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Seasonal Demand for Beef, Pork, and Broilers

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Changes in the nature of the demand for meat in the postwar years, as contrasted with prewar, is of particular interest and concern to the livestock industry. Most statistical studies of demand that have been made used annual time series data. However, differences in demand within the span of a year also appear to exist. In the study reported in this paper, quarterly data for beef, pork, and broilers were examined. An important difference in the nature of demand for pork between summer and winter was identified. While demand in winter approximates unit elasticity, that in summer is much more inelastic. In contrast, demand for broilers is stronger in summer than in winter. No significant difference in seasonal demand for beef was located. *The author acknowledges with appreciation the many suggestions and help given him by Anthony S. Rojko, Arthur A. Harlow, and Hyman Weingarten, of AMS, in carrying out this analysis and in preparing the manuscript.*

MOST EFFORTS to study demand in the aggregate are based on past experience, using annual time series data and statistical techniques of one kind or another. A number of limiting assumptions are always required. One is that consumer demand has been relatively stable during the time period covered. A second is that shifts in the supply relationship are primarily responsible for movements along the demand schedule.[1] As Working[2] pointed out in 1927, these assumptions are both heroic and necessary if estimates of demand relationships are to be made. But the importance of these necessary assumptions must not be forgotten or ignored as the intricacies of a statistical model absorb one's attention.

The demand for meat in the United States at retail, wholesale, and the farm has been the subject of many careful studies during the postwar period. A wide range of statistical models of varying complexity have been used to approximate the actual market situation. Most have relied on the use of annual data. Aggregate consumer demand necessarily has been visualized as being relatively constant throughout any given year. At least, changes within a year were assumed to correspond with the annual pattern over time. Little formal work has been done with time series data to investigate the nature of consumer demand for meats within the span of a year.

But can we assume that demand for individual meats remains constant throughout the year? Are there important seasonal differences? Are seasonal differences stable or regular enough in character to be identified? The purpose of this paper is to investigate these questions.

Scatter Diagrams and Simple Regression

An indication of seasonal differences in demand is obtained when deflated retail prices are plotted against per capita consumption of individual meats by quarters during the postwar years. Differences in demand between seasons of the year are reflected by a change in slope or level of the demand curve, or both. Quarterly data are available for the 12-year period (1948–59) for all three meats. This period seems appropriate for beef;

[1] Shifts in the demand schedule resulting from changes in income or the prices of competing products are permitted, and are explicitly allowed for, in the statistical model used. Changes in supply are still necessary to identify a demand relationship as such.

[2] Working, E. J., "What Do Statistical Demand Curves Show?" *Quarterly Journal of Economics*, February 1927, pp. 212-235.

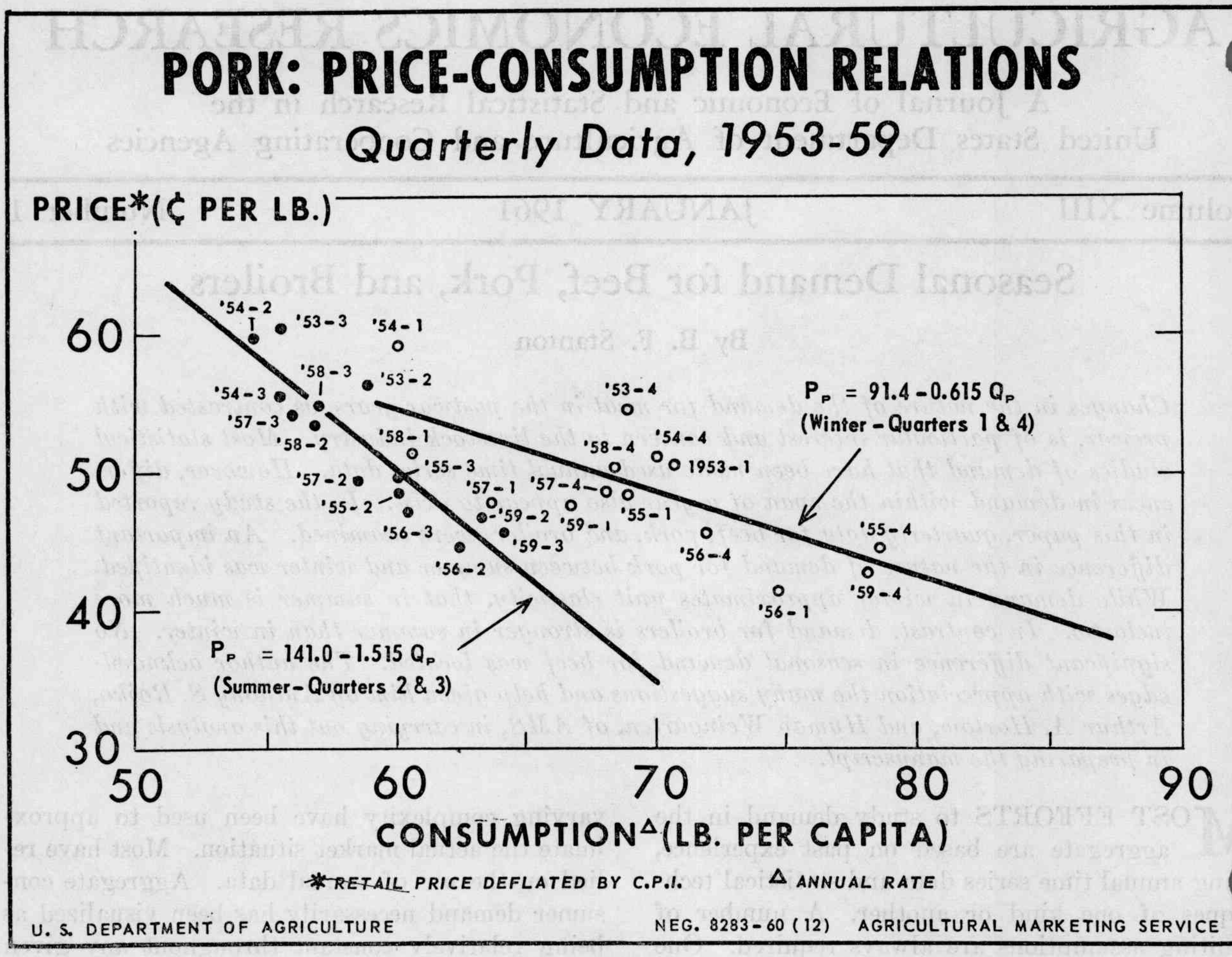

FIGURE 1.

the period 1953–59 is perhaps more meaningful for pork and broilers. A downward shift or decrease in demand for pork apparently occurred during the late 1940's and early 1950's. Increased consumption of beef and broilers at lower prices since 1952 may account for much of this shift. Broiler consumption has increased steadily during the last 12 years. But only in recent years have broilers been generally available on most of the national market.

Pork

The relationship between deflated retail prices and pounds of pork consumed per capita for 1953–1959 is shown in figure 1. Nearly all of the observations for the first and fourth quarters are above and to the right of those for the second and third. This indicates that probably separate demand curves are needed for summer and winter. For ease of discussion the second and third quarters are referred to as "summer" and the first and fourth as "winter," although these two terms are not fully descriptive of the time periods involved.

The summer price-consumption relationship covers a relatively narrow range of quantities and a relatively wide range of prices. The slope of the simple least squares regression line for the summer analysis is −1.515. This means that a 1.0 pound increase in consumption is associated with a decrease in retail price of about 1.5 cents on the average. In contrast, the slope of the regression line for the winter period is −0.615. This relationship includes a much wider range of quantities with about the same divergence in retail prices as in summer.

The two regression lines shown are not necessarily as good approximations of winter and summer demand curves for pork as might be drawn. These lines represent gross relationships

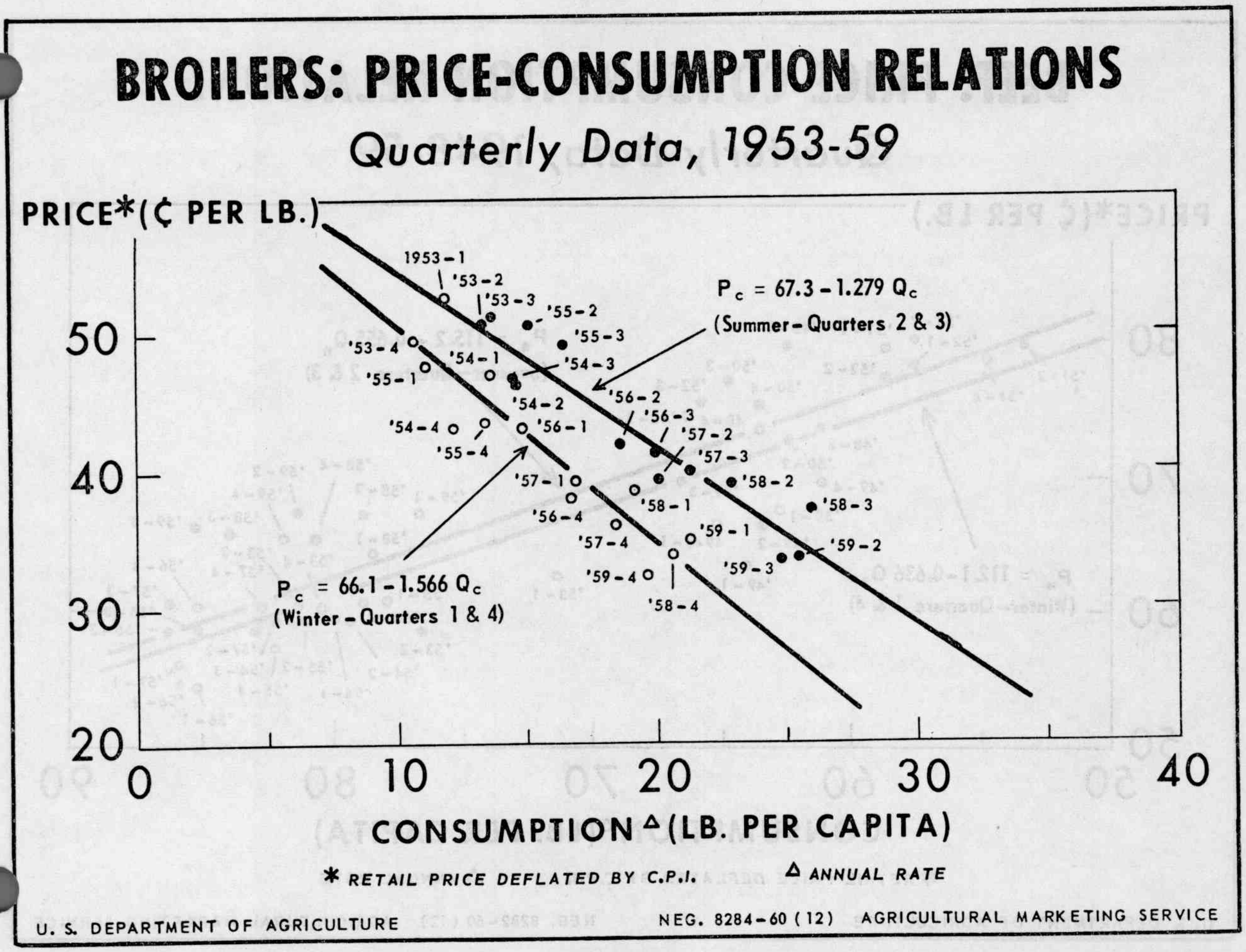

FIGURE 2.

Other factors, such as changes in income and the prices of other meats, may tend to obscure the true demand relationships.

Broilers

Deflated retail prices for ready-to-cook broilers are plotted against consumption per capita by quarters in figure 2. In contrast to pork, observations for the second and third quarters in each year are generally above and to the right of those for the winter quarters. It appears logical that consumers have a greater demand for pork during the winter months and a more limited demand during the summer. Pork does not lend itself as readily as beef and young chicken to broiling or summer cookery. The relatively high fat content of pork may also reduce its popularity during the summer months. Broilers, on the other hand, lend themselves well to summer use. During the winter months they must compete more directly with turkey and roasting fowl. Hence a stronger summer demand seems logical.

There appears to be a measurable difference in the level of demand for broilers between summer and winter. The variability around each of the lines of regression drawn through the two sets of plotted observations is small. The respective coefficients of determination are 0.90 in summer and 0.85 in winter. The differences exhibited between the summer and winter price-consumption relationships are less striking than those for pork. Yet they are large enough to be of interest and possible importance to producers, processors, and retailers.

Beef

Demonstrating that a difference exists between the summer and winter price-consumption relationships for beef is much more difficult. As noted

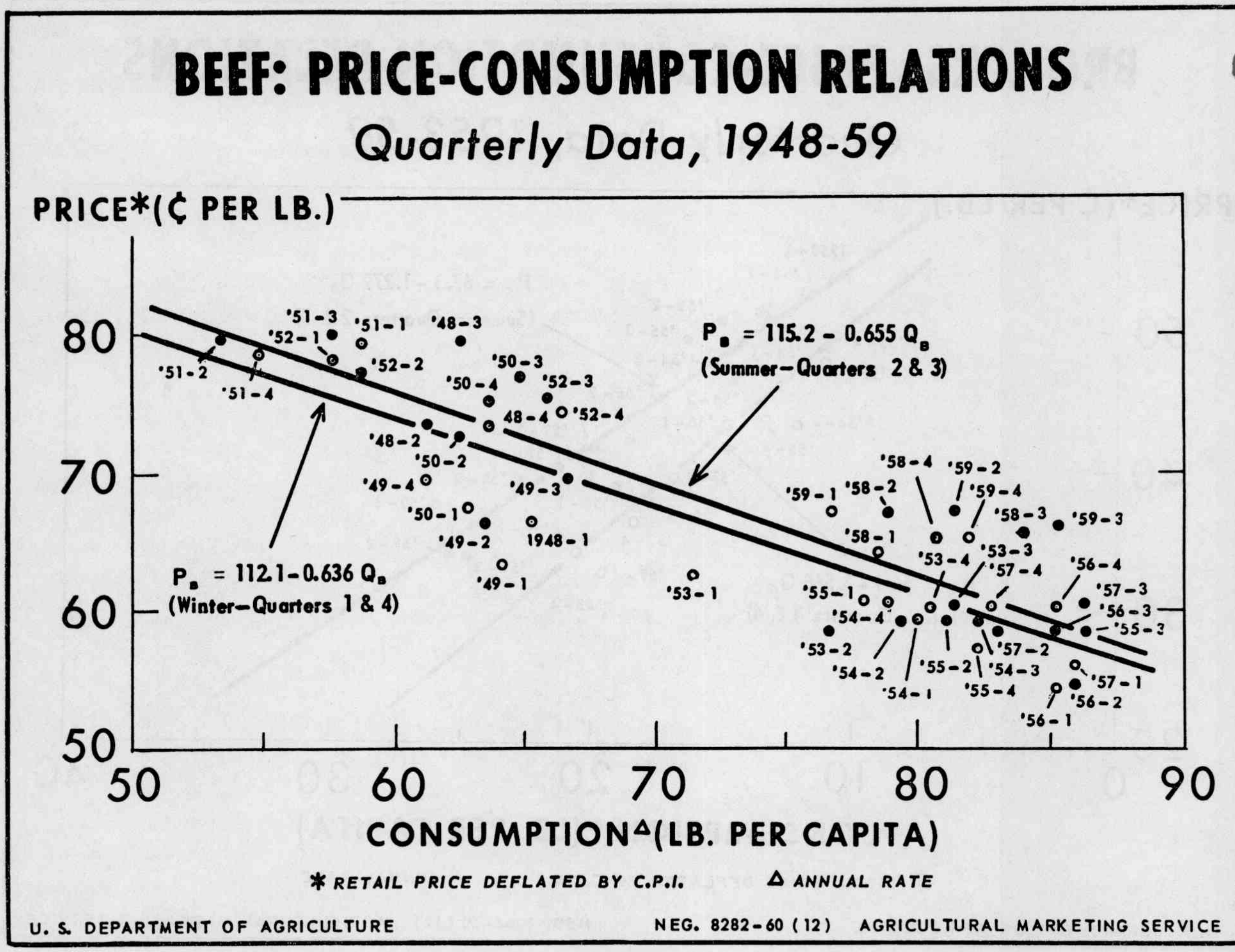

FIGURE 3.

earlier, looking at the price-quantity observations since 1953 by themselves is not very helpful. Prices have fluctuated quite widely over a relatively narrow range of consumption as shown in the lower right hand quadrant of figure 3. In addition, retail prices averaged about 5 cents more in 1958 and 1959 for equivalent levels of consumption than for the preceding 5 years. In general, the third quarter observations are above and to the right of the rest. The first quarter observations are generally somewhat below and to the left of the others.

When the price-quantity data for the second and third quarters were treated separately from those for the first and fourth, the calculated, simple regression lines had similar slopes. The line of average relationship for the summer months lies from 1.5 to 2.0 cents above that for the winter period. Considering the amount of variability in the observations around these lines this difference is not clearly significant.

General

All of the conclusions drawn concerning differences between summer and winter demand for pork, broilers, and beef from these scatter diagrams must be based in part on a number of assumptions. Demand in each season is assumed constant for the period of time covered. Movement along the demand relationship results from changes or shifts in supply. Deviations from the "true" line of relationship result from other variables, such as the prices of competing meats. The term "price-consumption relationship" is therefore most appropriate for the regression lines presented.

Despite these limiting assumptions, the scatter diagrams provide some rather telling evidence that real differences in seasonal demands do exist for pork. The case for broilers is not as clear, though summer prices and consumption levels are generally higher than those in winter. No clear difference was shown for beef.

Method of Analysis

While simple price-quantity diagrams provide a good indication of whether differences in seasonal demand exist, they do not take into account the influence of other variables which have an important effect on price and consumption. After all, the price of beef as well as the price of pork has some effect on pork consumption. The level of income has usually been considered an important demand shifter. And changes in tastes or trends in demand occur as well.

Demand theory conventionally specifies that, for an individual consumer, the quantity of the commodity consumed depends upon its own price, prices of competing items, the individual consumer's income, and factors that reflect changes in tastes and preferences. Market demand, which is our concern here, is the summation of these individual demands and may be defined as follows:

$$Q_b = f(P_b, P_p, P_c, Y, u_1) \quad (1)$$
$$Q_p = f(P_b, P_p, P_c, Y, u_2) \quad (2)$$
$$Q_c = f(P_b, P_p, P_c, Y, u_3) \quad (3)$$

where the Q's represent the aggregate per capita consumption of beef (Q_b), pork (Q_p), and broilers (Q_c), the P's represent the market prices for beef (P_b), pork (P_p), and broilers (P_c); Y represents aggregate per capita consumer income; and the u's represent random disturbances that affect consumption of beef, pork, and broilers. Consumption and income figures are on a per capita basis so that population need not be included as a separate variable in the analysis.

If time series data on prices, quantities, and incomes are given, the statistical method used to estimate the coefficients in these structural demand relations depends on assumptions that are made regarding the type of functional relation that generates the observed data. As for many agricultural commodities, the total amount of meat consumed within a short period of time is largely dictated by the supplies available. Quantities placed in storage provide some leeway between production and consumption in the short run. However, variation in meat consumption closely parallels that in production. For this reason, production and consumption may be used almost interchangeably in a statistical analysis. As a result, quantities of each meat consumed per capita can be treated as given variables in the statistical analysis. This means that a given combination of production of beef, pork, and broilers results in a unique set of market prices that is simultaneously determined. Thus, if we are to estimate the coefficients in the demand equations (1) to (3), we must use a statistical method that allows for the joint determination of the three competing prices.

Equations of the sort discussed here are usually just identified. Hence, the reduced form method of fitting simultaneous equations can be used to estimate these coefficients.[3]

The computational procedure in this method can be summarized in three steps: (1) The variables in the structural demand equations are recombined in such a manner that each of the jointly determined variables (P_b, P_p, and P_c) is expressed separately as a function of all the given variables appearing in all the demand equations. (2) These equations, commonly known as reduced form equations, are fitted by the least squares method. (3) The coefficients in the structural demand equations are then algebraically derived from the estimates of the regression coefficients in the reduced form equation.

Besides serving as a basis for estimating demand elasticities, these reduced form (price estimating) equations are useful directly in price forecasting or studying the effect of income and supplies of meat on price. Because of the interest in the influence of meat supplies on price, considerable emphasis is given to the price-estimating equations (price-consumption relationships) in the discussion that follows.

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[3] Meinken, Rojko, and King used this procedure in "Measurement of Substitution in Demand from Time Series Data—A Synthesis of Three Approaches," *Journal of Farm Economics*, August 1956, pp. 711–735, in their study of beef and pork for the period 1928–53. A good presentation of the use of simultaneous equations in obtaining estimates of demand elasticities for a group of competing products when supplies of each are predetermined (given) is presented by Foote, R. J., *Analytical Tools for Studying Demand and Price Structures*, USDA Agriculture Handbook 146, August 1958, pp. 87–94. The basic equations fitted and the method of transforming the coefficients from the "reduced form" equations to obtain elasticity coefficients are presented in detail. Working in his *Demand for Meat*, Chicago, University of Chicago Press, 1954, used reduced form equations in his analyses and discussed them with other alternatives in some detail in Chapter 2, "The Measurement of Demand: General Considerations."

A second approach was also used to estimate the coefficients in the structural demand equations which considered consumption of each meat as the dependent variable. In other words, the structural equations were fitted directly by least squares. This may be justified in the following manner. In a period as short as 3 months, retailers establish selling prices and offer whatever supplies are needed to match consumer demands at that price. For example, cold storage holdings of pork often are equivalent to at least 1 month's total consumption. Hence stocks may be used to augment current production to satisfy demand requirements at the established price. Consumers are faced with given prices of pork, beef, and broilers and vary their purchases accordingly. In this respect consumption may be considered the dependent variable. Demand elasticities or the effect on consumption of changes in price and income may be computed directly from the regression equations when consumption is the dependent variable.

Both of these approaches were used in the analyses for the individual meats. Neither is clearly superior on logical grounds. Together they provide a more complete picture of interrelationships between price and consumption.

A further problem was encountered in deciding how to handle seasonal differences in the regression analyses. The simple scatter diagrams indicated that seasonal differences in demand appeared to exist for pork and broilers. These differences might be of two different types.

One is a difference of level analogous to a shift in demand. Instead of income or a competing meat, the shifter here is the season of the year. Such a shift or change in level indicates that the basic nature of the demand relationship does not change. In this case a seasonal shifter or variable might be incorporated into a single regression analysis and separate analyses for each of the seasons need not be run.

The second type of difference involves the nature of the relationship as well as its level. For example, in a simple, two-variable case the slope of the regression lines for price and quantity may differ widely in two periods. In this case a seasonal variable or shifter will not adequately reflect such a change.

Separate analyses for each of the two seasonal periods were run. In this way, differences either in level or structure were not assumed by the method of analysis. Likewise if either or both existed they could be distinguished.

Quarterly data were used in all the analyses. Data for the first and fourth quarters were used in the winter analysis while those for the second and third quarters were in the summer analysis. A set of demand elasticities was obtained by each of the two basic approaches to determine if differences in the nature of demand existed between summer and winter. The constant terms in the fitted regressions were compared to evaluate differences in level of demand.

The data used in the analysis were converted to logarithms. This action infers that the several elasticities of demand are constant over the range of prices and quantities considered. The price and income series were deflated by the BLS Consumer Price Index. The consumption variable used for each meat represents apparent domestic disappearance per capita. This is obtained by adjusting production for changes in storage stocks, imports, exports, and military uses. Hence consumption is primarily a function of production or supply. Six different combinations of variables were considered for each meat.[4] Those involving consumption and prices of each of the three meats and discretionary income [5] per capita are presented here.

[4] For example, the following combinations of variables were used in the six regression analyses for pork using price as the dependent variable. The first analysis considered the pounds of pork, beef, and broilers consumed per capita, respectively, as the independent or predetermined variables. Then disposable income per capita was added as a fourth variable. Deflated discretionary income per capita replaced disposable income in the third analysis. Time replaced discretionary income in the fourth. In the fifth and sixth analyses each income variable, in turn, and time were considered along with the three consumption variables.

Disposable income per capita, time, and broiler consumption per capita were highly correlated. This intercorrelation complicated the interpretation of regression coefficients obtained from those analyses in which more than one of these variables were included. Hence, only the analyses involving discretionary income per capita and the price and consumption variables for the three meats are presented.

[5] A full explanation of the concept of discretionary income and procedures for its calculation are presented by Franklin, W. B., *Discretionary Income*, Technical Paper #6, National Industrial Conference Board, New York, 1958.

TABLE 1.—*Statistical price-consumption relationships for pork, quarterly data, United States, 1953–59* [1]

Period covered	Coefficient of multiple determination	Constant term	Effect on price of pork of a 1 percent change in—			
			Consumption per capita of: [2]			Deflated discretionary income per capita
			Pork	Beef	Broilers	
Winter	0.754	3.317	−0.872 (0.186)	−0.361 (0.323)	−0.136 (0.065)	----------
Summer	0.883	4.300	−1.521 (0.234)	−0.602 (0.320)	−0.031 (0.050)	----------
Winter	0.841	5.368	−0.554 (0.213)	−0.150 (0.290)	−0.015 (0.078)	−1.032 (0.465)
Summer	0.886	4.564	−1.422 (0.326)	−0.548 (0.354)	−0.022 (0.056)	−0.169 (0.370)

[1] Analyses based on data expressed in logarithms. The general form of the regression is:

$$\log P_p = \log a + b_1 \log Q_p + b_2 \log Q_b + b_3 \log Q_c + b_4 \log Y.$$

The numbers in parentheses are the standard errors of the regression coefficients. Prices and income deflated by C.P.I.

[2] Production adjusted for changes in storage stocks, imports, exports, and military uses.

Results of Analyses for Pork

On the basis of the scatter diagrams and simple regression equations presented earlier, the greatest differences between comparable coefficients in the summer and winter equations should be expected for pork. This was the case.

Regressions with Price Dependent

The effect of changes in the quantities of pork, beef, and broilers available for consumption on the deflated retail price of pork for the years 1953–59 is presented in table 1. The regression coefficients, sometimes called "price flexibility" coefficients, indicate the percentage change in price associated with a one percent change in the quantity of each meat consumed, all other variables held constant.

Some important differences are evident. The price flexibility coefficients for pork consumption in the summer and winter equations were −1.52 and −0.87, respectively. This suggests that summer demand is price inelastic. On the other hand, winter demand appears somewhat price elastic. Both of these coefficients are clearly significant in terms of the usual statistical tests. Beef consumption appears to have a stronger effect on pork prices in the summer months than in the winter. In contrast, consumption of broilers appears to influence the price of pork only during the winter months.

When deflated discretionary income per capita was added as a variable the basic coefficients were similar, although differing in magnitude. Discretionary income, prepared by the National Industrial Conference Board, is based on the U.S. Department of Commerce figures on personal disposable income. It separates out major fixed commitments such as long- and short-term debt and interest payments, rent, and home-owner taxes. Essential expenses including minimum amounts for food and clothing are deducted as well. The remainder is the amount over which consumers currently have some discretion as to its use. This uncommitted income might well be a more important determinant of changes in meat purchases than disposable income itself; hence its consideration as a variable. Moreover, discretionary income was less closely correlated with the other independent variables included in this analysis than was disposable income.[6]

The greatest change resulting when discretionary income was included in the analysis was a reduction in the size of all the coefficients associated with the three consumption variables. The difference between the price flexibility coefficients for pork consumption were still large and striking. And the standard errors were relatively

[6] The coefficient of determination obtained when disposable and discretionary income were correlated using quarterly series from 1948–1959 was 0.72.

TABLE 2.—*Estimates of elasticities of demand for pork from reduced form equations, quarterly data, United States, 1953–59* [1]

Period covered	Demand elasticities for pork with respect to—			
	Deflated retail prices of			Deflated discretionary income per capita
	Pork	Beef	Broilers	
Winter	−1. 274	+0. 327	+0. 398	--------
Summer	−0. 775	+0. 654	+0. 323	--------
Winter	−1. 829	+0. 242	+0. 127	−1. 849
Summer	−0. 708	+0. 693	+0. 355	+0. 198

[1] Elasticity coefficients were obtained algebraically from the price-consumption regressions for beef, pork, and broilers. (See tables 1 and 4.)

small. However, the seeming importance of broiler consumption as a competitor of pork in the winter was dissipated. The regression coefficient for income, however, was significantly different from zero and *negative*. Pork prices did fall during this period while incomes rose. But in economic terms it is more logical to state that pork prices fell despite rising incomes rather than because of them. In such a short-term analysis there may be good reason to question how reasonable it is to include income as a variable. Changes in the level of income over time undoubtedly shift demand. But to expect quarterly changes in income to have immediate effects on prices is another matter.

Demand Elasticities (Simultaneous Equations Approach)

Elasticity coefficients for pork, beef and broilers were obtained algebraically from the regression coefficients obtained in the reduced form equations (price-consumption relationships) for pork, broilers, and beef (see tables 1 and 4). These coefficients reflect the interaction of all the variables considered in each set of equivalent price-consumption relations. The elasticity estimates for pork are presented in table 2.

A comparison of direct price elasticities of demand for pork indicates that consumer response to price is greater during the winter months than in summer. When the income variable is included in the analysis, the direct price elasticity for the winter period is increased.

The cross elasticity coefficients carried the expected positive signs in both equations. In winter a 1 percent change in the price of beef had less effect on pork consumption than in summer. If one assumes that the income elasticity coefficient for the winter equation has no economic significance and has in fact by its inclusion reduced the "true" effect of broiler prices, then an estimate of 0.3 to 0.4 as the cross elasticity for broilers seems justified.

Demand Elasticities (Single Equation Approach)

Estimates of demand elasticities were also calculated by least squares regression with consumption of pork as the dependent variable. These are presented in table 3. These elasticity coefficients differ from those in table 2 in a number of respects. Yet the same basic difference in demand between summer and winter is suggested. In contrast to the other method, standard errors of the regression coefficients are also presented.[7] The direct price elasticities for pork are smaller than those presented in table 2. However, they are more nearly of the magnitude that might have been expected before these analyses were run. The coefficients are significant in a statistical sense. Those in the winter equations approach unit elasticity. Those for summer are more clearly inelastic.

None of the cross elasticity figures were statistically significant, however. Yet their signs and relative size seem reasonable. Beef appears to be the stronger substitute for pork in summer. The broiler coefficients approach statistical significance in the winter analysis. Discretionary income was not a significant variable. It did not increase the multiple coefficient of determination when added to the analysis. The income coefficients generated were not significantly different from zero.

General Conclusions

Each of the regression analyses indicated definite differences in the price-consumption relationships for pork in the summer and winter months. Moreover, the difference appeared to be one of

[7] Unfortunately, it is computationally tedious and difficult to obtain standard errors of demand elasticities derived from reduced form equations. For this reason, it was felt that sufficient clues would be obtained from the standard errors in the original regression equations.

TABLE 3.—*Direct estimates of elasticities for pork, quarterly data, United States, 1953–59* [1]

Period covered	Coefficient of multiple determination	Constant term	Demand elasticities for pork with respect to— Deflated retail prices of: Pork	Beef	Broilers	Deflated discretionary income per capita
Winter	0.658	1.714	−0.844 (0.199)	+0.326 (0.306)	+0.226 (0.135)	----------
Summer	0.856	1.565	−0.543 (0.086)	+0.220 (0.147)	+0.086 (0.075)	----------
Winter	0.668	2.918	−0.955 (0.300)	+0.292 (0.325)	+0.189 (0.158)	−0.332 (0.650)
Summer	0.865	0.966	−0.491 (0.110)	+0.246 (0.153)	+0.106 (0.081)	+0.159 (0.201)

[1] Analyses based on data expressed in logarithms. The general form of the least squares regression in these analyses is:

$$\log Q_p = \log a + b_1 \log P_p + b_2 \log P_b + b_3 \log P_c + b_4 \log Y.$$

The numbers in parentheses are the standard errors of the regression coefficients. Prices and income deflated by C.P.I.

structure as well as level. Direct price elasticities of about −0.9 to −1.2 in winter and −0.55 to −0.75 in summer were suggested. The cross elasticity figures obtained were not statistically significant. However, beef appeared to be the stronger substitute for pork in summer than in winter. Broilers apparently were important only in the winter months. For the recent short period of relatively high incomes, the income elasticity figures appeared to have no economic significance.

Results of Analyses for Broilers

The same type of regression analyses made for pork were carried out for broilers. The simple scatter diagrams comparing data on retail prices and consumption per capita indicated that summer demand was stronger than winter demand. Outdoor uses for chicken in summer, together with the stronger competition from turkey and other poultry during the winter months, support this hypothesis.

Regressions with Price Dependent

A comparison of regression coefficients obtained when the deflated retail price of broilers was related to the two sets of variables is shown in table 4. A few general conclusions stand out after studying these coefficients.

First, broiler consumption accounts for most of the variation in broiler prices whether full year, winter, or summer periods are considered. The simple r's are 0.65, 0.85, and 0.90, respectively. The respective partial correlation coefficients in the various multiple regression analyses bear this out even more strongly.

Second, the price flexibility coefficient for broiler consumption is the only significant variable in both of the summer equations. In winter, the coefficients for pork, beef, and income are all more important. This suggests that the relatively high level of broiler consumption during the summer months is not much affected by changes in the prices of other meats. In the winter this competition is more important. Pork appears to be the more important substitute. But the coefficients for beef are also large and significant in one equation.

Third, discretionary income appears to be a significant variable in the winter months. This apparent significance may result, however, from the close association between income and broiler consumption. On the other hand since price has steadily moved downward while income moved upward and the income coefficient still remains positive and reasonable, the statistical result cannot be ignored.

Demand Elasticities (Simultaneous Equations Approach)

Elasticity estimates were obtained from the reduced form regression coefficients in the same

TABLE 4.—*Statistical price-consumption relationships for broilers, quarterly data, United States, 1953–59* [1]

Period covered	Coefficient of multiple determination	Constant term	Effect on price of broilers of a 1 percent change in—			
			Consumption per capita of: [2]			Deflated discretionary income per capita
			Broilers	Beef	Pork	
Winter	0.916	2.822	−0.577 (0.061)	−0.348 (0.303)	−0.338 (0.175)	----------
Summer	0.911	1.838	−0.568 (0.066)	+0.329 (0.416)	−0.226 (0.305)	----------
Winter	0.954	0.638	−0.707 (0.067)	−0.514 (0.249)	−0.678 (0.183)	+1.100 (0.399)
Summer	0.919	1.156	−0.593 (0.071)	+0.188 (0.445)	−0.480 (0.409)	+0.436 (0.464)

[1] Analyses based on data expressed in logarithms. The general form of the regression is:

$$\log P_c = \log a + b_1 \log Q_c + b_2 \log Q_b + b_3 \log Q_p + b_4 \log Y.$$

The numbers in parentheses are the standard errors of the regression coefficients. Prices and income deflated by C.P.I.

[2] Production adjusted for changes in storage stocks, imports, exports, and military uses.

manner as those for pork. The direct price elasticities were higher in summer than in winter (table 5). In both cases, they were somewhat larger than expected. The addition of income in the winter analysis had a definite effect in dropping the direct price elasticity figure from −1.8 to −1.25. Income was a significant variable only in the winter analysis in the reduced form equations.

The cross-elasticity figures in the winter equations are more credible than those in summer. The lack of significance in the price flexibility coefficients in the reduced form equations for summer pointed to the likelihood of this kind of result. The importance of pork as a substitute for broilers in winter is made clear by both of the cross- elasticity figures. Beef is also important although less so than pork.

Because the addition of discretionary income had such a major effect on all of the coefficients in the winter equations there is good reason to question whether the absolute values have direct meaning in a predictive sense. They do establish the nature of the difference which appears to exist between summer and winter demand. The importance of the elasticity figures themselves is more relative than absolute.

Demand Elasticities (Single Equation Approach)

Regression analyses where prices are treated as the independent variables, can be justified more easily for broilers than the other two meats in terms of the production cycle. It takes only 9 weeks to grow a chick into a broiler ready for slaughter. Hence response to shifts in demand can be much more rapid. Stocks of broilers in cold storage are usually small reflecting the ability of the industry to move rapidly. Consumption per capita is less a predetermined variable than is the case for beef or even pork.

The elasticity coefficients themselves, in table 6, do not support the notion that summer demand

TABLE 5.—*Estimates of elasticities of demand for broilers from reduced form equations, quarterly data, United States, 1953–59* [1]

Period covered	Demand elasticities for broilers with respect to—			
	Deflated retail prices of—			Deflated discretionary income per capita
	Broilers	Beef	Pork	
Winter	−1.793	+0.369	+0.725	-------
Summer	−2.290	−1.181	+0.466	-------
Winter	−1.256	+0.538	+1.825	+3.663
Summer	−2.239	−1.119	+0.571	+0.311

[1] Elasticity coefficients were obtained algebraically from the price-consumption regressions for beef, pork, and broilers. (See tables 1 and 4.)

TABLE 6.—*Direct estimates of elasticities for broilers, quarterly data, United States, 1953–59* [1]

Period covered	Coefficient of multiple determination	Constant term	Demand elasticities for broilers with respect to— Deflated retail prices of: Broilers	Beef	Pork	Deflated discretionary income per capita
Winter	0.869	2.627	−1.534 (0.244)	+0.024 (0.555)	+0.230 (0.361)	------------
Summer	0.914	2.275	−1.324 (0.277)	+0.582 (0.541)	−0.286 (0.317)	------------
Winter	0.917	5.227	−1.290 (0.232)	+0.244 (0.477)	+0.952 (0.440)	+2.164 (0.953)
Summer	0.933	1.814	−1.189 (0.272)	+0.761 (0.516)	+0.073 (0.370)	+1.085 (0.678)

[1] The general form of the least squares regression in these analyses is:

$$\log Q_c = \log a + b_1 \log P_c + b_2 \log P_b + b_3 \log P_p + b_4 \log Y.$$

The numbers in parentheses are the standard errors of the regression coefficients. Prices and income deflated by C. P. I.

is quite different from that in winter. When the three retail price series were related to broiler consumption only the direct price-elasticity coefficients were statistically significant in both the summer and winter analyses. While both of these coefficients were greater than −1.0 they were not as large as those in table 5, obtained from the simultaneous equations approach. The cross-elasticity figures which seemed quite logical in the earlier winter equations were not significant using this regression model.

When discretionary income was included in the analysis the direct price elasticities were reduced somewhat although they were still above −1.0. Pork now appeared to be a direct substitute in winter for broilers. Its elasticity coefficient was statistically significant as well. Beef appeared to be an important substitute in summer although this was not as clearly established in a statistical sense. Both income coefficients were large and the signs were logical in an economic sense. Again, however, the length of time involved raises questions as to their meaningfulness.

General Conclusions

The two methods of analysis give conflicting evidence on seasonal differences in demand for broilers. One might try to rationalize these results and simply choose those which support most closely the original hypothesis posed. In point of fact, the size of the elasticity coefficients obtained from the single equation analyses most closely approximate original expectations. Those generated from the reduced form equations show the expected differences between summer and winter but are much larger than seem reasonable for prediction. The original hypothesis was not disproved. But neither was it strongly supported.

Results of Analyses for Beef

Regression analyses for beef were made for the 12-year period, 1948–59. Differences between quarters in the price-consumption relationships were difficult to observe in the simple scatter diagrams. There was about as much reason to combine the first two and the last two quarters of the year, as the first with the fourth, and the second with the third. Because pork and broilers did fit the second pattern quite closely, beef was studied in a similar manner.

Regressions With Price Dependent

Results from regression analyses where price was considered as the dependent variable are shown in table 7. All of the signs for the consumption variable were expected to be negative, but they were not. In every case the coefficient for broiler consumption had a positive sign. Broiler consumption did increase markedly during the period. Likewise there was an upward trend in beef prices once the level of beef consumption was taken into consideration. But the

TABLE 7.—*Statistical price-consumption relationships for beef, quarterly data, United States, 1948–59* [1]

Period covered	Coefficient of multiple determination	Constant term	Effect on price of beef of a 1-percent change in— Consumption per capita of: [2] Beef	Pork	Broilers	Deflated discretionary income per capita	Time
Winter	0.842	2.664	−0.854 (0.106)	+0.142 (0.137)	+0.100 (0.032)	----------	----------
Summer	0.806	3.175	−0.930 (0.163)	−0.195 (0.261)	+0.094 (0.047)	----------	----------
Winter	0.845	2.659	−0.855 (0.124)	+0.142 (0.160)	+0.100 (0.038)	+0.003 (0.280)	----------
Summer	0.815	2.656	−1.011 (0.186)	−0.308 (0.289)	+0.087 (0.048)	+0.282 (0.305)	----------
Winter	0.824	2.691	−0.807 (0.109)	+0.073 (0.146)	----------	----------	+0.037 (0.015)
Summer	0.778	2.839	−0.787 (0.163)	−0.045 (0.267)	----------	----------	+0.022 (0.024)

[1] Analyses based on data expressed in logarithms. The general form of the regression is:

$$\log P_b = \log a + b_1 \log Q_b + b_2 \log Q_p + b_3 \log Q_c + b_4 \log Y + b_5 \log T.$$

The numbers in parentheses are the standard errors of the regression coefficients. Prices and income deflated by C.P.I.

[2] Production adjusted for changes in storage stocks, imports, exports, and military uses.

upward rise in beef prices did not result *because* of increased broiler consumption *but in spite of it.* Income also was increasing during this period. The addition of discretionary income as a variable did not separate out this strong influence. Because of these related trends, it is reasonable to assume that the "significant" coefficients associated with broiler consumption in fact have no economic meaning.

Another analysis was run, eliminating broiler consumption per capita as a variable and introducing time to take account of trend. These results are also included in table 7. The price flexibility coefficients for beef consumption in every case are highly significant. They all suggest an elastic demand for beef with the winter coefficient, if anything, the larger of the two. The most elastic coefficients develop when broiler consumption is eliminated as a variable. But important differences between the summer and winter coefficients cannot be demonstrated.

Pork consumption does not have a significant effect on beef prices in either season. A study of the data suggests that when pork consumption is low beef prices may shift upward, but the reverse does not seem to occur. Beef generally has fared better than pork during the postwar years. These results suggest that pork has not been a very strong competitor for the beef market in either winter or summer.

Demand Elasticities (Simultaneous Equations Approach, 1953–59)

Estimates of demand elasticities derived from reduced form equations for beef for the period

TABLE 8.—*Estimates of elasticities of demand for beef from reduced form equations, quarterly data, United States, 1953–59* [1]

Period covered	Demand elasticities for beef with respect to— Deflated retail prices of: Beef	Pork	Broilers	Deflated discretionary income per capita
Winter	−0.929	+0.036	−0.286	--------
Summer	−1.592	+0.272	−0.696	--------
Winter	−0.948	−0.088	−0.346	−0.411
Summer	−1.756	−0.009	−0.832	−0.834

[1] Elasticity coefficients were obtained algebraically from the price-consumption regressions for beef, pork and broilers. (See tables 1 and 4.)

TABLE 9.—*Direct estimates of elasticity coefficients for beef, quarterly data, United States, 1948–59* [1]

Period covered	Coefficient of multiple determination	Constant term	Demand elasticities for beef with respect to— Deflated retail prices of: Beef	Pork	Broilers	Deflated discretionary income per capita
Winter	0. 930	3. 207	−0. 882 (0. 088)	+0. 160 (0. 121)	−0. 373 (0. 059)	----------
Summer	0. 912	3. 096	−0. 867 (0. 098)	+0. 274 (0. 144)	−0. 434 (0. 079)	----------
Winter	0. 939	1. 898	−0. 850 (0. 086)	+0. 253 (0. 127)	−0. 330 (0. 061)	+0. 380 (0. 216)
Summer	0. 922	1. 806	−0. 841 (0. 096)	+0. 350 (0. 147)	−0. 386 (0. 082)	+0. 384 (0. 243)
Winter	0. 847	0. 606	−0. 944 (0. 133)	+0. 055 (0. 193)	----------	+0. 844 (0. 314)
Summer	0. 830	0. 728	−0. 972 (0. 136)	+0. 083 (0. 201)	----------	+0. 803 (0. 334)

[1] The general form of the least squares regression in these analyses is:

$$\log Q_b = \log a + b_1 \log P_b + b_2 \log P_p + b_3 \log P_o + b_4 \log Y.$$

The numbers in parentheses are the standard errors of the regression coefficients. Prices and income deflated by C.P.I.

1953–59 are presented in table 8. They apply to only 7 years in contrast to the 12 years covered by the regression equations presented in tables 7 and 9. They are of primary interest with respect to differences in price elasticities suggested for beef between summer and winter.

In these equations summer demand is more elastic than winter demand. The price elasticity figures for beef in winter approach −1.0. In summer they are considerably larger. The large negative cross elasticities suggested for broiler prices, however, temper any enthusiasm one might have for these large differences. Likewise, the income elasticity figures are negative contrary to logic.

Demand Elasticities (Single Equation Approach)

Estimates of elasticities for the 12-year period (1948–59) from the regressions using consumption as the dependent variable are shown in table 9. Very little difference was demonstrated between the coefficients in the summer and winter equations. The direct-price elasticities for beef all ranged between −0.84 and −0.88 when broiler consumption was included in the analysis. Because all of the cross elasticities for broilers were negative and statistically significant as well, another analysis in which broiler prices were not included was run. In this case the direct-price elasticities for beef approached −1.0. The summer elasticity figure was slightly larger than that for winter. The difference cannot be considered significant, however.

It is also interesting to note the other effects resulting from the dropping of broiler prices from the analysis. Whereas the price of pork appeared as an important variable in the first two analyses in both summer and winter, it was not so when broilers were excluded. Instead, the income coefficient became more important. Although the corresponding coefficients are not shown in table 9 the same result occurred when time was substituted for discretionary income in the regression equation. The coefficients for time increased in size while those for pork decreased. The results from these different combinations would seem to suggest that income probably is important in the case of beef, but because of related trends in income and broiler consumption, the precise influence cannot be ascertained.

General Conclusions

These regression analyses suggest that seasonal differences in demand for beef are smaller than those for pork and broilers. In fact, the statistical evidence of a real difference in either level or structure is indeed meager. The elasticities generated from the reduced form equations for the 7-year period, 1953-59, were the only ones that suggested that a difference might exist, but the coefficients other than those for beef prices in these equations were subject to question.

Summary

This paper has investigated the likelihood that real differences exist in consumer demand for beef, pork, and broilers between seasons within a year. Seasonal movements in retail prices for beef and pork cannot be explained by changes in supply or consumption alone. This indicates that the demand for each meat is not stable throughout the year but differs seasonally in a definite pattern.

Simply plotting retail prices against per capita consumption data on a quarterly basis indicates the general nature of these differences. The greatest difference is noted for pork. Winter demand is much stronger than summer demand. On the other hand, the demand for broilers was stronger in summer. Differences for beef were less obvious. Both prices and consumption, however, were generally above average during the third quarter.

Regression analyses for each of the meats were run using quarterly data and separating data for the first and fourth quarters from those in the second and third quarters. Short run elasticity coefficients were obtained for pork and broilers using time series data for 1953–59. Similar estimates were made for beef over the 12-year period, 1948–59. The coefficients obtained generally supported the original hypotheses suggested by the simple scatter diagrams. All of the analyses showed a major difference in the structure of demand for pork between summer and winter. Direct price elasticities of -0.9 to -1.2 for winter and -0.55 to -0.75 for summer were indicated.

Like most studies, this one suggests that further effort might be profitable in more clearly determining the actual time span in which seasonal differences exist. The division of time into summer and winter was somewhat arbitrary. In the case of beef, inclusion of data for the second quarter with those for the third obscured some of the differences that appeared to exist originally.

Recognition of seasonal differences in demand should be of particular interest to specialized, year-round producers of hogs or broilers, as well as packers and processors. An individual must always make his own production decisions on the basis of what appears to be of greatest advantage to him. This analysis suggests some clear disadvantages to producers as a group from marketing a much higher proportion of the total supply of pork during the summer months, even though farm prices for pork historically have been highest during July, August, and September. Small changes in production at this time can result in major price breaks. In contrast, broiler producers as a group appear likely to profit most years by planning to reach maximum production during the summer. Again, however, an individual will profit most by correctly anticipating what other producers will do, then acting accordingly.