin-Watson d-statistic was between the lower and upper published bounds. Therefore the test of the null hypothesis that there was no autocorrelation in the errors was inconclusive. However, no additional transformations of the data were performed.

Dynamic farm-retail pork margin equation

The explanatory variables in the dynamic farm-retail pork margin equation included the current and lagged farm value of pork (FVP and LFVP), the cost index, and the 11 seasonal dummy variables. The coefficients on the farm-retail beef margin were both negative with the lagged farm value of pork in the equation. The negative coefficients could be the result of multicollinearity among the variables. It could also be that a lagged response to farm-retail beef margin changes that were similar to the lagged response to farm value of pork changes could explain the negative coefficients. Retailers may not respond to changes in the other margin in the current period but instead respond to changes one or more periods ago. The farm-retail beef margin variable was dropped from the dynamic farm-retail pork equation. The dynamic farm-retail pork margin equation was estimated with A2SLS and the results are presented in Table 8.1 and Table 8.3.

Data from both sample periods were transformed to correct for autocorrelated errors since the autocorrelation coefficients for both sample periods were significant at α=.05. The F-test of the null hypothesis that the error variances of the two periods were equal is presented in Table 8.1 along with the error variances. This study failed to reject the null hypothesis at the five percent significance level.

Two F-tests were conducted for structural change. The first F-test had the null hypothesis that the seasonal coefficients remained unchanged between the two sample periods. This study failed to reject the null hypothesis at the five percent significance level. The second of the two structural change hypotheses had the null hypothesis that the coefficients of the intercept, the current and lagged farm value of pork, and the cost index had all remained unchanged between the two periods. This study rejected the null hypothesis. This second test was conducted at the nominal five percent level of significance. Both F-ratios are presented in Table 8.1.

The final dynamic farm-retail pork margin equation is presented in Table 8.3. All of the nonbinary coefficients were individually significant at the five percent level. A lagged response to farm value of pork changes that were similar to that found in the dynamic farm-retail beef margin equation was seen in this equation. The same interpretation can be given to the signs of the coefficients as for those of the dynamic farm-retail beef margin equation. The Durbin-Watson d-statistic was at the lower published bound. Therefore, the test of the null hypothesis that there was no autocorrelation in the errors was inconclusive. However, no additional transformations of the data were conducted.

Wholesale-Retail Beef Margin Equations

Static wholesale-retail beef margin equation

The variables that were included in this margin equation were the wholesale-retail pork margin (WRMP), the wholesale value of beef (WVB), the cost index (CI3), and the 11 seasonal dummy variables. The cost index that was used here differs from the cost index that was used in the farm-retail margins. The wholesale-retail cost index consisted of two indexes of costs: the producer price index and the food store wage rate index. Weights and further discussion are provided in the Data Sources and Descriptions Chapter. The static wholesale-retail beef margin equation was estimated with A2SLS. Results are presented in Table 8.4 and Table 8.5.

Data in both sample periods were transformed to correct for autocorrelated errors since the autocorrelation coefficients in both sample periods were significant at α =.05 (see Table 8.4). The test of the null hypothesis that the error variances in the two periods were equal was tested with an F-ratio. This F-ratio and the error variances are presented in Table 8.4. This study rejected the null hypothesis and divided the period two data by the scalor $(w_2)^{1/2}$.

The first structural change hypothesis was that the seasonal coefficients were unchanged between the two sample periods. This study failed to reject the null hypothesis and imposed the 11 restrictions. The second structural change hypothesis was that the coefficients of the intercept, the wholesale-retail pork margin, the wholesale value of beef, and the cost index had remained unchanged between the two periods. This study failed to reject the null hypothesis and imposed the four restrictions. These F-ratios are presented in Table 8.4.

Refer to Table 8.5 for the static wholesale-retail beef margin equation. Two coefficients on the nonbinary variables were significant at the α =.05 level. The coefficient of the wholesale value of beef

Table 8.4. Results of tests for autocorrelated errors, heteroscedasticity, and structural change in the wholesale-retail margin equations

Statistic	Static WRMB	Dynamic WRMB	Static WRMP	Dynamic WRMP
ρ_1	0.64**	0.67**	0.70**	0.48**
ρ_2	0.62**	0.45**	0.81**	0.59**
s_1^2	8.061	6.980	8.364	6.020
s_2^2	15.096	12.690	10.009	8.716
F_{c2}	1.873**	1.818**	1.197	1.448
$(w_2)^{1/2}$	1.369	1.348		
F_{c3}	1.330	0.866	0.953	0.213
F_{c4}	1.646	2.723**	1.765	2.679**

** $\alpha < .05$.

was nonsignificant although it was of the expected sign. When this variable was dropped from the equation, the other coefficients changed very little. This variable was retained for nonstatistical considerations. The wholesale value of beef was retained in the equation to allow retail price and farm value changes to affect the wholesale-retail beef margin, albeit they had a small effect. The wholesale-retail pork margin coefficient and the cost index coefficient had the expected sign.

The Durbin-Watson d-statistic fell between the upper and lower published bounds with 14 variables, $\alpha = .05$, and sample size 198. The test of the null hypothesis that there was no first order

Table 8.5. Estimated static and dynamic wholesale-retail beef margin equations

	Static	Dynamic	
Variable	Periods 1 and 2	Period 1	Period 2
Intercept	-0.243 (-0.10)	-4.973 (-1.37)	0.178 (0.02)
WRMP	0.172** (2.43)	0	0.264** (3.14)
WVB	0.017 (0.62)	-0.481** (-3.41)	-0.433** (-4.53)
LWVB		0.573** (3.82)	0.714** (5.69)
CI3	0.239** (9.12)	0.261** (10.13)	0.170** (5.59)
Seasonal[a]	yes	yes	
DW[b]	1.72	1.66	

[a] Seasonal dummy variables included.

[b] Durbin-Watson d-statistic.

** $\alpha < .05$.

autocorrelation in the errors was inconclusive; however, no additional transformations were performed.

Dynamic wholesale-retail beef margin equation

The dynamic version of the wholesale-retail beef margin equation included the variables of the static version plus the lagged wholesale value of beef (LWVB). The coefficient on the first period wholesale-retail pork margin was nonsignificant and negative so this coefficient was set equal to zero. The dynamic wholesale-retail beef margin equation was estimated with A2SLS and results are presented in Table 8.4 and Table 8.5.

The data from both sample periods were corrected for autocorrelated errors since the $\hat{\rho}$s for periods one and two were both significant at the five percent level. The null hypothesis that the error variances of the two periods were equal was tested with the transformed data. The $\hat{\rho}_i$ and s_i^2 (i=1,2) are presented in Table 8.4 along with the F-ratio. This study rejected the null hypothesis in favor of the alternative and transformed the data with the scalor $(w_2)^{1/2}$.

The first structural change hypothesis was that the seasonal coefficients were unchanged between the periods. This study failed to reject the null hypothesis and imposed the 11 restrictions. The second structural change hypothesis was that the coefficients on the current and lagged wholesale value of beef and the cost index coefficient were unchanged between the two periods. This study rejected the null hypothesis. This second hypothesis test was conducted at a nominal α =.05. Both F-ratios are presented in Table 8.4.

All nonbinary variable coefficients (refer to Table 8.5) were significant at the α =.05 level. Also, all coefficients had the expected sign. The period two coefficient on the wholesale-retail pork margin is larger than the coefficient of this variable in the static wholesale-retail beef margin equation. The coefficient of the current wholesale beef value decreased in absolute value while the coefficient of the lagged wholesale beef value increased in absolute value. The percentage change in absolute value was greater for the coefficient of the lagged wholesale beef value than for the coefficient of the current wholesale beef value. The coefficient of the cost index fell about 35 percent between the two sample periods. The coefficient of the cost index in the static equation fell between the two coefficients of the cost index in the dynamic equation.

The Durbin-Watson d-statistic fell between the published lower and upper bounds for 18 variables, α =.05, and sample size 198. The test of the null hypothesis that there was no first order autocorrelation in the errors was inconclusive. No additional transformations of the data were performed, however.

Wholesale-Retail Pork Margin Equations

Static wholesale-retail pork margin equation

The list of variables included in this static pork margin equation included the wholesale-retail beef margin (WRMB), the wholesale value of pork (WVP), the cost index (CI3), and the 11 seasonal dummy variables. The wholesale value of pork coefficient was negative and nonsignificant in both sample periods and so this variable was dropped from the equation. The static wholesale-retail pork margin equation was estimated with A2SLS. Results are presented in Table 8.4 and Table 8.6.

The data from both sample periods were corrected for autocorrelated errors since the autocorrelation coefficients for both periods were significant at α=.05. The transformed data were used to test the null hypothesis that the error variances of the two periods were equal. The error variances and the F-ratio are presented in Table 8.4. This study

Table 8.6. Estimated static and dynamic wholesale-retail pork margin equations

	Static	Dynamic	
Variable	Periods 1 and 2	Period 1	Period 2
Intercept	-10.311** (-4.45)	-7.704** (-3.721)	-11.246 (-1.554)
WRMB	0.286** (3.23)		
WVP		-0.929** (-8.15)	-0.942** (-7.67)
LWVP		0.922** (7.91)	1.020** (8.48)
CI3	0.112** (3.86)	0.172** (7.65)	0.172** (8.99)
Seasonal[a]	yes	yes	
DW[b]	1.97	1.70	

[a]Seasonal dummy variables included.

[b]Durbin-Watson d-statistic.

** $\alpha < .05$.

failed to reject the null hypothesis. The data in the two periods were corrected for autocorrelated errors only.

The first structural change hypothesis was that the seasonal coefficients remained unchanged between the two periods. This study failed to reject the null hypothesis and imposed the 11 restrictions. The second of the two structural change hypotheses was that the coefficients on the intercept, the wholesale beef margin, and the cost index were all unchanged between the two periods. This study failed to reject the null hypothesis and imposed the three restrictions. These F-ratios are presented in Table 8.4.

The two nonbinary variable coefficients were significant at the α=.05 level and had the expected signs (refer to Table 8.6). The Durbin-Watson d-statistic was greater than the published upper bound. Therefore, the test of the null hypothesis that there was no autocorrelation in the errors was not rejected at the α=.05 level of significance.

Dynamic wholesale-retail pork margin equation

The dynamic version of this pork margin equation differs from the static equation by the addition of the lagged wholesale value of pork (LWVP). The wholesale-retail beef margin coefficient proved to be nonsignificant in both sample periods with the addition of the lagged wholesale value of pork in the equation. Multicollinearity among the variables could have been responsible for the change in the significance of the wholesale-retail beef margin coefficient. The wholesale-retail beef margin was dropped from the dynamic equation. The final dynamic wholesale-retail pork margin equation was estimated with A2SLS. Results are presented in Table 8.4 and Table 8.6.

The data from both sample periods required transformation to correct for autocorrelated errors since the autocorrelation coefficients in both periods were significant at α=.05 (see Table 8.4). The test of the null hypothesis that the error variances were equal in the two periods was conducted with the transformed data. This study failed to reject the null hypothesis (see Table 8.4).

The first structural change hypothesis was that the seasonal coefficients were unchanged between the sample periods. This study failed to reject the null hypothesis and imposed the 11 restrictions. The second structural change hypothesis was that the coefficients on the intercept, the cost index, and the current and lagged wholesale pork value were unchanged between the two periods. This study rejected the null hypothesis in favor of the alternative. Both F-ratios are presented in Table 8.4.

All nonbinary variable coefficients were significant at the α=.05 level and were of the expected signs (see Table 8.6). The coefficient on the cost index was quite large relative to the coefficient on this variable in the static version of the pork margin equation.

The Durbin-Watson d-statistic fell between the lower and the upper published bounds. Therefore, the test of the null hypothesis that there was no autocorrelation in the errors was inconclusive. No additional transformations were performed, however.

Farm-Wholesale Beef Margin Equation

The coefficient of the lagged farm beef value was nonsignificant in the dynamic farm-wholesale beef margin equation. Therefore, the static version of the equation serves as both the static and the dynamic farm-wholesale beef margin equation. Unlike the margin equations discussed so far, the coefficient of the cost index was nonsignificant in this margin equation. The cost index that was attempted in this equation, CI2, had the Producer Price Index and the meat packer wage rate index weighted equally. It could have been that the cost index CI2 did not capture the costs to which processors reacted. Instead of a cost index, the farm level byproduct allowance for beef (FBPA) was included. The byproduct allowance was an important salable product at the farm-wholesale processing level. Other variables that were included in the farm-wholesale beef margin equation were the farm-wholesale pork margin (FWMP) and the farm value of beef (FVB). The 11 seasonal dummy variables as a group were nonsignificant and so were not included in the equation. The final farm-wholesale beef margin equation was estimated with A2SLS and results are presented in Table 8.7 and Table 8.8.

The test of the null hypothesis that there was no autocorrelation in the errors for both sample periods was rejected at the α=.05 level of significance. The data for both periods were then transformed with the T-matrix of Chapter 4. The transformed data were then used in testing the null hypothesis that the error variances of the two sample periods were equal. The period two error variance was smaller than the period one error variance. This was opposite the case with the other margin equations discussed so far. This study failed to reject the null hypothesis at the α =.05 level of significance (see Table 8.7). No transformations to correct for heteroscedasticity were required.

The structural change test had the null hypothesis that the coefficients on the intercept, the farm-wholesale pork margin, the farm beef value, and the farm beef byproduct allowance were all unchanged between the two sample periods. This study failed to reject the null

Table 8.7. Results of tests for autocorrelated errors, heteroscedasticity, and structural change in the farm-wholesale margin equations

Statistic	Static FWMB	Static FWMP	Dynamic FWMP
ρ_1	0.34**	0.68**	0.64**
ρ_2	0.33**	0.44**	0.57**
s_1^2	1.587	2.521	2.485
s_2^2	1.256	2.543	2.442
F_{c2}	1.264	1.009	1.018
F_{c3}		1.264	0.548
F_{c4}	2.035*	6.027**	17.270**

* $\alpha < .10$.

** $\alpha < .05$.

hypothesis and imposed the four restrictions.

All coefficients, except on the intercept, were significant at the $\alpha = .05$ level (see Table 8.8). As with the other static margin equations discussed, the coefficient on the farm value of beef was postive. The coefficient on the farm beef byproduct allowance was negative. The explanation for this sign may be that as the farm beef byproduct allowance decreases, the processor requires a higher farm-wholesale margin for revenues to remain relatively stable. The same may be true for an increase in the byproduct allowance. Processors do not require the farm-wholesale margin to be as high to maintain revenues as the byproduct value increases.

The Durbin-Watson d-statistic was greater than the published upper

Table 8.8. Estimated static farm-wholesale beef margin equation

Variable	Static Periods 1 and 2
Intercept	0.083 (0.11)
FWMP	0.180** (5.68)
FVB	0.039** (4.21)
FBPA	-0.116** (-2.07)
Seasonal[a]	no
DW[b]	1.91

[a]Seasonal dummy variables included.

[b]Durbin-Watson d-statistic.

** $\alpha < .05$.

bound for three variables, $\alpha = .05$, and sample size 198. Therefore, this study failed to reject the null hypothesis that there was no autocorrelation in the errors.

Farm-Wholesale Pork Margin Equations

Static farm-wholesale pork margin equation

The list of variables in the static version of the farm-wholesale pork margin equation included the farm-wholesale beef margin (FWMB), the farm value of pork (FVP), and the cost index (CI2). The 11 seasonal dummy variables were also included. When the regressions were run seperately for the two sample periods, the coefficients on the first period farm-wholesale beef margin and the second period cost index were nonsignificant at the α=.05 level. The period two coefficient of the farm value of pork was negative and nonsignificant at the α=.05 level. Therefore, the coefficient on the period two farm pork value was set equal to zero. The final static farm-wholesale pork margin equation was estimated with A2SLS. Results are presented in Table 8.7 and Table 8.9.

The data for both periods required transformation to correct for autocorrelated errors since the ρs for periods one and two were significant at the α=.05 level (see Table 8.7). The transformed data were used to test the null hypothesis that the error variances of the two periods were equal. This study failed to reject the null hypothesis. No transformations were required to correct for heteroscedasticity.

The first structural change hypothesis was that the seasonal coefficients were unchanged between the two periods. The F-ratio for this test is presented in Table 8.7. This study failed to reject the null hypothesis and imposed the 11 restrictions. The second structural change hypothesis was that the farm-wholesale beef margin coefficient and the cost index coefficient were unchanged between the two sample periods. This study rejected the null hypothesis in favor of the alternative hypothesis (see Table 8.7).

The first period farm-wholesale beef margin coefficient and the second period cost index coefficient were still nonsignificant at the

Table 8.9. Estimated static and dynamic farm-wholesale pork margin equations

	Static		Dynamic	
Variables	Period 1	Period 2	Period 1	Period 2
Intercept	4.594** (2.08)	19.871** (6.06)	6.522** (3.73)	27.562** (6.91)
FWMB	0.312 (1.23)	0.853** (3.33)		
FVP	0.115** (3.90)	0	-0.099 (-1.50)	-0.258** (-5.04)
LFVP			0.224** (3.27)	0.192** (3.89)
CI2	0.096** (4.90)	0.019 (1.56)	0.101** (6.33)	0.043** (3.163)
Seasonal[a]	yes		yes	
DW[b]	1.94		1.95	

[a]Seasonal dummy variables included.

[b]Durbin-Watson d-statistic.

** $\alpha < .05$.

$\alpha = .05$ level (see Table 8.9). The nonbinary variable coefficients included had the expected signs though.

The Durbin-Watson d-statistic was greater than the published upper bound. Therefore, this study concluded that there was no first order autocorrelation in the errors.

Dynamic farm-wholesale pork margin equation

The farm-wholesale beef margin was dropped due to nonsignificance and the lagged pork value (LFVP) was added to obtain the dynamic equation. The final dynamic farm-wholesale pork margin equation was estimated with A2SLS and results are presented in Table 8.7 and Table 8.9.

The ρs for periods one and two were both significant at the α=.05 level (see Table 8.7). Therefore, data for both periods were transformed with the T-matrix of Chapter 4 to correct for the autocorrelation in the errors. The transformed data were used to test the null hypothesis that the error variances of the two periods were equal. This study failed to reject the null hypothesis at the α=.05 level of significance (see Table 8.7).

The first structural change hypothesis was that the seasonal coefficients were unchanged between the two periods. This study failed to reject the null hypothesis and imposed the 11 restrictions. The next null hypothesis was that the coefficients of the intercept, the farm pork value, the lagged farm pork value, and the cost index were unchanged between the two periods. This F-ratio is also presented in Table 8.7. This study rejects the null hypothesis.

All nonseasonal coefficients were significant at the α =.05 level except for the farm pork value coefficient in period one (see Table 8.9). All coefficient signs were as expected.

Durbin-Watson d-statistic fell between the lower and the upper published bounds. Therefore, the test of the null hypothesis that there was no first order autocorrelation in the errors was inconclusive. However, no additional transformations were performed.

Dynamic Stability

Stability of a system determines if the system of equations, given some initial values for the endogenous variables, converges on a vector M^* after a shock to the system, or

$$\lim_{t \to \infty} M_t = M^*$$

The vector M^* contains the values of the endogenous variables that result when t approaches infinity.

The Decomposition Methods Chapter presents the equation for the dynamic version of the model. Equation (5.8) is repeated here.

$$M_{it} = A_i^{-1} G_i M_{it-1} + A_i^{-1} C_i Z_{it} + A_i^{-1} F P_{it}$$

This equation, in matrix form, is for month t within sample period i. Definitions of the matrices and vectors are provided in the Decomposition Methods Chapter. This equation is applicable to both Form I and Form II of the model since only the size of the matrices and vectors change.

To test for stability, one calculates the eigen values of the matrix

8.1. $$B_i = A_i^{-1} G_i$$

for i=1,2 and for each form, Form I and Form II. One substitutes the estimated coefficients into the equation (8.1). If any eigen values are greater than one in absolute value, the system of equations is unstable.

The eigenvalues for the first period B for Form I were

(0, 0, -1.462, -86.976)

Therefore, the first period equations of Form I were an unstable system.

The eigenvalues for the second period Form I were

(0, 0, -1.462, 6.503)

This system of equations was also unstable.

For Form II of the model, the procedure was the same. The period one eigen values for Form II were

(0, 0, 0, 0, 0, -0.249, -1.104, -12.986)

Thus, this system of equations in the first period was unstable.

The period two eigen values for Form II were

(0, 0, 0, 0, 0, -0.259, -1.259, -17.586)

Therefore, the period two Form II system of equations was unstable.

The path of the values of the endogenous variables for each of the four systems above was divergent and did not converge to the vector M^*.

Even though the coefficients of the dynamic margin equations had the anticipated sign, none of the systems of equations could be used for further analysis. The decompositions of the dynamic margin equation systems could not be employed to investigate the source of the change in the margin levels observed in 1978. Likewise, the systems of equations could not be used to isolate the impact that demand coefficient structural change had on the margin level.

The world that generated the data used in this study was believed to be stable, so the conclusion was that the dynamic models were incorrect. Perhaps an alternative specification of the dynamics of the meat processing and retailing sector could have provided results that were consistent with observed behavior.

Only the dynamic margin equations were suspect. The dynamic and static demand equations and the static margin equations were still available to test the hypotheses of this study.

CHAPTER 9. MARGIN EQUATION DECOMPOSITIONS

Some margin equation coefficients changed between the two sample periods. Simply identifying coefficient changes does not in itself indicate the magnitude of the effect on the margin level, however. Coefficient and variable mean changes work together to explain margin level changes. The decomposition equations from the Decomposition Methods Chapter were used to isolate the effect of selected coefficient or variable mean changes on a particular margin change. These effects were calculated by substituting the estimated coefficients and variables' means into the decomposition equations.

Decompositions of the dynamic version of Forms I and II were not conducted since both dynamic forms were unstable (see Chapter 8). The decomposition results from the static version of Forms I and II are presented in this chapter. This chapter presents the impacts of margin coefficient changes, margin variables' mean' changes and the interaction of these coefficient and mean changes on the six margins: the farm-retail beef margin, the farm-retail pork margin, the wholesale-retail beef margin, the wholesale-retail pork margin, the farm-wholesale beef margin, and the farm-wholesale pork margin. The impacts that changes in demand coefficients and demand variable means had on the six margins are presented in the following two chapters.

The estimated coefficients for sample period i and the variables' means for calendar month m of sample period i were substituted into the reduced form of the static version of the model to yield

$$9.1. \quad \bar{M}_{im} = \hat{A}_i^{-1}(\hat{C}_i \bar{Z}_{im} + F\bar{P}_{im} + \bar{u}_{im})$$

which was similar to equation (5.2) from the Decomposition Methods Chapter. The $\bar{M}_{im}$ is the vector of endogenous variables' means. The $\bar{Z}_{im}$ is a vector of margin equation exogenous variables' means and $\bar{P}_{im}$ is a vector of nominal retail beef and pork price means. The $\bar{u}_{im}$ is the vector of residual means for calendar month m in sample period i. The other matrices are estimated coefficient matrices. For F, the elements are simply ones and zeros. For more detailed explanations of the reduced form, refer to the Decomposition Methods Chapter. This reduced form is equally applicable to either Form I or Form II since the only difference is the sizes of the vectors and matrices.

The total changes that occurred between the two sample periods for the margins, farm values, and wholesale values can be decomposed into three components: 1) the change due to margin coefficient changes, 2) the change due to margin variables' means changes, and 3) the change due to the interaction of coefficient and mean changes. Mathematically and in order, the three components of this decomposition are

$$9.2. \quad (\bar{M}^{*}_{2m} - \bar{M}_{1m}) = (\hat{A}_2^{-1}\hat{C}_2 - \hat{A}_1^{-1}\hat{C}_1)\bar{Z}_{1m} + (\hat{A}_2^{-1}F - \hat{A}_1^{-1}F)\bar{P}_{1m}$$

$$9.3. \quad (\bar{M}^{**}_{2m} - \bar{M}_{1m}) = \hat{A}_1^{-1}\hat{C}_1(\bar{Z}_{2m} - \bar{Z}_{1m}) + \hat{A}_1^{-1}F(\bar{P}_{2m} - \bar{P}_{1m})$$

$$9.4. \quad (\bar{M}^{***}_{2m} - \bar{M}_{1m}) = (\hat{A}_2^{-1}\hat{C}_2 - \hat{A}_1^{-1}\hat{C}_1)(\bar{Z}_{2m} - \bar{Z}_{1m}) + (\hat{A}_2^{-1}F - \hat{A}_1^{-1}F)(\bar{P}_{2m} - \bar{P}_{1m})$$

The decomposition is exact, and when $\bar{u}_{2m} = \bar{u}_{1m} = \underline{0}$, the sum of the three components above exactly equals the actual change in a particular margin between the two sample periods. Equations (9.2) and (9.3) are calculated directly. Equation (9.4) is calculated as the actual change in the monthly mean endogenous variables between the two periods less the sum of the two components, equations (9.2) and (9.3),

$$(\bar{M}^{***}_{2m} - \bar{M}_{1m}) = (\bar{M}_{2m} - \bar{M}_{1m}) - (\bar{M}^{*}_{2m} - \bar{M}_{1m}) - (\bar{M}^{**}_{2m} - \bar{M}_{1m})$$

Therefore, if either $\bar{u}_{2m}$ or $\bar{u}_{1m}$ does not equal zero, the interaction component, equation (9.4), includes some residual effects.

The first component, equation (9.2), can be interpreted as the predicted changes in mean margins if the only changes between the periods had been the set of coefficients in the margin equations. Therefore, equation (9.2) is the effects on mean margins due to structural change in the margin equations.

If there had been no coefficient changes in the margin equations between the two periods and only variables' means had changed, then equation (9.3) yields the change in the mean margins. Alternatively, if the only changes between the two periods had been the mean retail prices, then the second term on the right hand side of equation (9.3) yields the changes in the endogenous variables. Likewise, if the only changes between the two periods had been the means of the margin equation exogenous variables (holding mean retail prices constant), then the first term on the right hand side of equation (9.3) yields the changes in the endogenous variables.

When both margin coefficients and margin variable means are allowed to change between the two periods, the interaction, equation (9.4), is nonzero.

Farm-Retail Margin Decomposition

Some structural change was identified in Form I--the form of the model with farm and retail levels only. The structural change was identified in the farm-retail pork margin equation. Coefficients in the farm-retail beef margin equation were not statistically significantly different between the two sample periods. Equations (9.2) and (9.3) were calculated directly and equation (9.4) was calculated as a residual for each of the 12 calendar months. There was very little seasonal variation in the effects so the minimum and maximum values for the twelve months were chosen for each effect. These minimums and maximums are presented in Table 9.1. Both the first and the second terms on the right hand sides of equations (9.2) and (9.3) are presented in order to gain insights into the changes that have taken place in the endogenous variables.

The minimum and maximum total change in cents per pound in the monthly beef farm-retail margin were 42.53 and 48.62 and for the pork margin were 32.74 and 38.62. Simply summing, for example, the first column of numbers of Table 9.1 will not yield 42.53, however, since the minimum effects presented did not all occur in the same calendar month. The seasonal pattern of each of the effects differs. One may still, however, examine the relative magnitudes of the effects in order to gain an understanding of the changes that have taken place.

The changes in the means of the exogenous variables Z had by far the largest impacts on the two farm-retail margins. For both margins, the only exogenous Z variable mean that changed was the cost index CI1.

Table 9.1. Effects of changes in margin coefficients and variables' means upon mean farm-retail margins for beef and pork

Source	Effect on FRMB Minimum	Effect on FRMB Maximum	Effect on FRMP Minimum	Effect on FRMP Maximum
	(cents per pound)			
Margin coefficients				
$(\hat{A}_2^{-1}\hat{C}_2 - \hat{A}_1^{-1}\hat{C}_1)\bar{Z}_{1m}$	1.52	1.86	5.63	6.89
$(\hat{A}_2^{-1}F - \hat{A}_1^{-1}F)\bar{P}_{im}$	0.45	0.48	1.67	1.77
Margin variables' means				
$\hat{A}_1^{-1}\hat{C}_1(\bar{Z}_{2m} - \bar{Z}_{1m})$	43.41	44.87	41.61	43.02
$\hat{A}_1^{-1}F(\bar{P}_{2m} - \bar{P}_{1m})$	2.65	2.84	0.17	0.19
Total interaction[a]	-7.15	0.45	-16.62	-11.14
All sources	42.53	48.62	32.74	38.62

[a]Includes effects of nonzero residual.

This indicated that cost mean changes accounted for a majority of the mean margin level changes observed between the two sample periods.

The other effects listed in Table 9.1 were quite small relative to the effect of the change in the cost index mean. The change in the mean of the retail prices (the fourth line) had a small impact on the changes in the beef and pork margin mean. If the only change between the two sample periods had been the mean of the retail prices, then the beef margin mean would have been between 2.65 and 2.84 cents per pound higher. The pork margin mean would have been less than one cent per pound higher. The reason these two effects differed so greatly was that there was no markup pricing identified in the pork margin equation. In other words, the farm value of pork was not in the pork margin equation. The beef margin equation did have a markup, however, and so retail price changes did affect the beef margin level. The reason the pork margin mean changed at all was due to the presence of the interdependent margin variable in the pork margin equation. Therefore, retail beef prices affected the mean of the beef farm-retail margin which in turn affected the pork farm-retail margin. This interdependent margin coefficient in the pork margin equation was very small, however.

The margin coefficient changes affected the pork margin mean relatively more than the beef margin mean. If the only change between the two sample periods had been the margin coefficient changes that actually took place, the beef margin would have increased by between 1.97 (=1.52 + 0.45) and 2.34 (=1.86 + 0.48) cents per pound while the pork margin would have increased by between 7.30 (=5.63 + 1.67) and 8.66 (=6.89 + 1.77) cents per pound. The difference in the impacts between the two margins was not suprising since no structural change was identified in the beef farm-retail margin. Again, the only reason the beef margin mean changed at all was due to the presence of the pork margin variable in the beef margin equation. Therefore, structural change in the pork margin equation affected the pork margin mean which in turn affected the beef margin mean.

It is difficult to conclude from Table 9.1 that structural change in the meat processing and retailing sector had a large impact on the change in the beef farm-retail margin between the two sample periods. Variable mean changes accounted for a great majority of the observed change in the beef margin in the late 1970s. Structural change in the meat processing and retailing sector affected the pork farm-retail margin much more. However, the majority of the change observed in the pork margin was also accounted for by the change in the costs between the two sample periods.

The effects on the farm value of beef and pork are not presented but can be calculated from results that are presented in this chapter. The effects of changes in the coefficients of the margin equations (lines one and two of Table 9.1) and the effects of changes in the means of the exogenous variables in the margin equations on the farm value of beef (pork) (line three) are simply the negative of the effects on the farm-retail beef (pork) margin. This is the case since retail beef (pork) price was held constant for each of these effects.

The effect on the farm value of beef from the change in the mean of the retail beef price is calculated as

9.5. $\Delta FVB = \Delta PB - \Delta FRMB$

The total change in the mean retail price of beef between the two sample periods (ΔPB) is 103.18 cents per pound. The $\Delta FRMB$ here is the effect on the farm-retail beef margin from the change in retail beef price (line four in Table 9.1). The simple equation above is also used to calculate the effect on the farm beef value from the total interaction effect (line five) and from all sources (line six). The method is used to calculate the change in the farm value of pork. The total change in the mean retail price of pork between the two sample periods (ΔPP) is 56.58 cents per pound.

Wholesale-Retail and Farm-Wholesale Margin Decomposition

Very little structural change was identified in Form II of the model. The only margin equation where structural change was identified in this form was the farm-wholesale pork margin equation. The same decomposition equations used for Form I were applicable here. Only the size of the matrices and vectors differed.

The decompositions of the two wholesale-retail margin equations are presented in Table 9.2. Again, there was very little seasonal variation in the effects so only the minimum and maximum values for the 12 calendar months are presented for each effect. Also, as before, the various effects did not all have the same seasonal variation and, therefore, the columns of Table 9.2 do not sum exactly to the total change in the mean of the particular margin.

For comparison sake, the change in the monthly wholesale-retail beef margin mean ranged from 40.52 to 45.15 cents per pound and the change in the monthly wholesale-retail pork margin mean ranged from 27.11 to 31.37 cents per pound. Clearly, the overwhelming source of the change in the margin means was the change in the means of the exogenous variables. The mean of only one exogenous variable in the margin equations changed between the two sample periods and that was the cost index CI3.

Table 9.2. Effects of changes in margin coefficients and variables' means upon mean wholesale-retail margins for beef and pork

	Effect on WRMB		Effect on WRMP	
Source	Minimum	Maximum	Minimum	Maximum
	(cents per pound)			
Margin coefficients				
$(\hat{A}_2^{-1}\hat{C}_2 - \hat{A}_1^{-1}\hat{C}_1)\bar{Z}_{1m}$	0.04	0.05	0.01	0.01
$(\hat{A}_2^{-1}F - \hat{A}_1^{-1}F)\bar{P}_{1m}$	0.00	0.00	0.00	0.00
Margin variables' means				
$\hat{A}_1^{-1}\hat{C}_1(\bar{Z}_{2m} - \bar{Z}_{1m})$	36.82	38.44	25.95	27.09
$\hat{A}_1^{-1}F(\bar{P}_{2m} - \bar{P}_{1m})$	1.76	1.89	0.50	0.54
Total interaction[a]	0.44	6.30	0.55	4.53
All sources	40.52	45.15	27.11	31.37

[a]Includes effects of nonzero residual.

The change in the mean of the retail prices had a relatively small impact on the two wholesale-retail margins. A similar situation existed with the two wholesale-retail margins that existed with the farm-retail margins. The beef wholesale-retail margin had both a markup (the wholesale value of beef) and an interdependent margin variable (the wholesale-retail pork margin) whereas the pork wholesale-retail margin had only an interdependent margin variable (the wholesale-retail beef margin). Therefore, the change in the means of retail prices affected the wholesale-retail beef margin, which in turn affected the wholesale-retail pork margin. This explains why retail price changes affected the beef margin more than the pork margin.

The structural change in the Form II model had a negligible effect on the two wholesale-retail margins. The structural change in the farm-wholesale pork margin equation affected the farm-wholesale beef margin equation via the interdependent margin variable in the farm-wholesale beef margin. The effect then rippled through to the wholesale-retail beef margin via the markup variable in the wholesale-retail beef margin. Finally the effect reached the wholesale-retail pork margin via the interdependent margin variable in the wholesale-retail pork margin. The structural change effect became quite diluted as it worked its way to the wholesale-retail level. It appears that the structural change in the farm-wholesale pork margin had only a negligible effect on the wholesale-retail margins.

Decompositions for the farm-wholesale margin equations are presented in Table 9.3. The difference in the period two and period one means for the farm-wholesale beef margin ranged from 1.83 to 3.54 cents per pound and this difference for the farm-wholesale pork margin ranged from 5.41 to 7.00 cents per pound.

More than just the mean change in the cost index variable CI2 affected the two farm-wholesale margins. Since both of these margin equations had both a markup variable and an interdependent margin variable, the means of the cost index variables CI2 and CI3, and the farm byproduct variable (FBPA) all affect the farm-wholesale margins.

Table 9.3. Effects of changes in margin coefficients and variables' means upon mean farm-wholesale margins for beef and pork

Source	Effect on FWMB		Effect on FWMP	
	Minimum	Maximum	Minimum	Maximum
	(cents per pound)			
Margin coefficients				
$(\hat{A}_2^{-1}\hat{C}_2 - \hat{A}_1^{-1}\hat{C}_1)\bar{Z}_{1m}$	1.52	1.72	8.76	9.95
$(\hat{A}_2^{-1}F - \hat{A}_1^{-1}F)\bar{P}_{1m}$	-1.35	-1.19	-7.80	-6.85
Margin variables' means				
$\hat{A}_1^{-1}\hat{C}_1(\bar{Z}_{2m} - \bar{Z}_{1m})$				
CI2	1.91	1.98	11.03	11.41
CI3	-2.04	-1.96	-3.37	-3.23
FBPA	-1.05	-0.90	-0.29	-0.25
$\hat{A}_1^{-1}F(\bar{P}_{2m} - \bar{P}_{1m})$	4.93	5.23	6.67	7.53
Total interaction[a]	-2.74	-0.54	-11.75	-8.70
All sources	1.83	3.54	5.41	7.52

[a] Includes effect of nonzero residual.

The wholesale-retail level cost index CI3 entered via the markup. Several of the exogenous variable means were relatively large in absolute value. The cost index CI2 had a sizable impact on the farm-wholesale pork margin and the farm-wholesale beef margin relative to their respective total changes. The cost index CI3 also had a relatively large depressing effect on both margins; this was the effect holding all coefficients and other means (including retail prices) constant.

The change in the mean of the retail prices had a relatively large effect on the two farm-wholesale margins. These effects were greater in both absolute and relative terms than were the retail price effects on the two wholesale-retail margins. The reason for this was that both farm-wholesale margin equations had large (both statistically and relatively) coefficients on the farm value. The wholesale-retail pork margin did not have a wholesale value variable and the coefficient of the wholesale beef value variable in the wholesale-retail beef margin equation was small (both statistically and relatively). The farm-wholesale margins were much more responsive to retail price changes than were the wholesale-retail margins. This result seems counter intuitive and may be the result of poor coefficient estimates. Poor coefficient estimates may be the result of multicollinearity in the data. It may also be that retailers have a more complicated pricing rule than the simple markup that is hypothesized in this study.

The structural change in the farm-wholesale pork margin had its largest effect on that margin, as was expected. The effect of the coefficient change (lines one and two of Table 9.3) was offsetting to a large extent. The net effect of the coefficient changes was positive but small.

The interaction between coefficient and variable mean changes was quite large in absolute value relative to the total change in the means of the farm-wholesale values. This was, for the most part, expected since, all the structural change in Form II took place at the farm-wholesale level.

The effects on the wholesale and farm values of beef and pork are not presented but can be calculated from results that are presented in this chapter. The effects of changes in the coefficients of the margin equations (lines one and two of Table 9.2) and the effects of changes in the means of the exogenous variables in the margin equations on the wholesale value of beef (pork) (line three of Table 9.2) are simply the negative of these effects on the wholesale-retail beef (pork) margin. The effect on the farm values of beef and pork from these changes can be calculated as

$$\Delta FVB = -(\Delta WRMB + \Delta FWMB)$$

$$\Delta FVP = -(\Delta WRMP + \Delta FWMP)$$

The ΔWRMB and ΔFWMB are the effects due to the particular change and are found in Table 9.2 and Table 9.3, respectively.

The effect on the wholesale beef value from a change in the mean of the retail beef price is calculated as

$$\Delta WVB = \Delta PB - \Delta WRMB$$

which is analogous to equation (9.5). The effect on the wholesale pork value from a change in the mean of the retail beef price is simply the negative of this effect on the wholesale-retail pork margin (since retail pork price is held constant). The ΔPB is the same as presented previously, 103.18 cents per pound. The effect on the farm beef and pork values from a change in the mean of the retail beef price are calculated as

$$\Delta FVB = \Delta WVB - \Delta FWMB$$

$$\Delta FVP = \Delta WVP - \Delta FWMP$$

This method of calculation is also used for the effects of the total interaction on the wholesale and farm values of beef and pork where the retail pork price is held constant.

The method of calculation changes little for pork price changes. Changes in the retail pork price affect neither the wholesale-retail pork margin nor the wholesale-retail beef margin. Therefore, the effect on the wholesale pork value from the change in the retail pork price equals the change in the retail pork price, or

$$\Delta WVP = \Delta PP - \Delta WRMP = \Delta PP$$

Also,

$$\Delta WVB = - \Delta WRMB = \emptyset$$

The total change in the mean of retail pork price between the two sample periods was 56.58 cents per pound. The changes in the farm values of pork and beef from the change in retail pork price are simply

$$\Delta FVP = \Delta WVP - \Delta FWMP$$

$$\Delta FVB = - \Delta FWMB$$

Summary

Some structural change had been identified in the margin equations in both forms of the model. This study was unable to show that structural change in the margin equations was responsible for a majority of the change in the means of the six margins. For five of the six margins, the source of the largest change between the sample periods had been the mean of the cost index. Retail price mean changes played a much smaller role in margin changes. The exception was the farm-wholesale beef margin where changes in the cost index mean played a smaller role (in absolute value) than changes in the retail price mean. The farm-wholesale margin was quite small relative to the farm-retail margin and so this retail price effect did not go far in explaining the changes in the margin level that occurred in the late 1970s.

CHAPTER 10. DEMAND EFFECTS ON FARM-RETAIL MARGINS

This chapter presents results of further decomposition of material presented in Chapter 9. This chapter decomposes the effects of changes in retail price means on the farm-retail margins into demand coefficient, demand variables' means, and demand coefficient/variable mean interaction effects. These results identify to what extent structural changes in the two demand equations contributed to the changes observed in the farm-retail margins in the late 1970s. One of the three major hypotheses of this study is that structural change in the demand equations resulted in higher margins via the Holdren demand effect.

Equation (5.4) from the Decomposition Methods Chapter is used to decompose the changes in mean retail prices into the components. Since the complete model of this study is block recursive in retail prices, retail prices affect margins but not vice versa. Therefore, the retail price decomposition can simply be substituted into the right hand side of equation (9.3) to generate the effects of changes in demand coefficient and variable means on margins. The total change in margin means due to the change in mean retail prices can be decomposed by substituting equation (5.4) into the second term on the right hand side of equation (9.3) and setting $\bar{Z}_{2m} = \bar{Z}_{1m}$. Mathematically,

10.1. $$(\bar{M}^{**}_{2m} - \bar{M}_{1m}) = \hat{A}_1^{-1}F(\hat{B}_2 - \hat{B}_1)\overline{\pi Q}_{1m} + \hat{A}_1^{-1}F\hat{B}_1(\overline{\pi Q}_{2m} - \overline{\pi Q}_{1m}) + \hat{A}_1^{-1}F(\hat{B}_2 - \hat{B}_1)(\overline{\pi Q}_{2m} - \overline{\pi Q}_{1m})$$

The first term on the right hand side is the change in mean margins given that only the set of demand slope coefficients has changed between the two periods. The second term is the change in mean margins given that only the set of means of demand variables has changed between the two periods. The third term is then the change in mean margins due to the interaction of the demand coefficients and demand variables' means changes. The first two terms can be broken down further to yield the effects of individual coefficient or variable mean changes.

The effects on farm values are not presented but are easily calculated. The effect on the farm value of either beef or pork from a change in a coefficient is simply the effect of the change in the coefficient on retail price less the effect of the change in the coefficient on the farm-retail margin (both of which are presented in the tables in this chapter). The same procedure can be used to find the effect on the farm values from changes in variable means and the interaction term.

Static Demand Effects

Structural change was identified in the static pork demand equation but not in the static beef demand equation (see the Estimated Demand Equations Chapter). Furthermore, since the farm-retail pork margin equation did not have a markup variable, only changes in the beef price affect the two farm-retail margins. Even though there was structural change in the pork demand equation, it produced no effects on the two margins. Therefore, only changes in the means of variables in the static beef demand affected the two farm-retail margins. There were no

Holdren demand coefficient effects on the farm-retail margins then.

Table 10.1 presents the effects of changes in variables' means on the retail price of beef and the farm-retail margins for beef and pork. The seasonal variation in the various effects was small so only the minimum and maximum for the 12 calendar months for each effect are presented.

The first row in Table 10.1 indicates the change in each margin due solely to the change in retail price means. Since the pork retail price did not effect either margin, the first row is the effect of the change in the retail beef price mean on the margins. These four numbers are the same values that are presented in Table 9.1 of the last chapter. The total change in the retail beef price mean between the two periods was 103.18 cents per pound.

For the static beef demand equation, only variable means differed between the two periods--coefficients did not. Therefore, any discrepancy between the sum of the effects of variables' means on the mean of the retail beef price and the actual change in the mean of the retail beef price was due to a nonzero mean of the regression residual. This nonzero residual mean is included in Table 10.1.

The variable mean change that had the largest effect on the retail beef price mean was the intercept. The intercept in the reduced form became one multiplied by the CPI (1967=1.00). The mean of the CPI changed between the two sample periods and this increased the nominal retail beef price. The effect of the change in the intercept mean can be thought of as an inflation impact. The next largest mean effect came

Table 10.1. Effects of changes in mean retail prices and of variables' means in the static beef demand equation upon retail beef price and farm-retail margins

Source	Effect on PB		Effect on FRMB		Effect on FRMP	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(cents per pound)			
Retail beef price			2.65	2.84	0.17	0.19
Means						
Intercept	87.36	92.79	2.32	2.47	0.15	0.16
QB	-7.21	-5.85	-0.19	-0.16	-0.01	-0.01
QP	1.99	2.62	0.05	0.07	0.00	0.00
RY	26.18	27.85	0.70	0.74	0.05	0.05
PR73	-0.55	0	0.01	0	-0.00	0
Seasonal dummies	-1.72	2.97	-0.05	0.08	-0.00	0.01
Residual	-12.18	-7.18	-0.32	-0.19	-0.02	-0.01

from the change in the income mean, which was also positive.

These two effects of changes in variable means were multiplied by constants to yield their impact on the two farm-retail margins. These constants were elements in the matrix $\hat{A}_1^{-1}F$ (see equation (10.1)). The change in the intercept mean was about 88 percent of the total effect of the change in retail price means on the two farm-retail margins. The other mean effects netted out to be only about 12 percent of the total effect of the change in retail price mean.

The changes in the own and cross-quantity means had a smaller impact on the change in the retail beef price mean than the intercept or income effect. The increase in the mean percapita beef quantity decreased the retail beef price. The increase in the mean per capita pork quantity offsets only part of the negative effect of the change in the own-quantity mean. The effect of these two variable mean changes on the two farm-retail margins was quite small.

Dynamic Demand Effects

Structural change was identified in both dynamic demand equations. The only structural change in the dynamic beef demand however was in the income coefficients and the intercept coefficients. Again, changes in the retail pork price mean did not affect either farm-retail margin. Therefore, the only Holdren demand impacts on the farm-retail margins with the dynamic demands were from income coefficients of the beef demand equation.

Table 10.2 presents the effects of changes in the coefficients of the dynamic beef demand, of changes in variables' means, and of the interactions on the retail beef price and the farm-retail margins. The first row of Table 10.2 is identical to the first row of Table 10.1. The first two columns present the minimum and maximum coefficient, mean, and interaction effects on the change in the mean of retail beef price. The effects on retail price were multiplied by constants to yield the effects on the two farm-retail margins. The constants were elements in the $\hat{A}_1^{-1}F$ matrix of equation (10.1). Since the effects in a given column are not necessarily from the same calendar month, the sum of the effects

Table 10.2. Effects of changes in mean retail prices and of coefficient, variables' means, and interaction in the dynamic beef demand equation upon retail beef price and farm-retail margins

	Effect on PB		Effect on FRMB		Effect on FRMP	
Source	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(cents per pound)			
Retail beef price			2.65	2.84	0.17	0.19
Coefficients						
Intercept	-1729.1	-1631.6	-45.94	-43.35	-2.99	-2.82
RY & RYS	1614.18	1713.01	42.88	45.51	2.79	2.96
Means						
Intercept	77.90	82.74	2.07	2.20	0.13	0.14
QB	-9.13	-7.40	-0.24	-0.20	-0.02	-0.01
LQB	-4.47	-3.61	-0.12	-0.10	-0.01	-0.01
RY & RYS	48.34	51.42	1.28	1.37	0.08	0.09
PR73	-0.54	0	-0.01	0	-0.00	0
Seasonal dummies	-1.44	2.90	-0.04	0.08	-0.00	0.01
Total interaction[a]	-7.07	3.64	-0.19	0.10	-0.01	0.01

[a]Includes effect of nonzero residual.

does not equal the total change in the mean. Summing the average of the minimum and maximum for each effect can give the approximate size of the change in the sample period mean.

Only three dynamic beef demand coefficients were found to have changed between the two sample periods: the intercept coefficient, the real income coefficient, and the squared-real-income coefficient. The changes in the two income coefficients were grouped to provide an income specification effect. The effects of the changes in the intercept coefficient and the change in the income specification were both very large but were largely offsetting. The net of the intercept coefficient and income specification changes on the two farm-retail margins was small relative to the mean effects.

The two largest mean effects were again the intercept mean (CPI) and the income mean changes. The net effect of these two mean changes was somewhat larger than the net effect of the same two mean changes for the static beef demand. The reason for the difference was that the first period coefficients differed between the static and the dynamic demand. Just as with the static beef demand, the change in the intercept mean accounted for a large portion of the effect of the mean retail price change on the two farm-retail margins. The income mean effect was also relatively large.

The changes in the own-quantity and the lagged own-quantity means had a depressing effect on the retail beef price mean since both coefficients were negative. These mean changes had a relatively small impact on the two farm-retail margins.

Overall, the effects of variable mean changes from dynamic beef demand on the retail beef price and farm-retail margins were slightly larger in absolute value than these effects from the static beef demand. One exception was the effect of the change in the intercept mean. The two demands accounted for the variable mean effects in much the same way.

CHAPTER 11. DEMAND EFFECTS ON WHOLESALE-RETAIL AND FARM-WHOLESALE MARGINS

This chapter decomposes the total change in mean retail prices and identifies their effects on the four margins of Form II: the wholesale-retail beef margin, the wholesale-retail pork margin, the farm-wholesale beef margin, and the farm-wholesale pork margin. Structural change was identified in the dynamic beef demand equation and in both the static and the dynamic pork demand equations. However, since certain variables did not enter some margin equations, not all changes in margin means were affected by changes in the mean retail pork price.

Specifically, the wholesale-retail pork margin equation did not include the wholesale pork value. This implied that the wholesale-retail pork margin was unaffected by changes in retail pork price. Changes in retail pork price then also did not affect the wholesale-retail beef margin. Changes in the retail beef price affected the wholesale-retail beef margin via the wholesale beef value and affected the wholesale-retail pork margin via the interdependent margin variable (wholesale-retail beef margin).

Changes in both the beef and the pork retail prices affected the two farm-wholesale margins. Both farm-wholesale margins had a markup and an interdependent margin variable.

The effects on farm and wholesale values are not presented but are easily calculated. The effect on the wholesale value of either beef or pork from a change in a coefficient is simply the effect of the change in the coefficient on retail price less the effect of the change in the coefficient on the wholesale-retail margin (both of which are presented in the appropriate tables that follow in this chapter). The effect on the farm value of either beef or pork from a change in a coefficient is the effect of the change in the coefficient on the wholesale value less the effect of the change in the coefficient on the farm-wholesale margin. This same procedure can be used to find the effect of the farm values from changes in variable means and the interaction term.

Demand Effects on Wholesale-Retail Margins

Table 11.1 presents the static beef demand decompositions and their effects on the two wholesale-retail margins. The first row is the change in the mean of the wholesale-retail margin due to the total change in the retail beef price mean. These four numbers were taken from Table 9.2. The minimum and maximum effects of the 12 calendar months for the change in each variable mean on the mean of the retail beef price are repeated here from Table 10.1. These beef demand effects imply changes in the two wholesale-retail margins through $\hat{A}_1^{-1}F$ of equation (10.1).

Since the demand decompositions are the same as those in Table 10.1, the relative sizes of effects of changes in the margin means are the same. The difference between the effects on the farm-retail margins and the effects on wholesale-retail margins is the constants by which the demand decompositions are multiplied.

The intercept (CPI) and the income mean changes accounted for the great

Table 11.1. Effects of changes in mean retail prices and of variables' means in the static beef demand equation upon retail beef price and wholesale-retail margins

	Effect on PB		Effect on WRMB		Effect on WRMP	
Source	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(cents per pound)			
Retail beef price			1.76	1.89	0.50	0.54
Means						
Intercept	87.36	92.79	1.54	1.64	0.44	0.47
QB	-7.21	-5.85	-0.13	-0.10	-0.04	-0.03
QP	1.99	2.62	0.04	0.05	0.01	0.01
RY	26.18	27.85	0.46	0.49	0.13	0.14
PR73	-0.55	0	-0.01	0	-0.00	0
Seasonal dummies	-1.72	2.97	-0.03	0.05	-0.01	0.02
Residual	-12.18	-7.18	-0.22	-0.13	-0.06	-0.04

majority of the retail price effects on the two wholesale-retail margins. The other mean change effects were relatively small.

The Holdren demand effect hypothesis of this study could not be tested here since no structural change was identified in the static beef demand equation.

Structural change was identified in the dynamic beef demand equation, but neither the current nor the lagged beef quantity coefficients changed. Thus, the Holdren demand impact here consisted of changes in the income coefficients. Results of the decomposition of the dynamic beef demand equation are repeated in Table 11.2 from Table 10.2. The these coefficient and variable mean changes and the interaction had on the two wholesale-retail margins are presented in Table 11.2. Again the demand effects were the same; just the constants by which the demand effects were multiplied differed.

The change in the intercept coefficient had a large negative impact on the two wholesale-retail margins but the changes in the set of income coefficients had a positive and nearly offsetting effect on the two margins. The net effect of these coefficient changes was smaller in absolute value than the effect of either the intercept mean or income mean change. The change in the intercept mean accounted for about 78 percent of the total change in the mean of the wholesale-retail margins due to the change in the retail price means.

The change in the current and lagged beef quantity means had a relatively small and depressing effect on the two wholesale-retail margins. The changes in the means of the seasonal dummy variables and the price restriction variable (PR73) had a very small impact on the change in the wholesale-retail margin mean.

There was little difference in the conclusions reached with the static and the dynamic beef demands. Both demands provided essentially the same information on the sources of the changes in the wholesale-retail margin means. The effect of the structural change in the dynamic beef demand equation upon the wholesale-retail margins was quite small.

Table 11.2. Effects of changes in mean retail prices and of coefficients, variables' means, and interaction in the dynamic beef demand equation upon retail beef price and wholesale-retail margins

Source	Effect on PB		Effect on WRMB		Effect on WRMP	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(cents per pound)			
Retail beef price			1.76	1.89	Ø.5Ø	Ø.54
Coefficients						
Intercept	-1729.1	-1631.6	-3Ø.55	-28.83	-8.74	-8.24
RY & RYS	1614.18	1713.Ø1	28.52	3Ø.26	8.16	8.66
Means						
Intercept	77.9Ø	82.74	1.38	1.46	Ø.39	Ø.42
QB	-9.13	-7.4Ø	-Ø.16	-Ø.13	-Ø.Ø5	-Ø.Ø4
LQB	-4.47	-3.61	-Ø.Ø8	-Ø.Ø6	-Ø.Ø2	-Ø.Ø2
RY & RYS	48.34	51.42	Ø.85	Ø.91	Ø.24	Ø.26
PR73	-Ø.54	Ø	-Ø.Ø1	Ø	-Ø.ØØ	Ø
Seasonal dummies	-1.44	2.9Ø	-Ø.Ø3	Ø.Ø5	-Ø.Ø1	Ø.Ø1
Total interaction[a]	-7.Ø7	3.64	-Ø.12	Ø.Ø6	-Ø.Ø4	Ø.Ø2

[a]Includes effect of nonzero residual.

Demand Effects on Farm-Wholesale Margins

Retail price changes affect both the beef and the pork farm-wholesale margins since both margin equations contain a markup as well as an interdependent margin variable. The effects on the two farm-wholesale margins from the various components of the static and dynamic beef demand decompositions are presented first. Then the effects from the static and dynamic pork demand decompositions are presented.

Table 11.3 presents the decomposition of the static beef demand equation and the effects of the changes in the various coefficients and variables' means on the two farm-wholesale margins. The effects of the various coefficient and variable mean changes on the retail beef price mean change are repeated from Table 11.1.

The effect on the two farm-wholesale margins from the change in both retail price means (line one of Table 11.3) is repeated from Table 9.3. These numbers are substantially higher than the ones presented in line one of Table 11.1. The farm-wholesale margins are more responsive to retail price changes than are the wholesale-retail margins. The reason is that the farm-wholesale margin equations contain both a markup and an interdependent margin variable whereas the wholesale-retail margin equations do not contain all of these variables.

Since the decomposition of the change in the retail price means is the same as that of Table 11.1, the relative sizes of the effects on the two farm-wholesale margins are the same as in that table. Only the constant by which the effects are multiplied differs. The constants are elements of $\hat{A}_1^{-1}F$ from equation 10.1.

The change in the intercept (CPI) mean accounted for about 70 percent of the change in the farm-wholesale beef margin mean due to the change in the retail price means. The changes in the intercept mean accounted for only about 13 percent of the change in the farm-wholesale

Table 11.3. Effects of changes in mean retail prices and of variables' means in the static beef demand equation upon retail beef price and farm-wholesale margins

	Effect on PB		Effect on FWMB		Effect on FWMP	
Source	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(cents per pound)			
Retail prices			4.93	5.23	6.67	7.53
Means						
Intercept	87.36	92.79	3.41	3.62	0.91	0.97
QB	-7.21	-5.85	-0.28	-0.23	-0.08	-0.06
QP	1.99	2.62	0.08	0.10	0.02	0.03
RY	26.18	27.85	1.02	1.09	0.27	0.29
PR73	-0.55	0	-0.02	0	-0.01	0
Seasonal dummies	-1.72	2.97	-0.07	0.12	-0.02	0.03
Residual	-12.18	-7.18	-0.48	-0.28	-0.13	-0.07

pork margin mean due to the change in retail price means. The change in the income mean accounted for one fifth of the change in the beef farm-wholesale margin but a small fraction of the change in the pork margin at this level.

Table 11.4 presents the decompositions of the dynamic beef demand and the effects of the coefficient and variable mean changes on the two farm-wholesale margins.

The changes in the intercept coefficient and the set of income coefficients had, individually, a sizable impact on the two farm-

Table 11.4. Effects of changes in mean retail prices and of coefficients, variables' means, and interaction in the dynamic beef demand equation upon retail beef price and farm-wholesale margins

	Effect on PB		Effect on FWMB		Effect on FWMP	
Source	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(in cents per pound)			
Retail prices			4.93	5.23	6.67	7.53
Coefficients						
Intercept	-1729.1	-1631.6	-67.51	-63.70	-18.02	-17.00
RY & RYS	1614.18	1713.01	63.02	66.88	16.82	17.85
Means						
Intercept	77.90	82.74	3.04	3.23	0.81	0.86
QB	-9.13	-7.40	-0.36	-0.29	-0.10	-0.08
LQB	-4.47	-3.61	-0.17	-0.14	-0.05	-0.04
RY & RYS	48.34	51.42	1.89	2.01	0.50	0.54
PR73	-0.54	0	-0.02	0	-0.01	0
Seasonal dummies	-1.44	2.90	-0.06	0.11	-0.02	0.03
Total interaction[a]	-7.07	3.64	-0.28	0.14	-0.07	0.04

[a]Incudes effect of nonzero residual.

wholesale margins. However, as a group, the effects of the coefficient changes were almost completely offsetting.

The change in the intercept (CPI) mean again accounted for the majority (about 61 percent) of the change in the farm-wholesale beef margin mean due to the change in the retail price means. The changes in the income mean also contributed to this mean effect. Just as discussed for Table 11.3, however, the percent that the change in the intercept mean was of the change in the farm-wholesale pork margin mean due to the change in the retail price means was much smaller than for the beef margin. This was also true for the effect of the change in the income mean on the change in the pork farm-wholesale margin mean.

The change in the retail pork price mean also affected the two farm-wholesale margins. Structural change was identified in both the static and the dynamic pork demand equations. The structural change included the coefficients on the current and lagged pork and beef quantities. Therefore, the Holdren demand impacts on the farm-wholesale margins could be isolated.

Table 11.5 presents the static pork demand decompositions and their effects on the change in the retail pork price mean and the changes in the mean of the two farm-wholesale margins. The first row in the table is repeated here from Table 9.3.

Each of the changes in the static pork demand coefficients had a relatively large impact on the change in the retail pork price mean. The total change in the retail pork price mean between the two sample periods was 56.58 cents per pound. The changes in the intercept coefficient and the set of income coefficients were both quite large in absolute value but were also largely offsetting. The change in the pork quantity coefficient had a positive effect on the retail price of pork. The changes in the beef quantity coefficient had a negative effect on

Table 11.5. Effects of changes in mean retail prices and of coefficients, variables' means, and interaction in the static pork demand equation upon retail pork price and farm-wholesale margins

	Effect on PP		Effect on FWMB		Effect on FWMP	
Source	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(cents per pound)			
Retail prices			4.93	5.23	6.67	7.53
Coefficients						
Intercept	-46.17	-43.57	-0.87	-0.82	-5.01	-4.73
QP	8.08	9.63	0.15	0.18	0.88	1.04
QB	-10.15	-8.49	-0.19	-0.16	-1.10	-0.92
RY	32.24	34.84	0.61	0.66	3.50	3.78
Means						
Intercept	51.69	54.90	0.97	1.03	5.61	5.96
QP	-17.37	-13.21	-0.33	-0.25	-1.88	-1.43
QB	8.91	10.99	0.17	0.21	0.97	1.13
RY	33.77	35.92	0.64	0.68	3.66	3.90
PR73	-0.58	0	-0.01	0	-0.06	0
Seasonal dummies	-2.09	0.71	-0.04	0.01	-0.23	0.08
Total interaction[a]	-16.25	-11.98	-0.31	-0.23	-1.76	-1.30

[a]Includes a nonzero residual effect.

the retail pork price and more than offset the effect of the change in the pork quantity coefficient. These two quantity coefficient effects on the farm-wholesale margins were relatively large but were mostly offsetting. This lent only partial support for the Holdren demand hypothesis in this study. In other words, these coefficient changes influenced the margins but this influence did not explain the increase in the margin levels in the late 1970s.

The net effect of the coefficient changes on the retail pork price mean is about -11.80 cents per pound. If the only change between the two sample periods were in the pork demand coefficients, the retail pork price would have been about 12 cents per pound less in the second period than in the first period. The effect of these changes in the pork demand coefficients on the two farm-wholesale margins was also negative. The effects of the pork demand coefficients had a relatively small impact on the farm-wholesale beef margin and a relatively large impact on the farm-wholesale pork margin. This was not suprising since wholesalers were expected to change a margin more in response to retail price (and thus farm value) changes for that same meat.

The changes in the means of the pork demand variables as a group had a large positive influence on the retail pork price mean and therefore the farm-wholesale margin means as well. The change in the intercept (CPI) mean and the income mean were both large and positive. Only the change in the income mean and the change in the income coefficient affect retail pork price mean in the same direction. The effect of the change in the pork quantity mean was negative and larger in absolute value than the effect of the change in the pork quantity coefficient on retail pork price and the two margins. The opposite was true for the effect of the change in the beef quantitiy mean and the effect of the change in the beef quantity coefficient, but the effects were much closer in absolute value.

Table 11.6 presents the decomposition of the dynamic pork demand equation and the effects on the retail pork price mean and the two farm-wholesale margin means. Structural change was identified in the dynamic pork demand equation so the Holdren demand hypothesis could be investigated here also.

The change in the intercept coefficient and the set of income coefficients of the dynamic pork demand equation had large impacts, in absolute value, on the changes in the pork retail price mean. The net effect of the changes in the intercept coefficient and the two income coefficients (about -30.0 cents per pound) was fairly sizable also though. This was larger than the net effect of the change in the intercept coefficient and the the set of income coefficients in the dynamic beef demand equation on the beef retail price.

The changes in the current and the lagged quantity coefficients had a relatively large impact on the retail pork price. The two current quantity coefficient effects were larger in absolute value than the effect of the two current quantity coefficients in the static pork demand. However, the effects of the changes in the two lagged quantity coefficients on the retail pork price were also large in absolute value.

Table 11.6. Effects of changes in mean retail prices and of coefficients, variables' means, and interaction in the dynamic pork demand equation upon retail pork price and farm-wholesale margins

	Effect on PP		Effect on FWMB		Effect on FWMP	
Source	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
			(cents per pound)			
Retail prices			4.93	5.23	6.67	7.53
Coefficients						
Intercept	-1886.5	-1780.1	-35.50	-33.50	-204.67	-193.13
QP	16.00	19.06	0.30	0.36	1.74	2.07
QB	-19.27	-16.13	-0.36	-0.30	-2.09	-1.75
LQP	13.04	15.41	0.25	0.29	1.42	1.67
LQB	-9.58	-8.02	-0.18	-0.15	-1.04	-0.87
RY & RYS	1749.18	1857.99	32.92	34.97	189.78	201.58

Means

Intercept	71.84	76.31	1.35	1.44	7.79	8.28
QP	-35.76	-27.20	-0.67	-0.51	-3.88	-2.95
QB	17.49	21.57	0.33	0.41	1.90	2.34
LQP	-35.51	-24.03	-0.59	-0.45	-3.42	-2.61
LQB	12.90	15.96	0.24	0.30	1.40	1.73
RY & RYS	24.61	26.18	0.46	0.49	2.67	2.84
PR73	-0.93	0	-0.02	0	-0.01	0
Seasonal dummies	-3.86	0.12	-0.07	0.00	-0.42	0.01
Total interaction[a]	5.43	12.69	0.10	0.24	0.59	1.38

[a] Includes effect of nonzero residual.

For the dynamic pork demand decomposition, the net effect of all the quantity coefficient changes was about five cents per pound. For the static pork demand decompostion, the net effect of the two current quantity coefficient changes was less than a negative one cent per pound. The addition of the two lagged quantities in the pork demand equation changed the conclusion, to some extent, of the source of the change in the retail pork price mean. The effects of the current and lagged quantity coefficient changes on the farm-wholesale margins were fairly small. None of the quantity coefficient effects changed the farm-wholesale beef margin more than one half cent per pound. The effects of quantity coefficient were somewhat larger in the farm-wholesale pork margin, ranging in absolute value from just under one cent per pound to just over two cents per pound. The Holdren demand effects were not well supported with the dynamic retail pork demand equation either. Again, the own and the cross-quantity coefficient changes had an impact on the level of the two farm-wholesale margins but these impacts were relatively small and did not go far in supporting a major hypothesis of this study.

The largest impact on the two margins from the dynamic pork demand equation were from the changes in the variable means. The changes in the intercept (CPI) mean accounted for much of the retail pork price effect on the farm-wholesale pork margin, but the effect of the change in the quantity means were also high in absolute value. The effect of the change in the income mean was less in absolute value than the effect of the change in either the current or the lagged pork quantity means.

CHAPTER 12. SUMMARY AND CONCLUSIONS

This study investigated the change in the level of beef and pork margins in the late 1970s. Three major hypotheses of this study were 1) the Holdren interdependent margin hypothesis, 2) the Holdren demand effect hypothesis, and 3) the margin equation structural change hypothesis. The first two hypotheses resulted from Holdren's model of a multiproduct firm. The interdependent margin hypothesis states that margins are not determined independent of each other. This interdependence would allow changes in one margin to feed through to the other margin. The Holdren demand hypothesis states that changes in the slope coefficients of the demand equations change the optimal level of a margin. This study searched for structural change at the end of 1977. A decomposition technique was employed to determine to what extent structural change in the demand equations influenced the margin level changes in the late 1970s. This decomposition technique was also employed to investigate to what extent structural change in the margin equations themselves influenced the margin level.

The Holdren interdependent margin hypothesis was supported to some extent in this study. Interdependent margin variables were significant in all six static margin equations. The interdependent margin variables were significant in only two dynamic margin equations. In the farm-retail beef margin equation, the pork margin variable was significant and positive in both the static and the dynamic versions. In the farm-retail pork margin equation, however, the beef margin variable was significant only in the static version. The beef margin variable was significant in this equation only in the second period. The wholesale-retail pork margin variable entered both the static and the dynamic versions of the wholesale-retail beef margin equation. This variable was significant and positive in the static version but was significant and positive in only the second period of the dynamic version. The wholesale-retail beef margin variable entered significant and positive in only the static version of the wholesale-retail pork margin equation. The dynamic version of the farm-wholesale beef margin equation proved to be quite poor and so was not used. However, the farm-wholesale pork margin variable in the static farm-wholesale beef margin equation was significant and positive. In the static farm-wholesale pork margin equation, the farm-wholesale beef margin variable was significant and positive. The farm-wholesale beef margin variable did not enter the dynamic version of the farm-wholesale pork margin equation.

The results indicate that a beef margin at a given level in the marketing channel depends on the pork margin at that level more than the pork margin depends on the beef margin. Results in this study are fairly consistent with those in Ladd and Karg (1973). Ladd and Karg found that the farm-wholesale pork margin influenced the farm-wholesale beef margin but not vice versa. This study found that the farm-wholesale pork margin influenced the farm-wholesale beef margin but also that the farm-wholesale beef margin influenced the farm-wholesale pork margin (nonsignificantly in the period 1968-1977 and significantly in the period 1978-1984). The Ladd and Karg results were also supported at the wholesale-retail level.

The Holdren demand effect hypothesis was not well supported by this study. No structural change was identified in the static beef demand equation. Structural change was identified in the dynamic beef demand and the static and dynamic pork demand equations. Since there was no markup variable in the farm-retail pork margin equation, the structural change in the pork demand equations did not feed through to the margins. The only demand coefficient effects on the farm-retail margins were from the change in the income specification and the intercept coefficient in the dynamic beef demand equation. The net effect of the change in the intercept coefficient and the two income coefficients on the farm-retail margins was quite small. The net effect on both farm-retail margins was less than one cent per pound in absolute value.

The story was much the same for the wholesale-retail margins. For the same reasons listed for the farm-retail margins, the structural change in the pork demands did not feed through to the wholesale-retail margins. Therefore, the only demand coefficient effects on these two margins were the changes in the intercept coefficient and the two income coefficients of the dynamic beef demand equation. The net effect on the two wholesale-retail margins from these coefficient changes was less than one cent per pound in absolute value.

The Holdren demand effect hypothesis found some support in the farm-wholesale margins. The net effects of the changes in the intercept coefficient and the two income coefficients of the dynamic beef demand on the farm-wholesale margins were less than one cent per pound in absolute value. Structural change in the static and the dynamic pork demand equation did affect the two farm-wholesale margins. Structural change in the static pork demand equation decreased the farm-wholesale beef and pork margins by about 0.22 and 1.30 cents per pound, respectively. Structural change in the dynamic pork demand equation had a somewhat larger effect on the farm-wholesale beef and pork margins at about -0.45 and -2.60 cents per pound, respectively.

The Holdren demand effects are not very large and are quite small relative to the total change that took place in the margin levels in the late 1970s.

The third major hypothesis of this study was that structural change within the margin equations may have influenced the changes in the margin levels in the late 1970s. This hypothesis was supported to some extent in the two farm-retail margins and the two farm-wholesale margins. The effects of the structural change in the margin equations on the farm-retail beef and pork margins were about 4.7 percent and 22 percent, respectively, of the total change in the two farm-retail margins. The effects of the structural change in the margin equations on the farm-wholesale beef and pork margins were about 13 percent and 31 percent, respectively, of the total change in the two farm-wholesale margins. Since the interaction effects were negative for all four of these margins, care must be used in interpreting these percentages. The interaction effects for the two wholesale-retail margins were positive but the structural change in the margin equations accounted for less than one percent of the total changes in these two margins.

The structural change in the margin equations had a relatively large impact on the farm-wholesale margins but identifying this impact did not go far in explaining the rather large changes in the farm-retail margins levels in the late 1970s.

The largest sources of change in the margin levels, as one may have expected, was the change in the cost index level. Unfortunately, there was too much multicollinearity among the two wage rates and the Producer Price Index to estimate a coefficient on each in the margin equations. This study had hoped to isolate the effect that changing labor cost location within the marketing channel had on the margins (as may have occurred with the increased use of boxed beef). However, the two wage rates and the Producer Price Index were combined into cost indexes to estimate the margin equations.

There were three additional findings in this study: 1) the heteroscedasticity in error variance, 2) the income specification in the demand equations, and 3) the instability of the dynamic model.

The two chapters of estimated equations presented F-tests for heteroscedasticity. A significant difference in error variances between the first and second halves of the first sample period was identified for both the beef and the pork demands. However, a significant difference in the error variances between the two sample periods was identified for the beef demands but not the pork demands. A significant difference in the error variances between the two sample periods was identified in the farm-retail beef and the wholesale-retail beef margins. No significant difference was identified in any of the pork margins. Changes in the error variance between the sample periods is a type of structural change. On the basis of these F-tests, the beef demands, the farm-retail beef margin, and the wholesale-retail beef margin are more difficult to predict now than previously partly because the variance of the random component of these data series has increased. The increased residual variance increases the standard error of the forecast.

Another finding in this study was the relationship of income in the beef and pork demands. A demand equation linear in real income seemed to be sufficient for the sample period 1968-1977. The linear specification was less satisfactory for the second sample period (1978-1984). A squared real income variable was significant in both the beef and the pork demands in the second sample period. Even though the effects of the changes in the two income coefficients on the margin levels were offset, for the most part, by the effects of the change in the intercept coefficient, the nonlinear income relationship is of interest to economic forecasters. This study found that there were some ranges of real income over which the effect of changes in the income level was negatively related to real price of beef and pork.

The instability of the dynamic versions of the model in this study was a surprising finding. The hypothesized retailer and wholesaler behavior was reasonable and the implementation of this hypothesized behavior in the margin equations was straightforward. The system of equations in both forms of the model was, however, quite unstable. It was ironic that the dynamic versions of both forms of the model had fewer nonsignificant coefficients than the static versions and yet the dynamic versions were unusable.

There are likely several sources of the instability in the dynamic versions. It may be that multicollinearity in the data distorted the actual relationships between the explanatory variables and the dependent variable. Alternatively, the source of the instability may be in the misspecification of the retailer behavior. Perhaps retailers have a more complicated pricing rule. It is possible that different lags in the farm or wholesale values or that lagging other variables may have eliminated the instability in the systems.

Another possible source of the instability in the dynamic versions may have been in the misspecification of retail price determination. It may be that if the model were not block recursive in retail prices that the dynamic versions would be stable. Unfortunately, this would have complicated the estimation of the model as well as the decomposition of the changes in the margins.

A final observation on the model of this study has to do with the seasonal pattern in the data. No change in the coefficients of the seasonal dummy variables was identified between the two sample periods. As a result, this study was unable to identify an increase in seasonal volatility in the margin equations.

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APPENDIX: SEASONAL DUMMY COEFFICIENTS

Table A.1. Static and dynamic demand seasonal dummy variables

Month	Static beef demand	Dynamic beef demand	Static pork demand	Dynamic pork demand
February	0.46	0.32	0.04	-1.06
	(1.07)	(0.77)	(0.10)	(-2.88)
March	0.77	0.68	-0.01	-0.96
	(1.15)	(1.09)	(-0.01)	(-1.79)
April	0.78	0.80	-1.32	-1.22
	(0.91)	(1.01)	(-1.54)	(-1.89)
May	1.85	1.72	-1.69	-2.23
	(1.93)	(1.94)	(-1.76)	(-3.13)
June	2.26	2.32	-1.41	-2.86
	(2.19)	(2.42)	(-1.34)	(-3.62)
July	2.53	2.44	-0.42	-2.84
	(2.37)	(2.52)	(-0.39)	(-3.50)
August	1.68	1.62	0.24	-2.64
	(1.60)	(1.68)	(0.23)	(-3.19)
September	0.95	1.02	0.43	-2.04
	(0.95)	(1.11)	(0.42)	(-2.56)
October	-0.47	-0.08	0.59	-1.02
	(-0.53)	(-0.10)	(0.66)	(-1.40)
November	-1.43	-1.08	-0.04	-0.35
	(-1.98)	(-1.61)	(-0.06)	(-0.59)
December	-1.16	-1.20	-0.21	0.10
	(-2.45)	(-2.72)	(-0.45)	(0.26)

Table A.2. Static and dynamic farm-retail pork margin seasonal dummy variables

Month	Static pork margin	Dynamic pork margin
February	-0.71 (-0.80)	-0.81 (-1.09)
March	2.37 (2.06)	-2.85 (-2.87)
April	2.61 (1.98)	-1.94 (-1.86)
May	0.35 (0.25)	0.13 (0.13)
June	-2.20 (-1.57)	-1.15 (-1.08)
July	-2.59 (-1.83)	-0.29 (-0.26)
August	-2.06 (-1.46)	-2.25 (-2.06)
September	0.39 (0.28)	-3.66 (-3.22)
October	2.09 (1.60)	-1.68 (-1.55)
November	3.30 (2.79)	-0.57 (-0.56)
December	0.33 (0.35)	1.88 (2.37)

Table A.3. Static and dynamic wholesale-retail margin seasonal dummy variables

Months	Static beef margin	Dynamic beef margin	Static pork margin	Dynamic pork margin
February	0.96 (1.12)	-0.54 (-0.65)	-0.36 (-0.47)	0.72 (0.99)
March	0.38 (0.35)	-1.28 (-1.18)	1.89 (1.86)	-0.46 (-0.49)
April	-2.05 (-1.68)	-1.81 (-1.63)	2.14 (1.83)	0.09 (0.09)
May	-2.22 (-1.71)	-2.96 (-2.52)	0.90 (0.72)	1.97 (1.90)
June	-0.85 (-0.64)	-3.34 (-2.67)	-0.60 (-0.47)	1.49 (1.41)
July	0.56 (0.41)	-2.09 (-1.64)	-0.96 (-0.73)	3.16 (2.85)
August	1.49 (1.12)	-1.42 (-1.09)	-1.12 (-0.86)	1.46 (1.37)
September	2.24 (1.72)	-0.51 (-0.39)	-0.51 (-0.40)	-0.53 (-0.50)
October	2.20 (1.76)	-0.59 (-0.48)	0.84 (0.70)	-0.58 (-0.57)
November	2.52 (2.22)	0.95 (0.88)	-0.03 (-0.03)	0.04 (0.04)
December	1.33 (1.47)	1.08 (1.32)	-1.22 (-1.48)	0.48 (0.63)

Table A.4. Static and dynamic farm-wholesale pork margin seasonal dummy variables

Month	Static pork margin	Dynamic pork margin
February	-0.27 (-0.55)	-0.93 (-2.27)
March	0.74 (1.09)	-1.44 (-2.57)
April	1.02 (1.41)	-0.99 (-1.65)
May	-0.16 (-0.23)	-1.02 (-1.67)
June	-1.18 (-1.71)	-1.74 (-2.77)
July	-1.57 (-2.26)	-1.72 (-2.65)
August	-0.80 (-1.11)	-1.52 (-2.36)
September	0.96 (1.47)	-0.36 (-0.55)
October	1.67 (2.52)	0.11 (0.18)
November	3.72 (6.28)	2.28 (3.97)
December	1.82 (3.85)	1.68 (3.84)