DEMAND FOR BROILERS IN THE UNITED STATES

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY

Glenn W. Woodley

1959

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by

Glenn W. Woodley

AN ABSTRACT

Submitted to the College of Agriculture of Michigan
State University of Agriculture and Applied
Science in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics

1959

Approved by Lester V. Manderscheid

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ABSTRACT

The two objectives of this study were: (1) to examine and explain the relation of various factors affecting the demand for broilers and to determine a model to estimate the demand for broilers in the United States and (2) to examine the relative demand for broilers with respect to beef and pork and to test the hypothesis that the demand for broilers has increased relative to the demand for beef and pork.

The demand relationships examined in this study were: (1) the demand for broilers, (2) the demand for beef relative to broilers, (3) the demand for pork relative to broilers and (4) the demand for beef relative to pork. Two approaches, graphic and multiple regression analysis, were used in this study. The graphic analysis was used to examine the relationship between the price and quantity and to determine whether any shifts occurred in the relationship during the period studied. A further use of the graphic analysis was to determine the time period and appropriate mathematical function to use in the regression analysis. The purpose of the regression analysis was to obtain more precise estimates of the relationships than was obtained from the graphic analysis.

In the graphic analysis, actual and relative time series data for the retail price and per capita consumption of the commodities were plotted with price or price ratio on the vertical axis and consumption or consumption ratio on the horizontal axis. The time periods examined were 1940 to 1958 for the actual and relative demand for broilers and 1925 to 1958 for the demand for beef relative to pork. This analysis indicated changing relationships between price and consumption data

prior to 1950 and more stability in the relationships after 1950. Since the relationships after 1950 appeared to remain stable, single equation least squares regression equations were fitted to the data for 1950 to 1958. Two models were fitted for the demand for broilers with retail price and per capita consumption of broilers each considered as the dependent variables; all relative demand models were fitted with the price ratio as the dependent variable. Per capita disposable income was included in each model as a demand shifter. Although each of the models estimated the annual observations with a high degree of accuracy, reliability of the regression coefficients is questionable due to the high intercorrelation existing between the independent variables included in the models; this in turn limits the reliability of any statements made concerning the various elasticities.

This study indicated that prior to 1950 the demand for broilers increased relative to the demand for beef and pork while the demand for beef increased relative to the demand for pork. Since 1950 the demand for broilers and the demand for broilers relative to the demand for pork appeared to remain stable while the demand for beef relative to the demand for broilers and pork increased. Availability and improved quality of broilers were considered as the most important factors which caused the increased preference and demand for broilers prior to 1950.

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ACKNOWLEDGEMENTS

The author wishes to express his appreciation to the many people who made the completion of this thesis possible.

The author wishes to express a very special debt of gratitude to Mr. Lester V. Manderscheid for his helpful assistance during the preparation of this manuscript. The author's association with Mr. Manderscheid was the most rewarding experience of his graduate study.

The author is indebted to Dr. L. L. Boger and the Department of Agricultural Economice for the opportunity to study at Michigan State University and the financial assistance while at Michigan State.

Credit is due to Mrs. Helen Westman and other members of the statistical pool for their cooperation with the statistical computations. Many thanks are due to Miss Beverly Hamilton and Mrs. Sandra Rogers for their cooperation in typing the first draft of this thesis.

The author also wishes to express his appreciation to his fellow graduate students for making his graduate study at Michigan State most enjoyable; their association during his graduate study was most appreciated.

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Chapter I

INTRODUCTION

As an introduction to this study, this chapter is to present the objectives of the study and to describe some of the changes and trends in the broiler industry.

Objectives of the Study

The first objective of this study is to examine and explain the relation of various factors affecting the demand for broilers and to determine a model to estimate the demand for broilers in the United States.

The second objective of this study is to examine the relative demand for broilers with respect to beef and pork and to test the hypothesis that the demand for broilers has risen relative to that of beef and pork.

Growth of the Broiler Industry[1]

Technological advances in production, processing and packaging, transportation and marketing have enabled the broiler industry to

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[1] Parts of the material presented in this section without footnotes have been developed from previous articles and publications concerning the broiler industry. Among these are: Herman Bluestone, Delmarva-Maryland-Delaware Broiler Statistics and related data...1934-37, issued cooperatively by the Agricultural Extension Services of the Universities of Maryland and Delaware and the Maryland-Delaware Crop Reporting Service, Agricultural Marketing Service, United States Department of Agriculture, August 1958; Edward Karpoff and John J. Scanlan, "Eggs and Poultry," Marketing, The Yearbook of Agriculture-1954, United States Department of Agriculture, pp. 467-75; A.B. Kennerly, "The Broiler Industry in Transition," Texas Agricultural Progress, Volume 4, No. 4, July-August 1958, pp. 7-9; W. P. Mortenson, Trends in the Poultry Industry... Effects on the Midwest, Bulletin 523, Agricultural Experiment Station, University of Wisconsin, Madison, Wisconsin, June 1956; and Richard F. Saunders, Contract Broiler Growing in Main, Bulletin 571, Maine Agricultural Experiment Station, University of Maine, Orono, Maine, May 1958.

expand in the last twenty-five years. A discussion of the changes occurring in the broiler industry as a result of these factors is an attempt to provide sufficient background information to describe the setting of this study.

Prior to the 1930's poultry meat available to consumers was essentially a by-product of egg production. Cockerels and adult birds that had outlived their usefulness in laying flocks were the main sources of Sunday chicken dinners. Therefore, the quantity of poultry meat available varied widely according to the seasons. When broilers were beginning to become economically important during the early 1930's, three important things happened in the poultry industry. (1) With the greatest emphasis on commercial size flocks, light breed chickens gradually replaced meat breeds for laying flock replacements. (2) As the technique of sexing chicks became perfected, only female chicks were sold with the male chicks being destroyed under the assumption that it was unprofitable to grow them out. (3) Feeding, breeding and management practices were improved so that more eggs were produced per layer, thus requiring fewer layers to provide the eggs necessary to supply the market demand. These changes in production methods meant a decrease in the supply of poultry meat from laying flocks.[2] These developments in the poultry industry created a greater opportunity for specialized production of poultry meat. As a result of these changes specialized or commercial broiler production was developed to meet this opportunity.

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[2]Mortenson, op. cit., p. 5.

Production. It was 1934 when broiler production had expanded to the point where the United States Department of Agriculture began to collect separate statistics for the production of commercial broilers and farm chickens; annual production estimates are shown in Figure 1 for both broilers and total chicken meat.[3] In 1934 farm chickens were still the source of nearly all chicken meat produced in the United States. At that time broilers made up only about 4 percent of total chicken meat production. In the years following 1934 the broiler industry rapidly expanded. From 1934 through 1951 broiler production increased at an average annual rate of 21 percent. In 1951 broilers became the most important source of chicken meat by accounting for 51 percent of the total chicken meat produced in the United States. Since 1951 the year to year percentage increases have not been as large as those in the earlier years, and the average annual rate of growth was only 12 percent. For the entire period 1934 to 1958 the average rate of growth was 19 percent.[4] However, actual growth of production has

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[3]Commercial broiler production is meant to apply to specialized broiler enterprises where broilers include all young chickens of the heavy or cross-breeds raised only for meat production. More precisely, the term broiler generally refers to a young chicken (usually under 16 weeks of age) of either sex that is tender meated with soft, pliable smooth-textured skin and flexible breastbone cartilage.

Farm chicken production is usually used to denote the production of chickens on farms not including commercial broilers. Farm chicken meat is largely a by-product of egg production in the form of old hens and roosters.

Data for total chicken meat production shown in Figure 1 includes broiler and farm chicken meat production. Farm chicken meat production is the area between the two curves.

[4]Averages for the periods 1934 to 1951 and 1934 to 1958 include the two years, 1944 and 1946, when production declined below the production of the previous year.

Figure 1

Commercial Broiler and Total Chicken Meat Production
United States, 1934 to 1958

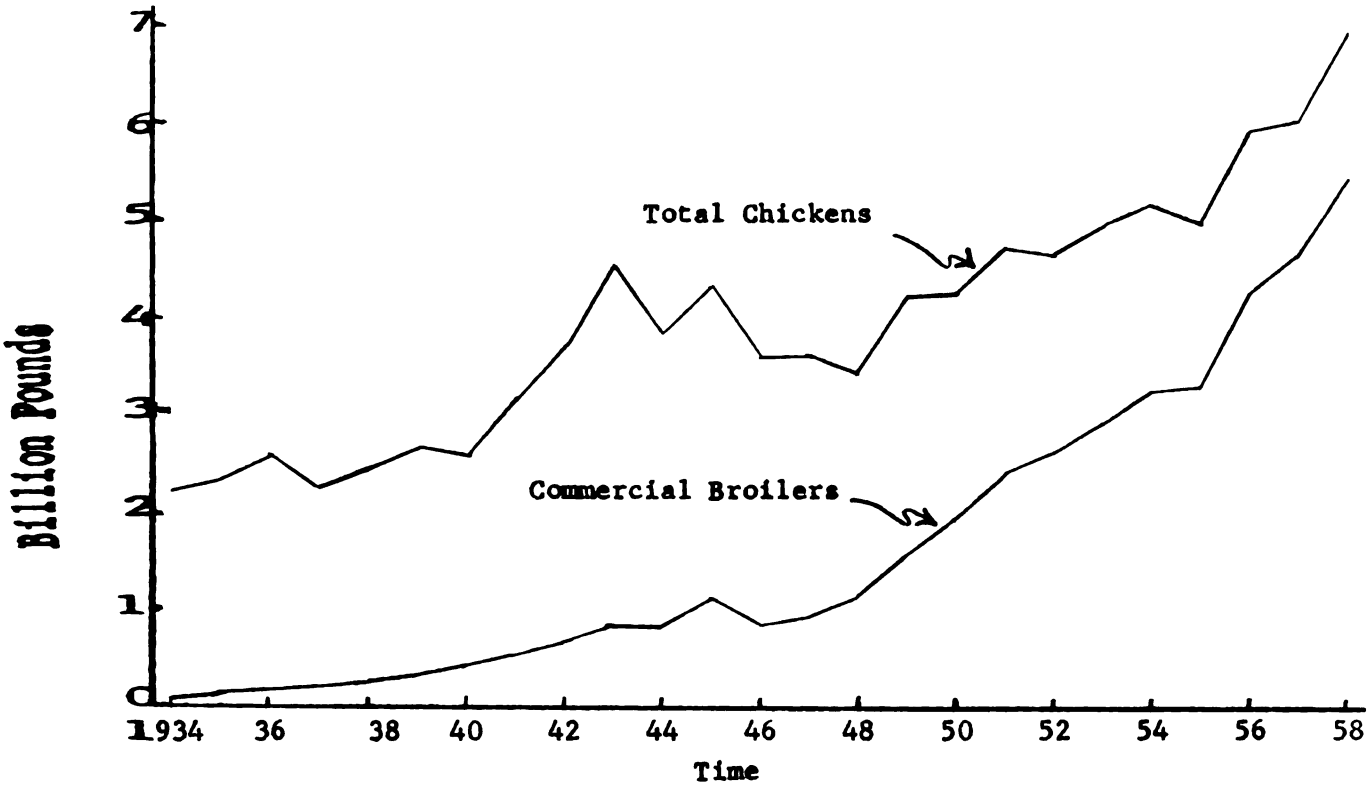
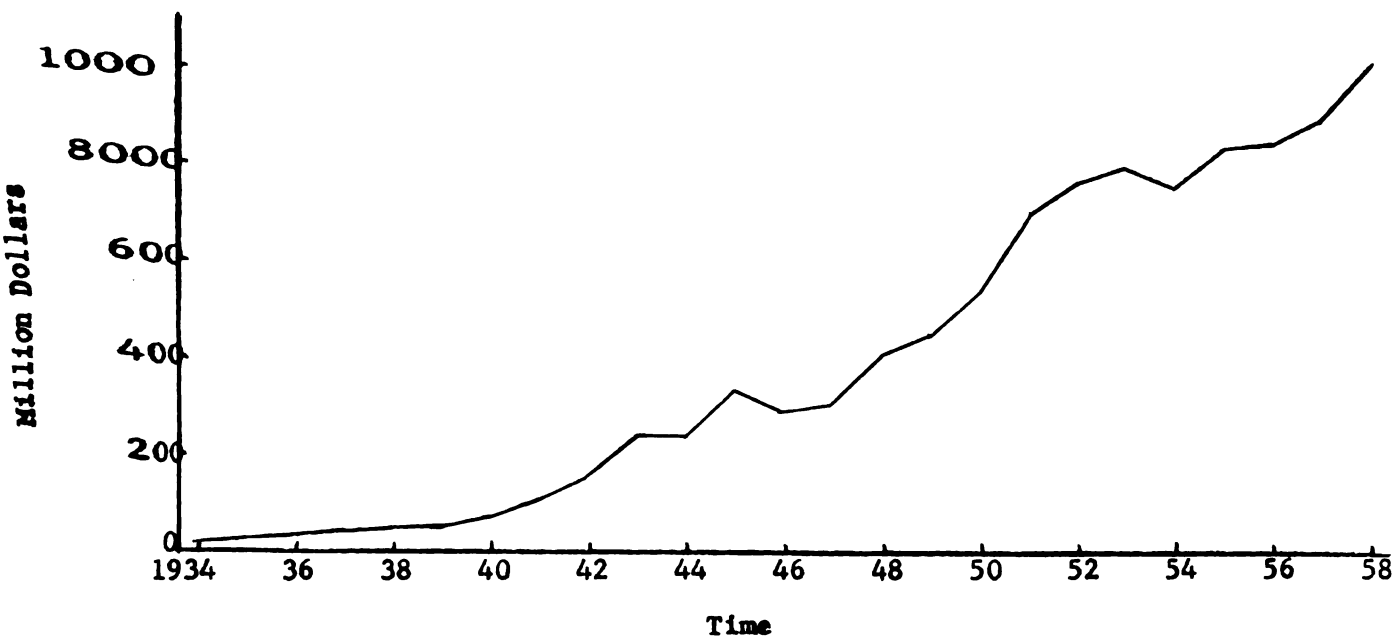


Figure 2

Gross Income from Commercial Broilers
United States, 1934 to 1958



been larger in the 1950's than in the previous years. In fact actual growth in the last three years has been the largest in the history of the broiler industry. Production of broilers in 1958 exceeded 5 billion pounds which was an all time high, an increase of 16 percent over 1957 and 179 percent over 1950 production, or represented 78 percent of the total chicken meat produced.

During the period of rapid growth occurring in the broiler industry, production of farm chickens increased with sharp increases occurring in the early war years until reaching a maximum in 1943. Production rose slightly in 1945, but since then production has continued in a downward trend. Since 1952, farm chicken production has decreased below the 1934 level of production.

Combined broiler and farm chicken production rose rapidly in the years following 1940. During the war years poultry made up most of the slack in the meat supply, and this probably resulted in many people cultivating a taste for chicken meat. Total production of all chicken meat declined in the years following the war up through 1948 and has since tended to increase with slight declines occurring in 1952 and 1953.

Gross Income. From $34 million in 1934 gross income from broiler production as shown in Figure 2 has rapidly increased. Large increases in gross income from broiler production occurred in the war years, and even larger increases occurred in the late forties and early fifties. In 1958, broiler production became a billion dollar business at the farm level in the United States, the highest in the history of the broiler industry. Only four times since 1934 has annual gross income

from broiler production decreased. Two of these were only very slight declines of less than $6 million; the two much larger declines in gross income occurred in 1946 and 1954. The 1946 decline in gross income was accompanied by a decline in pounds produced with a rise in price per pound while the 1954 decline was accompanied by a rise in pounds produced with a decline in price per pound.

Vertical Integration. Dependent upon the quantity of broilers produced were the processors and the feed dealers and manufacturers who had developed businesses in the specialized broiler areas. As production expanded in the specialized production areas, it encouraged these businesses to expand their facilities to handle the increased quantities of broilers being produced. Increased production required additional investments for these businesses and, in order to keep their operating costs at low levels, they had to maintain a steady volume of production throughout the year. This resulted in the integration of various segments within the industry. Contract farming or vertical integration developed rapidly in the poultry industry. Broilers are almost entirely produced on some type of integrated basis; in most areas the feed dealers are the major contractors of broiler production but some contracting is done by the processing plant.[5] Integration in the broiler industry has resulted in placing larger quantities of broilers on the market with less seasonal variation in the supply and has transferred some of the uncertainties faced by growers to the contracting agencies.

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[5]United States Department of Agriculture, Contract Farming and Vertical Integration in Agriculture, Agriculture Information Bulletin No. 198, July 1958, p. 17.

Technological Advancements. In spite of the downward trend in the farm price of broilers since the late forties, expansion in broiler production has been made possible by greater efficiency in production. Increased feed efficiency of broilers and other technological advances in production through research development have made much of this possible.

In the earlier years of the broiler industry most of the processing was done either on the farms or by small processors who had limited equipment and facilities or the live birds were shipped from the production areas to processing plants located in the central markets. In recent years processing plants in the production areas have greatly increased in size and have replaced obsolete equipment with modern facilities which have resulted in lower unit cost and improved sanitary conditions. One of the greatest developments in processing was the adoption of the "assembly line" method of processing broilers.

Advancements in refrigeration and transportation have extended the market areas of various broiler producing areas. Advancements made in motor transportation have caused a shift in the transportation of broilers from rail to motor carriers. Time in transit for broilers from the processors to the market areas has been greatly reduced by motor carrier shipments due to the availability and flexibility of their services, and hence better quality broilers now reach the retail outlets.

Changes at the retail level have also occurred over the years. Years ago, poultry products were regarded as of minor importance in retail sales and little attention was directed to the packaging and

merchandising of poultry products. In the years prior to about 1950, most of the broilers sold at retail outlets were either New York dressed or whole eviscerated. In recent years, most of the broilers marketed at retail have been sold as ready-to-cook broilers either as cut-up broilers or cut into specific parts; this added service was done to meet the demands of consumers. Many retailers have recently directed more attention to the merchandising aspects of displaying the product and provide a continuous supply of broilers for their customers.

To this point the changes occurring in the production, processing and marketing of broilers have been presented, but no attempt has been made to describe the effects of these changes on the price level or per capita consumption of broilers. The remaining portion of this chapter will emphasize these changes.

Prices. Farm prices of broilers in the United States, as shown in Figure 3, rose in 1940 above the 1939 level of 17.0 cents per pound, which is still the lowest farm price in the history of the broiler industry, and continued in an upward trend through 1948. By 1948 farm prices had risen to 36.0 cents per pound. Since 1949 the trend in farm prices of broilers has been downward. In only three years since 1949 have farm prices showed an increase over the preceding year, and since 1953 farm prices have declined in every year except one. In 1958 the average price per pound received by producers declined to 18.5 cents. This was the fourth lowest annual average price received by producers since statistics have been recorded for commercial broilers and the lowest price since 1941.

Figure 3

Average Retail and Farm Prices of Broilers
United States, 1940 5o 1958

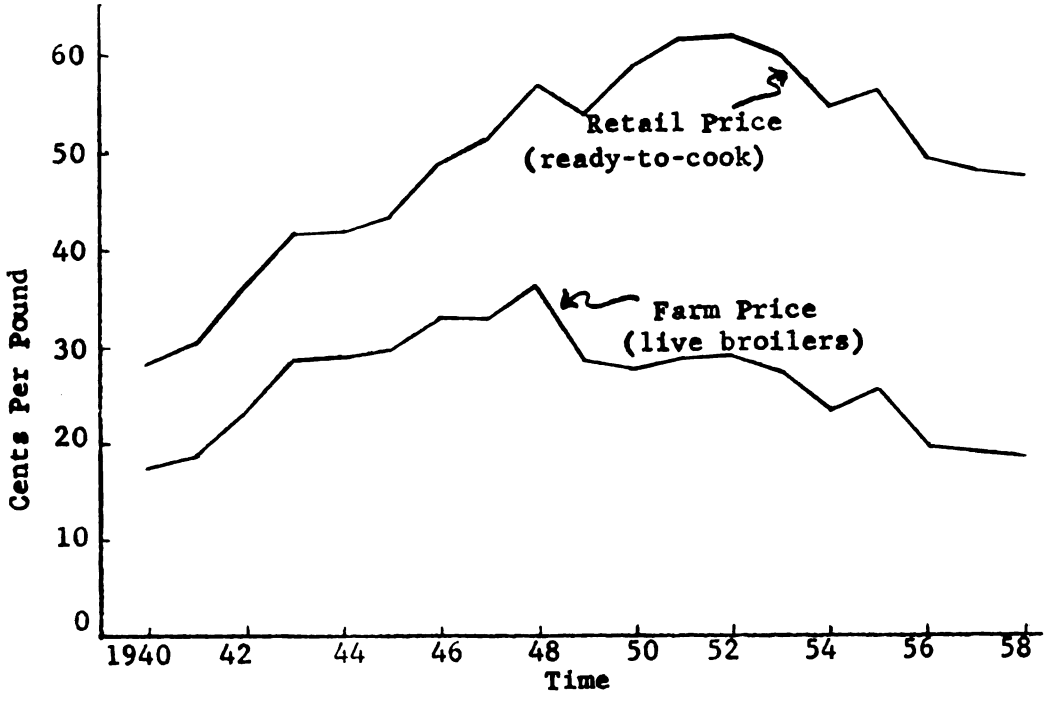
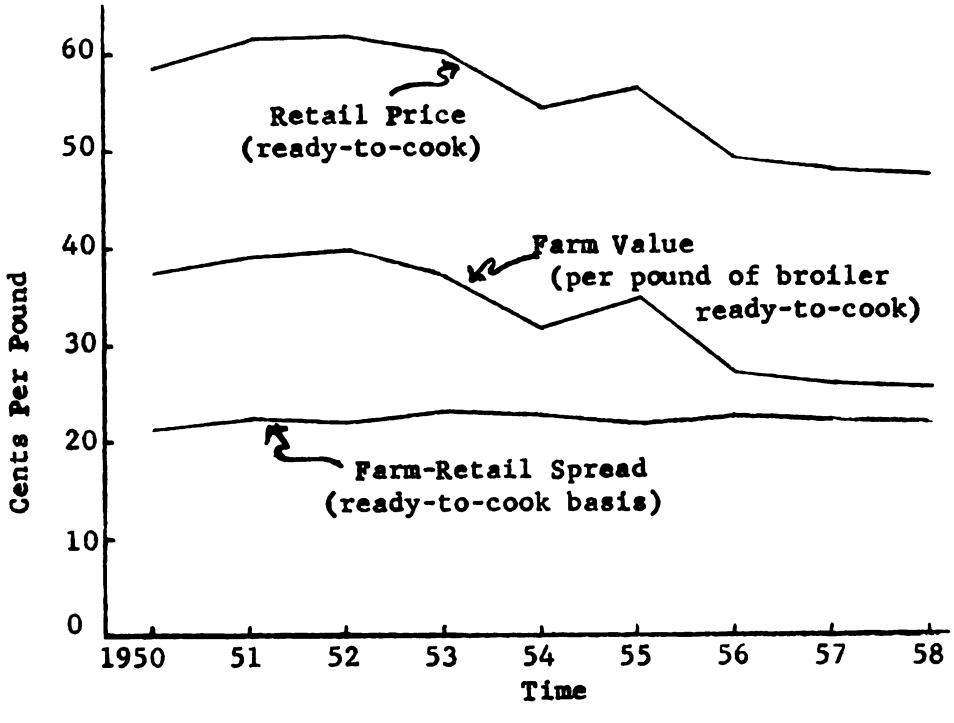


Figure 4

Retail Price, Farm Value and Farm-Retail Spread for Broilers
United States, 1950 to 1958



Retail prices of broilers, as shown in Figure 3, have tended to move in the same direction as changes in farm prices since 1940 except for two years. Retail prices of broilers increased in each year from 1940 through 1952 except for 1949 and reached their highest point of 61.6 cents per pound in 1952. Since 1953 the retail price of broilers tended downward and declined to 47.4 cents per pound in 1958. Only one year since 1952, 1955, showed a rise in the retail price above the previous year.

The farm-retail price spread[6] for broilers, unlike that for many other food products, has not tended upward in recent years. This is indicated by the data for the retail price and farm-value of broilers shown in Figure 4. Since 1950 the farm-retail spread has remained relatively stable and has fluctuated only in the range of 21.1 to 23.0 cents per pound. However, the farmers' share of the retail price has fallen from 64 percent in 1950 to 54 percent in 1958 because of the declining price of broilers.

Declining farm and retail prices and relatively stable farm-retail spreads indicate that the broiler and poultry industry have increased efficiency in production, processing and marketing enough to offset costs from increased services, higher wages for labor and price increases of other inputs.

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[6]Farm-retail price spread as used here means the difference between the retail price and farm value where farm value is the payment to producers for 1.37 pounds of live weight which is equivalent to 1 pound of ready-to-cook weight.

Per Capita Consumption. Annual per capita consumption of chicken meat in the United States, as shown in Figure 5, fell within the range of 13 to 16 pounds per person in the period from 1909 through 1937. Although a decline in per capita consumption of chicken meat of only 0.9 pound occurred in 1938, it was enough to drop annual per capita consumption to the lowest point since 1909 which is the beginning date of available statistics. Per capita consumption rose rapidly during the war years with peaks in 1943 and 1945 of 23.0 and 21.6 pounds respectively. By 1947 consumption had fallen to 18 pounds. This was followed by an upward trend in per capita consumption in the following years. Since 1947 the only major decline in consumption occurred in 1955. Per capita consumption of chicken meat rose to an all time high of 28.5 pounds in 1958. The rapid increase in per capita consumption of chicken meat in recent years can be attributed to the increased per capita consumption of broilers which is also shown in Figure 5. In the mid-thirties when the broiler industry was in its infancy, per capita consumption of broilers was less than one pound. By 1940 per capita consumption of broilers had reached two pounds. Five years later broiler consumption had increased to six pounds per person. Per capita consumption declined in 1946 to five pounds but has increased rapidly in each of the years since then. In 1958 per capita consumption of broilers rose to 21.7 pounds or 76 percent of total chicken meat consumption.

Relative trends. Only the trends in the actual broiler prices and per capita consumption have been mentioned above. Since broilers must compete at retail outlets it is perhaps appropriate to examine the

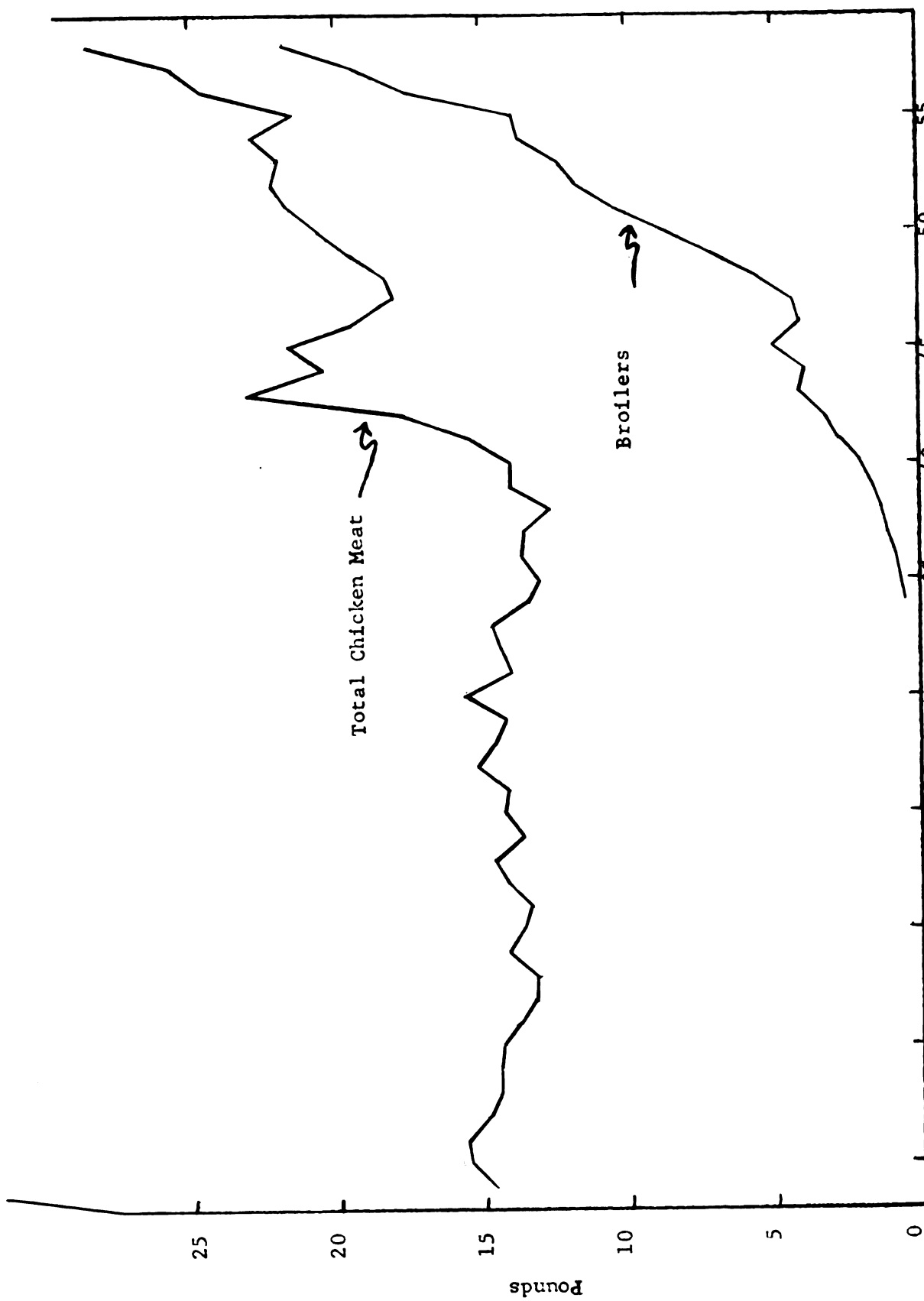

Figure 5. Per Capita Consumption of Total Chicken Meat and Broilers, Ready-to-Cook Basis, United States, 1909 to 1958

changes in retail broiler prices and consumption relative to the retail prices and consumption of two products, beef and pork, assumed to be their close competitors.

The trends of the ratios of the retail prices of beef and pork to the retail price of broilers, as shown in Figure 6, rose over the period 1940 to 1958. With the exception of the period 1948 to 1953, the ratios moved in patterns similar to each other. In the period 1948 to 1953, the ratios moved in diverging directions but came back together in 1953. Through the entire period the ratio of the price of beef to the price of broilers exceeded the ratio of the price of pork to the price of broilers.

The ratios of the per capita consumption of beef and pork to the per capita consumption of broilers, as shown in Figure 7, tend to change over time in similar patterns. For both there is a definite downward trend. In each of the years but two, 1947 and 1953, changes occurring in the ratios have been in the same direction. The ratio of the per capita consumption of pork to broilers exceed or equaled the ratio of the per capita consumption of beef to broilers from 1940 through 1952, but since 1953 the pork ratio has been less than the beef ratio.

To summarize this section, new technology in the broiler industry in recent years has made possible the marketing of larger quantities of broilers at lower prices. Because of this new technology and steadily declining retail prices relative to competing meats, broilers now comprise a larger proportion of the diet of the American consumer.

Figure 6

Retail Price Ratios of Beef and Pork to Broilers
United States, 1940 to 1958

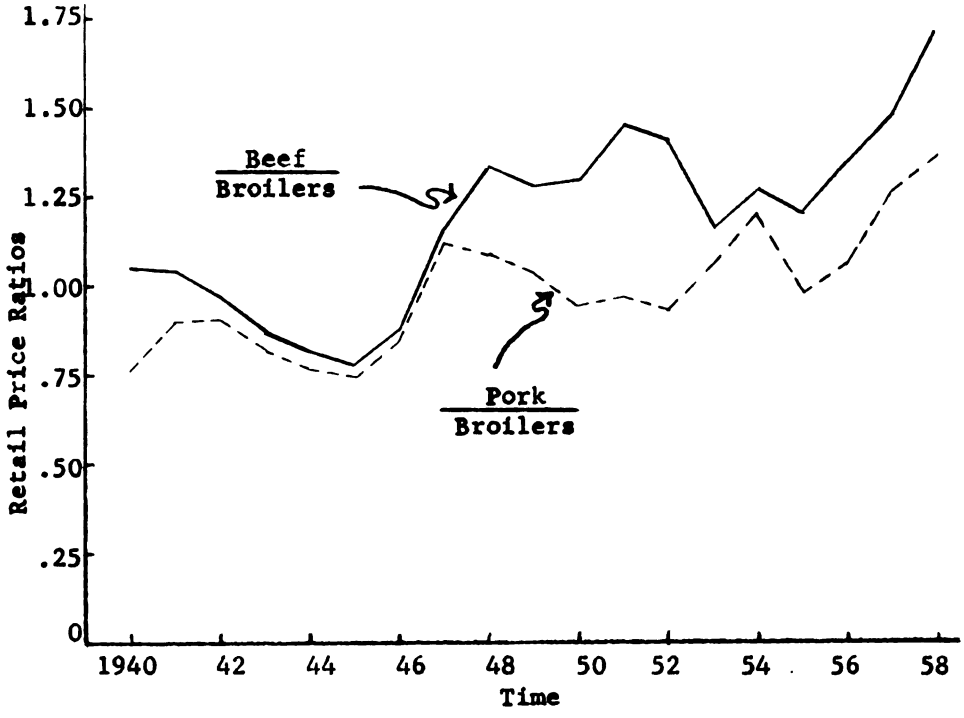

Figure 7

Per Capita Consumption Ratios of Beef and Pork to Broilers
United States, 1940 to 1958

Chapter II

CONCEPTS OF DEMAND

Construction of economic models involves knowledge of the relevant economic theoy before statistical estimation because statistical methods require knowing something about the model underlying the problem under consideration. Therefore the purpose of this chapter is to present economic theories and concepts of demand which are believed to be relevant to this study; discussion will be directed to demand curves, relative demand and demand elasticities.[1]

Demand, as used in economics, is defined as a schedule of the various quantities of a good which consumers are willing to buy from the market at various alternative prices, other things being equal.

Leftwich[2] lists the most important factors affecting the quantity of goods which consumers will take from the market as: (1) the price of the good, (2) consumers' tastes and preferences, (3) the number of consumers under consideration, (4) consumers' incomes, (5) the prices of related goods, and (6) the range of goods available to consumers. When the latter five factors are held constant, as required by the stated definition of demand, we assume an inverse relationship to

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[1]Generally accepted economic theories and concepts which are presented in this chapter without footnotes are developed from material presented in various textbooks in economics. See: Joe S. Bain, Price Theory, Henry Holt and Co., New York, 1952; Kenneth E. Boulding, Economic Analysis, 3rd Edition, Harper & Brothers, New York, 1955; J. R. Hicks, Value and Capital, 2nd Edition, Oxford University Press, London, 1946; Richard H. Leftwich, The Price System and Resource Allocation, Rinehart & Co., Inc., New York, 1955; George J. Stigler, The Theory of Price, Revised Edition, Macmillan Co., New York, 1952; Sidney Weintraub, Price Theory, Pitman Publishing Corporation, New York, 1949.

[2]Leftwich, op. cit., p. 27.

exist between the price of the good and the quantity taken. Hence, the higher the price of the good the less consumers will take, or the lower the price of the good the greater the quantity consumers will take. Thus, the stated definition is essentially the same as the "law of demand" as formulated by Marshall.[3] It states that the greater the amount to be sold, the smaller must be the price at which it is offered in order that it may find purchasers; or in other words, the amount demended increases with a fall in price and diminishes with a rise in price. Marshall also stated that the ultimate regulator of all demand is consumers' demand.[4]

Demand Curves

In the presentation and discussion of the definition of demand the inverse relationship existing between the price and quantity taken of the product was introduced. This relationship can be summarized into a demand schedule which shows the amount of the product that will be taken at various prices. When this schedule is presented graphically with price on the vertical axis and quantity on the horizontal axis and the various points are connected, the resultant is referred to as a demand curve. Since there is an inverse relationship between price and quantity, the demand curve slopes down and to the right. In order that the quantity demanded at each price level has a meaning, the time period involved must be specified. Thus, a demand curve shows the quantities of a product per unit of time which consumers will take from the market at various alternative prices, other things being equal.

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[3]Alfred Marshall, Principles of Economics, 8th Edition, Macmillan & Co., London, 1920, p. 100.

[4]Ibid., p. 92.

Demand curves as discussed in this section may apply to either the individual consumer or market demand curves for products for both are defined in essentially the same way. The market demand curve for a product is an aggregation of the demand curves of all individual consumers for the product.

A distinction should be made between a change in demand and movement along a single demand curve for a change in the quantity taken does not necessarily mean that there has been a change in demand. Movement along a given demand curve refers to a change in the quantity taken resulting from a change in the price of the product with other things influencing demand remaining unchanged. A change in demand refers to a shift in the entire demand curve. It implies that consumers are now willing to take a different quantity of the product at each price level. An increase in demand refers to the case where the quantity taken increases at all prices; similarly, a decrease in demand is where the quantity taken decreases for each price. Circumstances causing shifts in the demand curve to occur are changes in the "other things being equal" phrase of the definition of demand, such as changes occurring in the incomes or the tastes and preferences of the consumers.

Relative Demand

Since relative demand is being studied in this thesis, a section on the theory of relative demand appears to the relevant of this chapter.

Articles by Clawson[5] and Staehle[6] were attempts to revive the use of relative prices to the position in economic analysis which they lost to the influence of income during the "keynesian revolution." Although the article written by Clawson preceded the one by Staehle, only the latter will be discussed in detail in this chapter. The reason is that the article by Staehle pertains more to the theoretical development of the analysis while Clawson directs his presentation more to the features and implications of graphic methods which relate the ratio of prices of two commodities to the ratio of their quantities. A discussion of the article by Clawson will be included in Chapter III.

Staehle states that:

> "In those old-fashioned branches of economic reasoning relative prices used to play a preponderant role" and "he (Staehle) believes that the moment has come to put in a modest plea in favor of increased attention to the influence of relative prices."[7] "If the neglect of the effect of changes in relative prices were rigorously limited to theoretical work, with conclusions clearly labeled as inapplicable to the real world, there would be little harm in this type of economics. The results would simply fall into that already so heavily filled box marked 'Partial, i.e., incomplete analysis: Never to serve economic policy'."[8]

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[5]Marion Clawson, "Demand Interrelations for Selected Agricultural Products," Quarterly Journal of Economics, Vol. 57, February 1943, pp. 265-302.

[6]Hans Staehle, "Relative Prices and Postwar Markets for Animal Food Products," Quarterly Journal of Economics, Vol. 59, February 1945, pp. 237-279.

[7]Ibid., p. 237.

[8]Ibid., p. 239.

Staehle developed a theoretical foundation for the individual consumer demand for a commodity. He assumed the demand of an individual for a given commodity (X) to be dependent upon his real income (r) and the price (p) of the commodity. He assumed the particular relationship to be

$$X = f(r) + \phi(P).$$

If this function is considered to be common to all consumers and there are n of them, then the consumption per person would be

$$\bar{X} = \frac{\Sigma f(r)}{n} + \frac{\Sigma \phi(P)}{n}.$$

If the influence of income were linear,

$$f(r) = a + br,$$

consumption per person would become

$$\bar{X} = f(\bar{r}) + \frac{\Sigma \phi(P)}{n}.$$

That is to say that if the individual function connecting consumption and income, f(r), were linear, average consumption equals the consumption that corresponds to the average income. In that case the average income is the only parameter of the frequency distribution of incomes which needs to be taken into account. The simple additive relation assumed between the influence of income and price is quite arbitrary. It means that a price change will induce individual consumers to change their levels of consumption quite independent of their incomes.[9]

Demand Elasticities

The theory presented above assumed that the factors affecting demand were constant except for the price of the commodity; however, in

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[9] Ibid., p. 247.

real world the other factors are constantly changing. The purpose of this section is to present some of the elasticity concepts which are used to distinguish and measure the functional relationships existing in the real world between prices, consumer incomes and quantities of products demanded.

Price Elasticity. Price elasticity of demand, commonly referred to as elasticity of demand, measures the relationship between prices and the quantities taken. It is defined as the percentage change in quantity taken associated with a one percent change in price.

Price elasticity of demand can be measured between two points (arc elasticity) or at a single point (point elasticity). If the two points between which the arc elasticity is being measured are moved closer together, they will eventually merge into a single point; therefore, point elasticity is the same as arc elasticity when the distance between the two points is infinitesimally small.

For a very small change in price, the mathematical expression for the price elasticity of demand is:

$$E_d = \frac{\frac{\Delta q}{q}}{\frac{\Delta P}{P}} = \frac{\Delta q}{\Delta P} \cdot \frac{P}{q}$$

where p is the price and q is the quantity taken.

Income Elasticity. The income elasticity of demand is defined as the percentage change in the quantity taken associated with a one percent change in income or as the ratio of the relative change in quantity taken to the relative change in income. Mathematically this can be expressed as:

$$E_{I_d} = \frac{\frac{\Delta q}{q}}{\frac{\Delta I}{I}} = \frac{\Delta q}{\Delta I} \cdot \frac{I}{q}$$

where q is the quantity taken and I is the income.

If the income elasticy of demand is positive, then an incease in income results in an increase in purchases; this is the case for most goods. If the income elasticity is negative, an increase in income results in a decline in the quantity taken; goods of this nature are usually referred to as inferior goods.

Cross Elasticity. Cross elasticity of demand measures the extent to which commodities are related to each other. It is defined as the percentage change in the quantity taken of one commodity associated with a one percent change in the price of a related commodity. Cross elasticity of demand for a commodity with respect to a second commodity can be expressed mathematically as:

$$E_{x_d} = \frac{\frac{\Delta q_1}{q_1}}{\frac{\Delta p_2}{p_2}} = \frac{\Delta q_1}{\Delta p_2} \cdot \frac{p_2}{q_1}$$

where q_1 is the quantity of the first commodity and p_2 is the price of the second commodity.

If the cross elasticity between the two commodities is positive, the commodities are considered as substitutes for each other. If negative, the two commodities are considered to be complements.

Chapter III

REVIEW OF PREVIOUS STUDIES

The purpose of this chapter is to discuss some of the previous demand studies for poultry and competitive products. Individual studies to be discussed in this chapter vary in nature from the more advanced mathematical and statistical approaches to those largely descriptive and based upon interviews with consumers at the retail level. Some attention will be directed to the techniques used and variables included in the analyses as well as to brief descriptions of the results obtained.

Aggregate Demand for Broilers

Christensen and Mighell[1] suggested that the changes in national demand at the consumer level for chickens and eggs between the two 5-year periods, 1925 to 1929 and 1945 to 1949, were affected by changes in (1) total population, (2) real incomes of consumers and their distributions, (3) food preferences and (4) supplies of substitute foods. Changes in the quantity and value of chicken-meat consumption have been affected by changes in character of the product. The character of chicken meat available to consumers has changed with the large expansion in the commercial broiler business. This would have the effect of expanding consumption of chicken meat even though there had been no change in price relationships between products.[2] They indicate that unpublished studies of the Bureau of Agricultural Economics suggest

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[1] Raymond P. Christensen and Ronald L. Mighell, Competitive Position of Chicken and Egg Production in the United States, Technical Bulletin No. 1018, Bureau of Agricultural Economics, United States Department of Agriculture, August 1950, p. 35.

[2] Ibid., pp. 37-38.

that the elasticity of demand for chickens is higher than for eggs, perhaps as high as -1.0.[3]

Riely,[4] Gieseman,[5] and Parsons[6] used data obtained from the Michigan State University Consumer Panel to study consumer demand for various meat products in Lansing, Michigan.

Riley found that in any given week approximately one-third of the panel families bought some kind of poultry meat and that poultry expenditures made up about 12 percent of the total meat bill over a two-year period. Fryers were the most important chicken product purchased.[7] He used a seven variable regression model to estimate the quantity of poultry purchased. The independent variables included in the model for the period July 1951-December 1952 were:

X_1 = price of beef
X_2 = price of pork
X_3 = price of sausage
X_4 = price of poultry
X_5 = price of fish
X_6 = average weekly income per family

The multiple correlation coefficient obtained was 0.58. Prices of poultry

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[3]Ibid., pp. 43.

[4]Harold D. Riley, Some Measurements of Consumer Demand for Meats, Unpublished Ph.D. Thesis, Department of Agricultural Economics, Michigan State College, 1954.

[5]Raymond W. Gieseman, Changes in Meat Purchases During 1952 and 1953 Related to Family Characteristics, Unpublished M.S. Thesis, Department of Agricultural Economics, Michigan State University, 1956.

[6]Merril M. Parsons, Newspaper Advertising of Meat Products and Its Relation to Consumer Purchases in Lansing, Michigan, During 1956, Unpublished M.S. Thesis, Department of Agricultural Economics, Michigan State University, 1958.

[7]Riley, op. cit., p. 185.

and pork were both significant explanatory variables with the price of poultry being the most important. The price elasticity of demand measured at the mean was -1.43, and the cross elasticity of demand with respect to pork prices was 1.02.[8]

Parson's analysis indicated that when newspaper advertising space during 1956 was allocated among the broad meat groups, poultry ranked third in the classification behind beef and pork. However, when advertising space was allocated according to specific meat items, broilers were given more space than any of the other meat items studied.[9] He used a regression equation which expressed the quantity of broilers purchased as a function of the following variables:

X_1 = price of beef
X_2 = price of pork
X_3 = price of broilers
X_4 = temperature
X_{17} = advertising space featuring broilers as a special

The adjusted multiple correlation coefficient obtained was 0.89. Advertising space for broilers proved to be a highly significant variable in the equation. The regression coefficient for advertising space indicated that at the mean a ten percent increase in the amount of advertising space featuring broilers as a special was associated with an increase of 1.49 percent in the quantity purchased. The amount of advertising space was more closely related to the quantity of broilers purchased than for any other meat studied. The coefficient of simple correlation between advertising space and the quantity of broilers purchased was 0.79. Regression coefficients for the prices of broilers and pork were significantly different from zero at the five percent level.[10]

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[8] Ibid., p. 189.

[9] Parsons, Op. cit., pp. 19-22

[10] Ibid., pp. 71-72.

Baker and Farris[11] investigated the short run consumer demand relationships for broilers. Data used in this study were obtained from thirteen retail food stores in the Lafayette-West Lafayette, Indiana area covering an eleven week period, April 1, 1956 through June 16, 1956. Multiple correlation techniques were used to analyze the data. The combination of independent variables chosen as the best predictor of changes in broiler sales included the prices of broilers, short loins and chuck roast. The coefficient of multiple determination obtained from these variables was 0.933. Using these variables the price elasticity of demand for broilers in the Lafayette-West Lafayette area for the time period studied was estimated to be -1.2. It was pointed out that this coefficient also reflected broiler advertising influence; advertising and price influences of broilers could not be separated because of the relatively high intercorrelation between the two variables. The two cuts of meat most closely associated with broiler sales were short loins and chuck roast; both were found to be competitive with broilers. The cross elasticities of demand for broilers with respect to the price of short loins and the price of chuck roast were 1.6 and 1.3 respectively. It appeared in general that broiler sales were more influenced by the price and advertising of beef cuts than pork cuts.

Nordin, Judge and Wahby[12] set up a detailed model to estimate the retail demand conditions for beef, pork and poultry products. As

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[11]George L. Baker, Jr. and Paul L. Farris, An Empirical Estimate of Broiler Price Elasticity and Cross Elasticities at Retail, Paper presented at the Joint Annual Meeting of The American Farm Economic Association and The Canadian Agricultural Economics Society, Winnipeg, Canada, August 20-22, 1958.

[12]J. A. Nordin, George G. Judge and Omar Wahby, Application of Econometric Procedures to the Demands for Agricultural Products, Research Bulletin 410, Agricultural Experiment Station, Iowa State College, Ames, Iowa, July 1954.

originally constructed, the model was overidentified. Consequently, some of the variables were dropped out to make the model uniquely determined. The variables included in their uniquely determined model were:

Y_1 = per capita quantity of pork sold at retail
Y_2 = retail price of pork
Y_3 = retail price of beef
Y_4 = retail price of poultry products
Y_5 = retail price of dairy products
Y_6 = retail price of oleomargarine
Y_7 = per capita quantity of beef sold at retail
Y_8 = per capita quantity of poultry products sold at retail
Z_1 = time
Z_3 = retail price of other foods
Z_4 = per capita disposable income
Z_5 = weighted average of Z_4 for the 5 preceding years.

Retail prices and disposable income were deflated by the consumer price index. The data were converted to logarithms and covered the period 1921 to 1941. The three demand equations included in their uniquely determined model were:[13]

Pork

$$Y_1 = -0.91Y_2 + 0.60Y_3 + 0.87Y_4 - 1.23Y_5 - 0.91Y_6 - 0.03Z_1 + 0.16Z_3 + 0.76Z_4 + 0.29Z_5 + 2.70$$

Beef

$$Y_7 = 0.53Y_2 - 0.77Y_3 + 0.67Y_4 - 0.22Y_5 - 1.09Y_6 - 0.02Z_1 + 0.29Z_3 + 0.65Z_4 - 0.12Z_5 + 3.06$$

Poultry products

$$Y_8 = 0.12Y_2 + 0.28Y_3 - 0.68Y_4 + 0.22Y_5 + 0.31Y_6 + 0.002Z_1 + .0.36Z_3 + 0.53Z_4 + 0.28Z_5 + 0.42$$

Since the variables are expressed in logarithms, the elasticities can be read directly from the equations. Hence, it can be seen that a one percent rise in the price of poultry products can be expected to

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[13] Ibid., p. 1016.

result in a 0.68 percent fall in the quantity of poultry products purchased at retail and that a one percent rise in income can be expected to result in a 0.53 percent rise in the quantity of poultry products purchased at retail.

Demand studies for products competitive with poultry, which are similar to those presented above, have been published by Shepherd,[14] Wallace and Judge[15] and Working.[16]

Consumer Attitudes and Preferences

Consumers have preferences which influence their choices. It is difficult to isolate these preferences, but since consumers make a selection it is possible to observed some of the factors which may have influence their choice. Discussion to this point has been directed more to the effects of retail prices on consumption. It now seems appropriate to present some of the studies which concern individual consumer preferences and other factors affecting individual purchases.

Harold Smith[17] interviewed 1,156 housewives in Baltimore, Maryland; Trenton, New Jersey; and New York, New York to examine consumer purchases

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[14]Geoffrey Shepherd, Changes in the Demand for Meat and Dairy Products in the United States Since 1910, Research Bulletin 368, Agricultural Experiment Station, Iowa State College, Ames, Iowa, November 1949.

[15]Thomas D. Wallace and George G. Judge, Econometric Analysis of the Beef and Pork Sectors of the Economy, Technical Bulletin T-75, Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, August 1958.

[16]Elmer J. Working, Demand for Meat, Institute of Meat Packing, University of Chicago, Chicago, Illinois, 1954.

[17]Harold D. Smith, Consumer Preferences and Buying Habits for Chicken, Bulletin X-5, September 1951 and Consumer Demand for Chicken as Related to Demand for Total Meat, Miscellaneous Publication No. 112, October 1951, Department of Agricultural Economics and Marketing, Maryland Agricultural Experiment Station, University of Maryland, College Park, Maryland.

and consumer demand for chicken as related to the demand for total meat. Special attention was given to the effects of factors such as consumer income, religion, race and size of family. He found some variations in consumer demand for meat and chicken between the three cities. High income people were found to consume more meat and chicken than low income people. In Baltimore and Trenton per capita consumption of chicken was highest for families making $6,000 or more a year, and for New York consumption was highest in families with incomes between $4,000 and $6,000. Families of less than three members consumed more meat and chicken per capita than larger families. Although large families consumed less meat and chicken per capita, chicken represented a larger part of their total meat consumption.[18] The kind of meat served most frequently in all three cities was beef, pork, chicken and lamb in that order. More than 70 percent of those surveyed served beef more frequently than other meats. Chicken was generally purchased on Friday and Saturday and was served on Sunday. Low income families tended to serve chicken on Sunday more often than high income families.[19]

Raskopf[20] surveyed 3,611 families in Tennessee in 1955 to evaluate the factors believed to affect per capita consumption of broilers. The family characteristics studied in relation to their effects on per capita consumption of broilers were religion, race, occupation, residence, size

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[18]Smith, Consumer Demand for Chicken as Related to Demand for Total Meat, pp. 34-35.

[19]Smith, Consumer Preference and Buying Habits for Chicken, pp. 21-23.

[20]B. D. Raskopf, Consumer Rating of Broilers in Tennessee, Bulletin No. 255, November 1956 and Factors Affecting Per Capita Consumption of Broilers in Tennessee, Bulletin No. 288, August 1958, Agricultural Experiment Station, University of Tennessee, Knoxville, Tennessee.

of family, education of family head, family income, members of family purchasing broilers, preferred method of cooking broilers and per capita consumption of other meats. Raskopf found that small families consumed more broilers annually per capita than large families and that families with higher incomes generally consumed more broilers than did lower income families. He also found that each increase of one year in the education of the head of the family was related to about one-third of a pound increase in annual per capita consumption of broilers.[21]

Branson and Mountney[22] suggested that apparently an "educational rebound" exists against chicken. In their survey of consumers in Houston, Texas they found that the more educated the housewife the greater the likelihood that her family will perfer some meat other than chicken. In the medium income families they found that only 6 percent of the families where the homemaker had a grade school education served chicken less than once a week, compared to 16 percent where the homemaker was college educated.

Chicken was found to be the first choice meat of only 17 percent of the families surveyed in Houston. However, when asked for their second preference, chicken ranked far ahead of any other meat. Chicken was definitely a second choice meat among both high and middle income families; only among low income families was chicken the preferred meat.[23]

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[21]Raskopf, Factors Affecting Per Capita Consumption of Broilers in Tennessee, pp. 3-4.

[22]Robert E. Branson and George J. Mountney, Consumer Attitudes and Preferences Regarding Chicken, Bulletin 895, Texas Agricultural Experiment Station, College Station, Texas, March 1958, p. 9.

[23]Ibid., pp. 3-4.

Most families that had increased chicken purchases during the year indicated that they did so because the family increased in size or because chicken was more economical than other meats.[24]

Lebrun[25] indicated that of the Portland and South Portland, Maine consumers interviewed 78 percent purchased their poultry meat on Friday and Saturday and that nearly 60 percent of the poultry meat was consumed on Sunday. The factors which Lebrun found to be related to purchases of poultry meat included family income, occupation of the wage earner, size of the family and religion.

R. C. Smith[26] examined the relationship between consumer purchases of fryers and such factors as prices of different kinds of meats, quality factors, merchandising practices, income, size of family, and nationality of consumers. He found that approximately 63 percent of the changes in weekly volume of fryer sales in two large retail chain firms in the Philadelphia, Pennsylvania - Wilmington, Delaware area were associated with changes in prices of fryers, stewers, beef, pork loin, veal and lamb. Fryer sales were found to form a pattern opposite that of pork loin. A positive relationship existed between the price of fryers and the price of beef. Price and volume of fryer purchases varied inversely; changes in retail price were found to be associated with approximately 41 percent of the changes in the volume purchased.

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[24] Ibid., p. 7.

[25] Edmond J. Lebrun, Consumer Purchase and Use of Poultry Meat, Bulletin 524, Maine Agricultural Experiment Station, University of Maine, Orono, Maine, January 1954, pp. 10-12.

[26] R. C. Smith, Factors Affecting Consumer Purchases of Frying Chickens, Bulletin No. 298 (Technical), Agricultural Experiment Station, University of Delaware, Newark, Delaware, July 1953, pp. 30-31.

Relative Demand

A somewhat different approach to the measurement of demand is through the use of the techniques of relative demand. In addition to the previously mentioned articles by Clawson and Staehle, other studies using this type of analysis have been made by Szatrowski,[27] Shepherd, Purcell and Manderscheid[28] and Waugh.[29]

The method used by Clawson was completely graphic. In his analysis he presented illustrative charts to portray the relationships between commodities within the meat, fruit and grain groups. The commodities included in the meat group were beef, pork, veal, lamb and chicken. He constructed the charts mentioned above by plotting the price ratios of the two commodities on the vertical axis and the consumption ratios on the horizontal axis. After he plotted the data for the period studied, he then determined the relationship between the variables by inspection and drew a line through the observations to represent the average relationship. He mentioned that the advantage of this type of diagram was that it showed the relation between four variables rather than two as most price-quantity diagrams do. However, he added that about all that can be said from this type of diagram is that a close relation exists

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[27]Zenon Szatrowski, "Time Series Correlated with Beef-Pork Consumption Ratio," Econometrica, Vol. 13, No. 1, January 1945, pp. 60-78.

[28]Geoffrey Shepherd, J. C. Purcell and L. V. Manderscheid, Economic Analysis of Trends in Beef Cattle and Hog Prices, Research Bulletin 405, Agricultural Experiment Station, Iowa State College, Ames, Iowa, January 1954.

[29]Frederick V. Waugh, Graphic Analysis in Economic Research, Agricultural Handbook No. 84, Agricultural Marketing Service, United States Department of Agriculture, June 1955, pp. 48-49; "A Partial Indifference Surface for Beef and Pork," Journal of Farm Economics, Vol. 38, No. 1, February 1956, pp. 102-112; Graphic Analysis in Agricultural Economics, Agriculture Handbook No. 128, Agricultural Marketing Service, United States Department of Agriculture, July 1957, pp. 46-47.

or does not exist between the four variables or that this relation has shifted during the time period studied. Since the extent of a shift is not apparent until a few years after it occurs, this imposes a limitation on using this type of diagram for forecasting purposes.

In one of the charts Clawson plotted the cattle/hog price ratio against the beef/pork consumption ratio, then he drew in two lines to represent the relationship between the two ratios. Years 1899 to 1914 and 1934 to 1939 were found to have identical relationships and were represented by one line. The other line drawn was for the period 1919 to 1933. Years 1915 to 1918 were a transition period and did not fit well with either the earlier or later periods. Among other charts presented with the observations for the chicken/cattle price ratio and chicken/beef consumption ratio, but Clawson did not draw a line of average relation for the observations due to extreme clustering of the dots. He suggested that the relation was slight and uncertain and that the clustering of years probably reduces the reliability of the results considerably.[30] Clawson claimed that none of the charts presented or made and not presented provided any evidence that the general price level or real incomes of consumers affected the relation in any way. Years of widely divergent price and income conditions not infrequently fell close together. The price ratio apparently eliminated most of the effect of changing prices and changing real income.[31]

Clawson stated that if the quantity of beef consumed rose in comparison with the quantity of pork consumed, it would not be unreasonable

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[30]Clawson, op. cit., pp. 271-83.

[31]Ibid., p. 278.

to expect the price of beef to fall in comparison with the price of pork. The closeness of this relation and the extent of the price fall would be significant to producers of each commodity.[32]

The elasticity of the lines of average relation depend upon the shape and position of the line. Straight lines inclined downward to the right always have decreasing elasticity as X increases, whereas curved lines convex when viewed from the point of origin generally have constant or increasing elasticity, although they may be inelastic throughout.[33]

To prove his hypothesis that the principle factor responsible for the deviations in consumption of meat was the relative price of meat, Staehle presented the relationships by graphic analysis. His first step was plotting time series data for annual consumption of meat per person and annual income per person on a diagram with a derived function relating annual meat consumption to levels of income per person.[34] He named the deviations between the two levels of consumption the "influence of price." He then plotted the influence of price and relative retail price of meat which he obtained by establishing the money price for each year and deflating it by the index-number for the cost of food. He then estimated the relation between the two variables and drew a line through the observations to represent the relationship.

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[32] Ibid. p. 265.

[33] Ibid., p. 278.

[34] The function relating annual meat consumption and levels of income per person was derived from family budget data for three levels of income. The function, referred to in Chapter II as f(r), was fitted from this data by graphic interpolation and was found not to deviate substantially from a straight line.

In order to verify his hypothesis he stated that it was necessary to study the relation between the relative price and the influence of price and if the relation was close and exhibited a negative slope, his theory could be accepted as verified.[35] This he obtained. Staehle then proceeded to examine various commodities with the methods described above and with the relative price and quantity ratios as used by Clawson.

Szatrowski, whose article was published about the same time as those by Clawson and Staehle, used multiple regression analysis to statistically examine the relationship between the beef-pork consumption ratio and other time series data for the period 1901 to 1941. In the analysis the beef-pork consumption ratio was as a function of the following variables:

X_1 = time trend
X_2 = beef-pork price ratio
X_3 = consumption ratio of preceding year
X_4 = cattle-hog population ratio
X_5 = corn yield of previous year in bushels per acre
X_6 = income, dollars per capita.

The data were analyzed for two separate periods, 1901 to 1920 and 1921 to 1941, and then for the whole period. Results of the study indicated that the relationship between the beef-pork consumption ratio, the beef-pork price ratio and the beef-pork consumption ratio of the preceding year were essentially the same for the two separate periods.

Shepherd et al. used techniques similar to those described in the above studies to examine the relative demand of beef to pork. In their analysis beef and pork retail price ratios were plotted against beef and pork consumption ratios for the period 1925 to 1952. The plotted observations showed a tendency to cluster around three different lines of relationship, with negative sloped like demand curves. Their analysis

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[35] Ibid., p. 257.

indicated that a shift occurred in the relationship during the years 1932 to 1934 and again in 1947. The line drawn to represent the relationship during the war years was nearly horizontal; they attributed this to the price ceilings in effect during the war which kept the price relationships unchanged regardless of changes in relative consumption. Their analysis revealed that the relative demand for beef rose over the period studied. Further investigation indicated that the demand for beef had increased over the period while the demand for pork had decreased.

Waugh used a still different approach in his analysis. He constructed and attempted to justify what he called "a partial indifference surface for beef and pork." In his analysis he plotted the annual per capita consumption of pork on the vertical axis and per capita consumption of beef on the horizontal axis of what appears to be a cross section of a three-demensional surface. Through each dot representing the combination of beef and pork consumed in the year indicated, he constructed a short heavy line representing the negative adjusted retail price ratio of beef to pork for that year.[36] He then drew in light contour lines to represent a smooth three-dimensional surface. The slope of the contours were drawn at about the same slope as the neighboring observed price ratio lines. These lines conformed to a characteristic feature of indifference curves for when they were extended beyond

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[36]Price ratios were adjusted for the effects of changes in consumer incomes. Waugh in his Journal of Farm Economics article showed contours for both adjusted and unadjusted price ratios and found the two to be essentially the same. He attributed this to the fact that the elasticity of the price ratio with respect to income was small and not significant. In this case he found both price ratios to be a good approximation to a partial indifference surface, but stated that in the general case price ratios need to be adjusted for income effects.

the length of the price ratio lines they did not cross. Waugh believed these contours to be a partial indifference surface for beef and pork alone, indicating the amount of satisfaction obtained from the two commodities. This analysis implies that for each level of money income there is a definite indifference surface for beef and pork.

Although the nature of the studies presented in this chapter vary widely, these studies have been used in formulating the analysis for this study especially in the techniques used and in the selection of the variables for the statistical models.

Chapter IV

METHOD OF ANALYSIS

The purpose of this chapter is to describe and justify the methods of analysis used in this study. Discussion will center on the choice of variables, time periods and statistical functions included in the analysis.

The method of analysis used in this study is similar to that used by Clawson, Staehle and Shepherd et al. This analysis is most closely related to the analysis by Shepherd et al.; the main difference being the introduction of a third commodity, broilers, in the analysis. The methods used in these analyses were previously discussed in Chapter III of this thesis. As a general summary of the graphic techniques used in these analyses, retail price ratios and per capita consumption ratios of the commodities studied were plotted for time series data with price ratios on the vertical axis and per capita consumption ratios on the horizontal axis. Through the plotted observations lines of average relationship were drawn to show the relationship between the price and consumption ratios and the shifts occurring in the relationship during the period. Similar diagrams have been used in this study to examine the relationships, and these have been supplemented by a statistical analysis of the relationships in recent years.

Choice of Variables

If an analysis is designed primarily for use in forecasting and it is assumed that no change in structure has taken place over the period included in the analysis or for which the forecast is made, a single equation using as the dependent variable the item for which a forecast

is desired will be appropriate. If the analysis is designed mainly to estimate the elasticity of demand or other structural coefficients and a single-equation approach is applicable, the independent variables should be those that can be considered as predetermined as by weather, by economic forces in an earlier period or by broad economic forces.[1]

In economic theory demand is usually spoken of in terms of the quantity demanded as a function of prices, but for purposes of prediction most demand studies are now concerned with predicting prices and hence consider the quantities consumed to be predetermined. The author of this study is also more interested in predicting price, and hence price is considered to be the dependent variable in the economic model to be developed.

As a basis for determining the variables to be included in the statistical analysis, an economic model for the demand for broilers can be developed as:

$$P = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_0)$$

where

P = the price of broilers
X_1 = consumption of broilers
X_2 = consumption of farm chickens
X_3 = consumption of beef
X_4 = consumption of pork
X_5 = consumption of turkey
X_6 = consumption of lamb and mutton
X_7 = consumption of fish
X_8 = disposable income
X_9 = population
X_0 = changes in consumption habits or tastes and preferences of consumers

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[1]Richard J. Foote and Karl A. Fox, Analytical Tools for Measuring Demand, Agriculture Handbook No. 64, Agriculture Marketing Service, United States Department of Agriculture, January 1954, p. 8.

A flow diagram of the demand and supply structure for chickens and broilers constructed by Fox[2] supports this economic model. The diagram indicates that the retail price of chickens is directly affected by the consumption of farm chickens and broilers, supply of red meats and turkeys and disposable consumer income.

The retail price of broilers was selected as the price to be included in the model. This would be expected since this is an attempt to measure the consumer demand for broilers. This selection is justified by Foote[3] for he suggests that equations designed to measure the demand for consumer goods should be based preferably on prices at the retail level or, if they are not available, then at the wholesale rather than the local market level.

Population can be eliminated as a variable within the model by expressing consumption of the commodities included on a per capita basis. By doing this trends in consumption due to the effects of population changes are eliminated. Inclusion of data in this form appears to represent the consumption trends of an "average consumer" within the population; however, data in this form can be multiplied by the population and total market data for the commodity are obtained.

Inclusion of all the other variables mentioned previously would result in an equation which would be extremely difficult to handle. If the more important and relevant variables were included first, then it

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[2]Karl A. Fox, The Analysis of Demand for Farm Products, Technical Bulletin No. 1081, United States Department of Agriculture September 1953, p. 49.

[3]Richard J. Foote, Analytical Tools for Studying Demand and Price Structures, Agriculture Handbook No. 146, Agricultural Marketing Service, United States Department of Agriculture, August 1958, p. 23.

would be expected that each additional variable added in a statistical model would add little to the coefficient of multiple determination. Because of the short time period chosen for the statistical analysis, the number of independent variables included should be held to a minimum so that there will be sufficient degrees of freedom to test whether the regression coefficients for the included variables differ significantly from zero. Through the use of economic theory and knowledge of the specific commodities the more important and revelant variables can be selected for possible inclusion in the statistical analysis. Likewise the less important can be eliminated.

Since this study is an attempt to examine the demand for broilers, no questions should arise from the inclusion of the per capita consumption of broilers as a variable in the statistical model. Beef and pork are believed to be the closest substitutes for broilers and have been included in the analysis. Previous studies support this belief.[4]

Fish and lamb are perhaps minor competitors of broilers at the retail outlets. Since per capita consumption of these commodities was very small compared to beef, pork and broilers, fish and lamb were deleted in the statistical analysis. Turkey consumption was also small relative to the meats included in the statistical model. Since consumption of turkeys has been highly seasonal in the past, the author believes that the annual estimates do not represent the real influence of turkey consumption on the demand for broilers; hence, it has been deleted from the analysis. Unfortunately, the author knows of no statistical studies from time series

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[4]See the discussion in Chapter III concerning the studies by Riley, Parsons and Baker and Farris.

data that justify the deletion of these variables or reveal the influence of these variables on the demand for broilers. However, Branson[5] found that among the Houston, Texas families interviewed only 2 percent of the families listed fish as their favorite. Turkey and lamb were each listed as the preference of 1 percent of the families interviewed. It is harder to justify deletion of the consumption of farm chickens or other chicken meats excluding broilers from the analysis. However, since the thirties broiler consumption has accounted for an increasing percentage of total chicken meat consumption. In 1950 broilers accounted for about one-half of total chicken meat consumption and have since continued to increase steadily. The downward trend in consumption of farm chickens leads the author to believe that consumption of farm chickens now has little effect on the demand for broilers, and for this reason it has been omitted from the statistical analysis.

Disposable income is generally considered to be important in approximating demand functions. Fox[6] states that the disposable income of domestic consumers has proved to be the best over-all indicator of their demand for agricultural products. Per capita disposable personal income was chosen as a variable in this study to represent the general level of consumer demand.

Consumption habits or tastes and preferences of the consumers affect their demand for broilers. No really adequate quantitative variable is

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[5]Robert E. Branson, The Consumer Market for Beef, Bulletin 856, Texas Agricultural Experiment Station, College Station, Texas, April 1957, p. 7.

[6]Karl Fox, "Factors Affecting Farm Income, Farm Prices and Food Consumption," Agricultural Economic Research, Volume 3, No. 3, July 1951, p. 67.

available to measure the relationship; however, this relationship is often indicated in demand studies by the introduction of a time variable. Schultz[7] indicated that the time variable is "a catch-all for the disturbing factors." The inclusion of time in the analysis assumes a linear change in these variables, and it is the change that is measured not the level of preference. Time was included in the original equations for this study as a measure of the influence of the variables not included in the analysis. A high intercorrelation ($r = .98$) existed between income and time. Time was then deleted from the equations, and the equations were refitted with income as the demand shifter.

The above discussion has mentioned only the absolute values of the variables included in the analysis. It should be mentioned in this section that price and consumption variables were included as ratios in parts of the analysis. The general form of the equations using relative variables included the price ratio of two commodities as the dependent variable with the pre-determined variables including the consumption ratio of the same two commodities, actual consumption of the third commodity and income. The general form of these equations can be expressed mathematically as:

$$\frac{P_a}{P_b} = f\left(\frac{Q_a}{Q_b}, Q_c, Y\right)$$

where P is price, Q is per capita consumption for the commodities a, b and c and y is per capita disposable income.

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[7]Henry Schultz, The Theory and Measurement of Demand, University of Chicago Press, Chicago, Illinois, 1938, p. 184.

Choice of Time Periods

The selection of the time period for the statistical analysis was made on the basis of the relationships shown in the statistical demand curves for the commodities; statistical demand curves indicate whether a change occurred in the price-quantity relationships over the range of the data.

The problem of identification of statistical demand curves was pointed out by Working.[8] He stated that:

> "If we construct a statistical demand curve from data of quantities sold and corresponding prices, our original data consist, in effect, of observations of points at which the demand and supply curves have met. Altho we may wish to reduce our data to static conditions, we must remember that they originate in the market itself. The market is dynamic and our data extended over a period of time; consequently our data are of changing conditions and must be considered as the result of shifting demand and supply schedules."[9]

Working suggested that if the shifts occurring in the supply curve were greater than the shifts in the demand curve, then the points representing the intersections of the two curves trace out what appears to approximate a statistical demand curve. He further suggested that a curve could be fitted to these points, and from it we can determine the elasticity of demand.

Both actual and relative broiler data used in this analysis were first graphed in price-quantity diagrams for the period of available data. When this was done, the time sereis data were examined for possible statistical demand curves. In the earlier years of the data wide

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[8] E. J. Working, "What do Statistical 'Demand Curves' Show?", Quarterly Journal of Economics, Volume XLI, No. 2, February 1927, pp. 212-235.

[9] Ibid., p. 218.

fluctuation existed between the annual observations for both actual broiler data and for beef and pork relative to broilers, indicating large shifts in both the demand and supply curves. About 1950 the points representing the annual observation began to show less variation between the years and to form a pattern resembling a statistical demand curve. For this reason only the data for 1950 to 1958 were included in the statistical analysis.

Choice of Functions

For all models included in this analysis, single equation least squares regressions were used to estimate the structural relationships.

A choice existed between natural numbers and logarithms as the form for including the variables in the equations. In general, logarithmic equations should be used when the relationships between the variables are believed to be multiplicative or the relations are believed to be more stable in percentage than in absolute terms or both. If the relationship between the variables is believed to be additive, arithmetic variables should be used.[10] A function which is linear in logarithms has constant elasticity while a function which is linear in natural numbers has a constantly changing elasticity. Although logarithmic equations have the mechanical advantage of yielding curves having a constant elasticity, this is not a valid criterion for deciding on their use; in fact this may be a rather unrealistic assumption, especially at the extremes.[11] Although the advantages and disadvantages of each function can be

[10]Foote and Fox, op. cit., pp. 9-10.

[11]Foote, op. cit., p. 37.

pointed out, it is difficult to choose by a priori reasoning the appropriate mathematical function to use. Perhaps a valid a priori grounds exist for fitting the relative demand curves in logarithms for it seems unrealistic to assume a constant marginal rate of substitution over any range of reasonable length. However, all models were fitted using both natural numbers and logarithms.

The regression coefficients obtained were first checked to see if they were consistent with expectations. Expectations were based upon economic theory and results of previous studies. The t test was then used to test the null hypothesis that the regression coefficients did not differ significantly from zero against the alternative hypothesis that they did differ significantly from zero. Since the test of significance was designed to test whether the regression coefficient was zero, the calculated t value was the ratio of the regression coefficient to its standard error. The calculated values were checked against the t values obtained from the "Student's" distribution. If economic theory lead to the expectation of either a positive or negative sign for the regression coefficient, a one-tailed test was used to test the null hypothesis. If no expectations were made regarding the sign of the coefficient, then a two-tailed test was used. Tests of significance were made at the .01, .05 and .10 levels.

Previously it was mentioned that functions linear in logs have a constant elasticity; hence, the elasticities are the regression coefficients and can be read directly from the regression equations. Since the elasticities change along functions which are linear in natural numbers, the points along the functions where the measures are taken

should be specified; the elasticity are usually specified at the mean values. The regression coefficients of functions including relative data have been referred to as the "elasticity of substitution," but there appears to be some questions concerning the restrictive conditions and the validity of these estimates.[12] Therefore the "elasticity of substitution" will hereafter be used in quotes.

Originally, it was planned that the unexplained residuals in the equations would be tested for serial correlation by the Durbin-Watson test, but the available tables did not extend down below fifteen observations; below fifteen observations it is almost impossible to get results other than inconclusive from the Durbin-Watson test. As a result serial correlation among the residuals was examined by inspection only.

Data

All data included in the analysis of this study were obtained from series published by the United States Department of Agriculture. Since no comprehensive publication of poultry statistics was available at the time when the data were sought, data were obtained from numerous publications including The Poultry and Egg Situation; Chickens and Eggs - Farm Production, Disposition, Cash Receipts, Gross Income by States; Livestock and Meat Statistics; Consumption of Food in the United States, 1909-52; and, Agricultural Outlook Charts, 1959. Data used in the analysis are included in Appendix A; more precise references as to the

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[12]See: Irving Morrisett, "Some Recent Uses of Elasticity of Substitution--A Survey", Econometrica, Volume 21, No. 1, January 1953, pp. 41-62 and Kenneth W. Meinken, Anthony S. Rojko and Gordon A. King, "Measurement of Substitution in Demand from Time Series Data--A Synthesis of Three Approaches," Journal of Farm Economics, Volume 38, No. 3 August 1956, pp. 711-735.

source of the data are also given there. Egg and Poultry Statistics Through 1957, Statistical Bulletin No. 249, was published during the analysis phase of this study; it contains most of the statistics used in the analysis.

The retail price series for broilers included in the analysis is questionable. This series was based on prices collected by the Bureau of Labor Statistics which included prices for the first three days of the week.[13] Since these prices are based on the first three days of the week, studies previously mentioned in Chapter III indicate that these prices are based on only a small portion of the volume of broilers sold at retail outlets since the largest sales of broilers occur during the last days of the week. Therefore these prices do not measure the effects on sales as a result of broilers being featured as weekend specials in the retail outlets and probably do not represent a true estimate of the retail prices of broilers.

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[13] For a more complete discussion see: Leo R. Gray and William L. Mitchell, Marketing Spreads for Eggs and Frying Chickens in the U. S. and Selected Cities, AMS-296, Agricutural Marketing Service, United States Department of Agriculture, January 1959 and "Weekend Prices of Food" Retail Food Prices by Cities (mimeograph), Bureau of Labor Statistics, United States Department of Labor, September 1956 and October 1956.

Chapter V

RESULTS OF ANALYSIS

The purpose of this chapter is to present and explain the results of the analysis obtained from the methods and procedures discussed in the previous chapters of this thesis. This chapter is organized into two main sections; the first section contains a discussion of the results of the graphic analysis while the second contains the results of the regression analysis. Each of these sections is divided into subsections for the results obtained for the demand for broilers, demand for beef relative to broilers, demand for pork relative to broilers and demand for beef relative to pork.

Graphic Analysis

The purpose of the graphic analysis is to examine the relationship between the price and quantity data, to determine whether any shifts occurred in the relationship during the period and to determine the time period and appropriate mathematical function to use in the regression analysis.

In Chapter I it was hypothesized that the demand for broilers has been increasing relative to the demand for beef and pork. If the demand for broilers has been increasing relative to the demand for beef and pork, the increase in the relative demand for broilers could have resulted from: (1) the demand for broilers increasing while the demand for beef and pork was decreasing, (2) the demand for broilers increasing while the demand for beef and pork was constant, (3) the demand for broilers, beef and pork increasing with the demand for broilers increasing faster, (4) the demand for broilers being constant while the demand for beef and pork was decreasing and (5) the demand for broilers, beef and

pork decreasing with the demand for beef and pork decreasing faster. Similar reasons could be stated for the case of the relative demand of beef to pork, but they would be duplicates of the above and will not be stated again. The following sections have been developed to examine the average relationships between price and quantity data and to provide evidence for later conclusions concerning the nature of and the reasons for changes in the demand for broilers relative to the demand for pork and beef.

Demand for Broilers. The consumer demand for broilers at retail appears to have fluctuated more than the supply of broilers in the 1940's, but both were increasing. This is indicated by the data shown in Figure 8[1] for the retail price and per capita consumption of broilers. A positive relationship existed between the retail price and per capita consumption of broilers during this period. If a line were drawn through the observations to represent the relationship between the retail price and per capita consumption of broilers during this period. If a line were drawn through the observations to represent the relationship between the retail price and per capita consumption, it would more nearly approximate a supply curve than a demand curve for the line would slope upward and to the right indicating that demand had been changing greater than the supply during the period. Further inspection of the diagram reveals that a change occurred about 1950 in the relationship between the retail price and per capita consumption. A line fitted by inspection to the observations for the period 1950 to 1958 slopes

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[1] The years when price celings and rationing were in effect due to World War II have been indicated in Figure 8 by circles around the observations for those years.

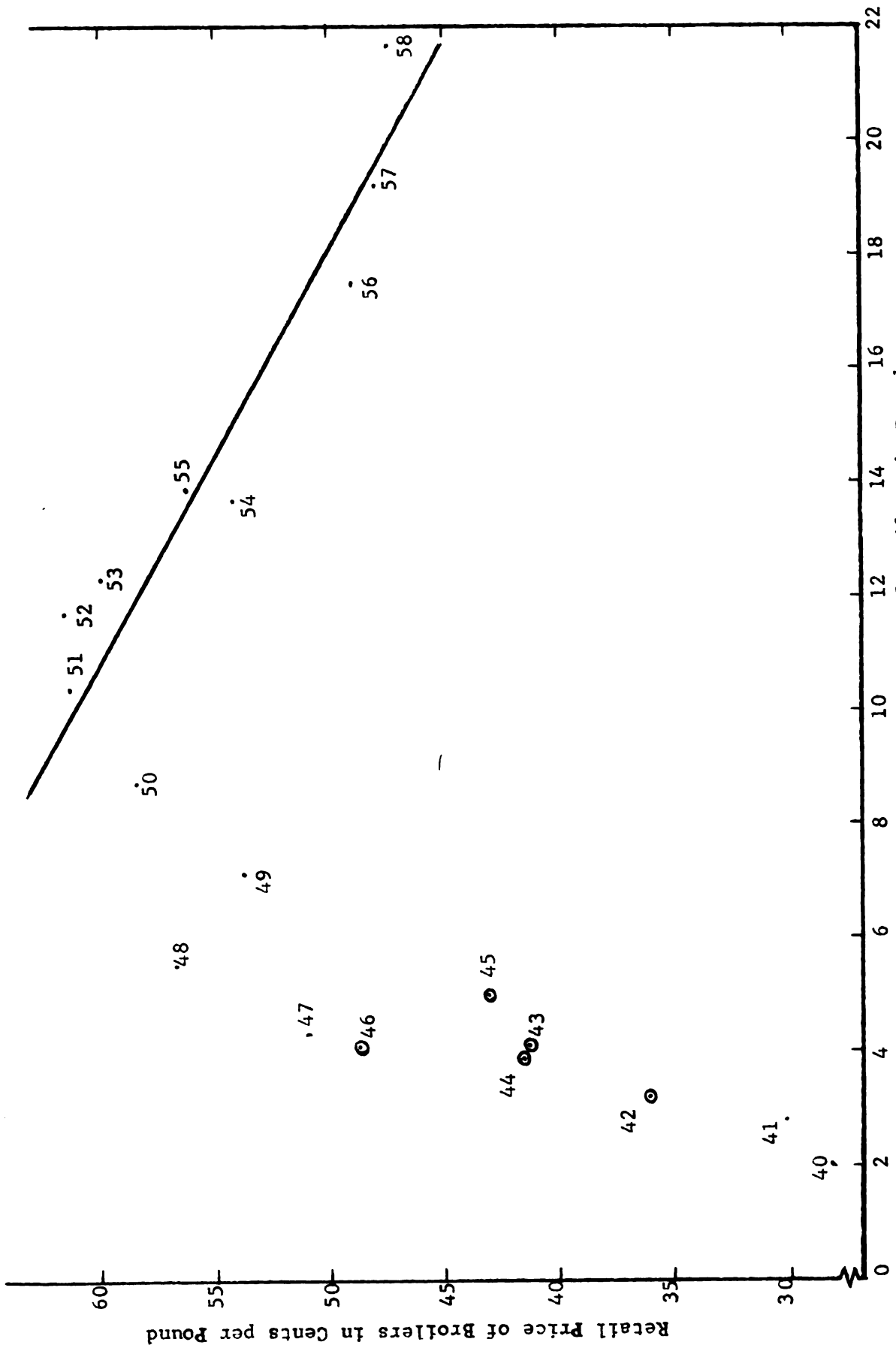

Figure 8. Demand for Broilers in the United States, 1940 to 1958

down and to the right, which indicates that supply was changing greater than the demand; and appears to more nearly represent a demand curve for broilers for the period. The downward slope indicates that the relationship between the retail price and per capita consumption was negative. Annual observations during the period tended to move consistently down a demand curve. There are no indications of any shifts occurring during this period in the relationship between the retail price and per capita consumption of broilers.

Demand for Beef Relative to Broilers. The demand for beef relative to the demand for broilers, as shown in Figure 9[2], has been declining. This is indicated by changes in the relationship between the ratio of the retail price of beef to broilers and the ratio of the per capita consumption of beef to broilers. Inspection of Figure 9 reveals that large year to year changes occurred in the ratio of the per consumption of beef to broilers in the 1940's while relatively small changes occurred in the ratio of the retail price of beef to broilers except in 1947 when price ceilings were removed. The ratio of the per capita consumption of beef to broilers was decreasing which indicates that consumption of broilers was increasing relative to beef. Since consumers were increasing their consumption of broilers relative to beef at fairly constant relative prices, this indicates that the demand for broilers was increasing relative to the demand for beef. About 1950 the large shifts between annual observations ceased to appear, and the relationship between the price and per capita consumption ratios appeared to remain stable during the period 1950 to 1958. A line fitted by inspection to

[2]The years when price ceilings and rationing were in effect due to World War II have been indicated in Figure 9 by circles around the observations for those years.

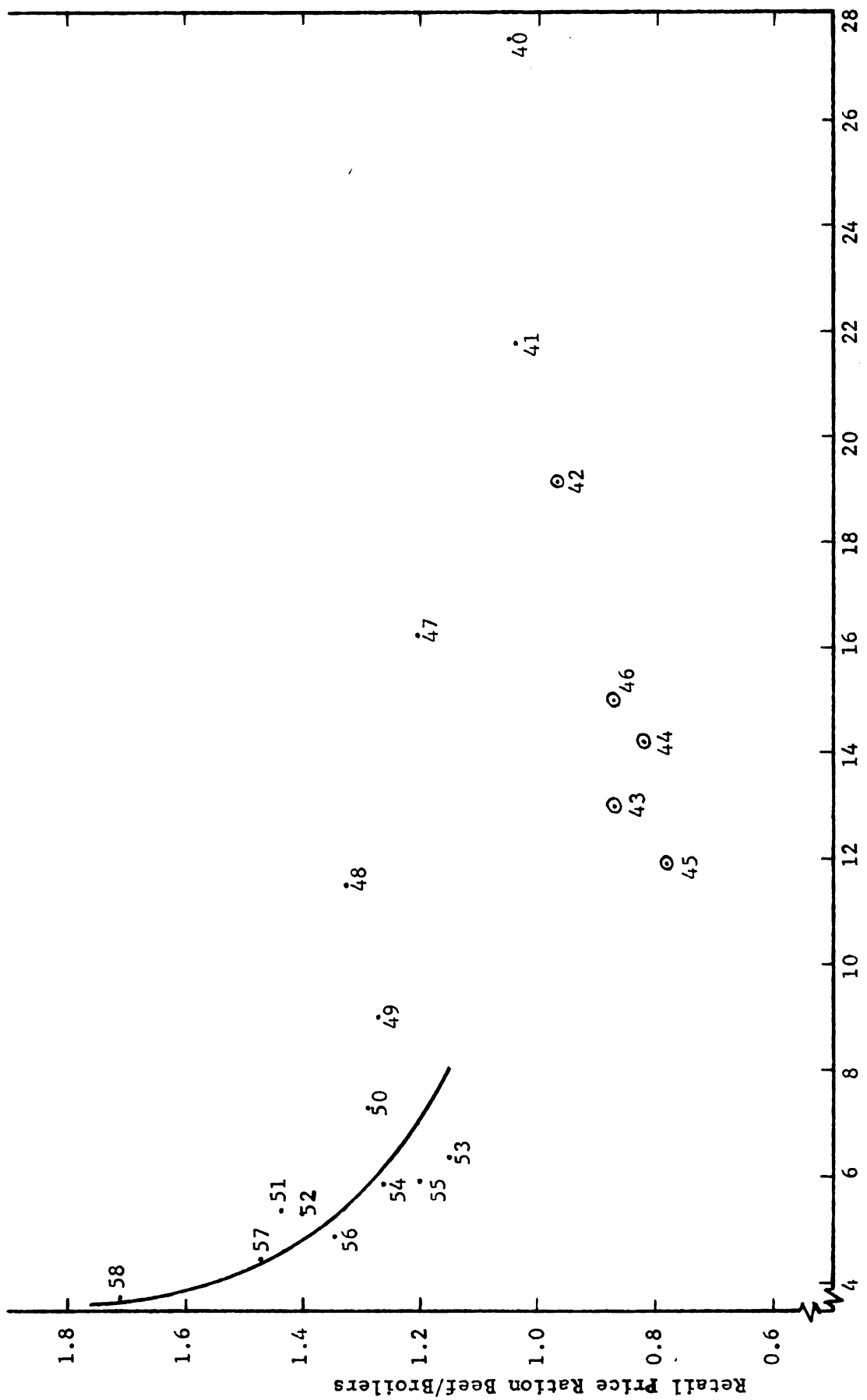

Figure 9. Demand for Beef Relative to Broilers in the United States, 1940 to 1958

the observations for the period 1950 to 1958 appears to more nearly represent a demand curve for the relative data; a curved line appears to fit the relationship better than a straight line. The downward slope of the curve represents an inverse relationship between the ratio of the retail prices of beef to broilers and the ratio per capita consumption of beef to broilers. No indications are present in the diagram to suggest that any shifts occurred in the relationship between the ratios during the period 1950 to 1958.

Demand for Pork Relative to Broilers. The retail price ratios of pork to broilers and the per capita consumption ratios of pork to broilers, which are shown in Figure 10,[3] indicate that the demand for pork relative to the demand for broilers has been declining. Annual observations for the 1940's indicate that changes occurred in the relationship between the retail price ratio of pork to broilers and the per capita consumption ratio of pork to broilers; this is indicated by the large changes that occurred in the per capita consumption ratio while changes in the retail price ratio were much smaller. The relationships appears to have remained relatively stable in the 1950's. A line which was fitted by inspection to represent the average relationship between the price and per capita consumption ratios for the period 1950 to 1958 slopes down and to the right and appears to more nearly represent a demand curve for the relative data; a curved line appears to be a better fit for the relationship than a straight line. The downward slope of

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[3]The years when price ceilings and rationing were in effect due to World War II have been indicated in Figure 10 by circles around the observations for those years.

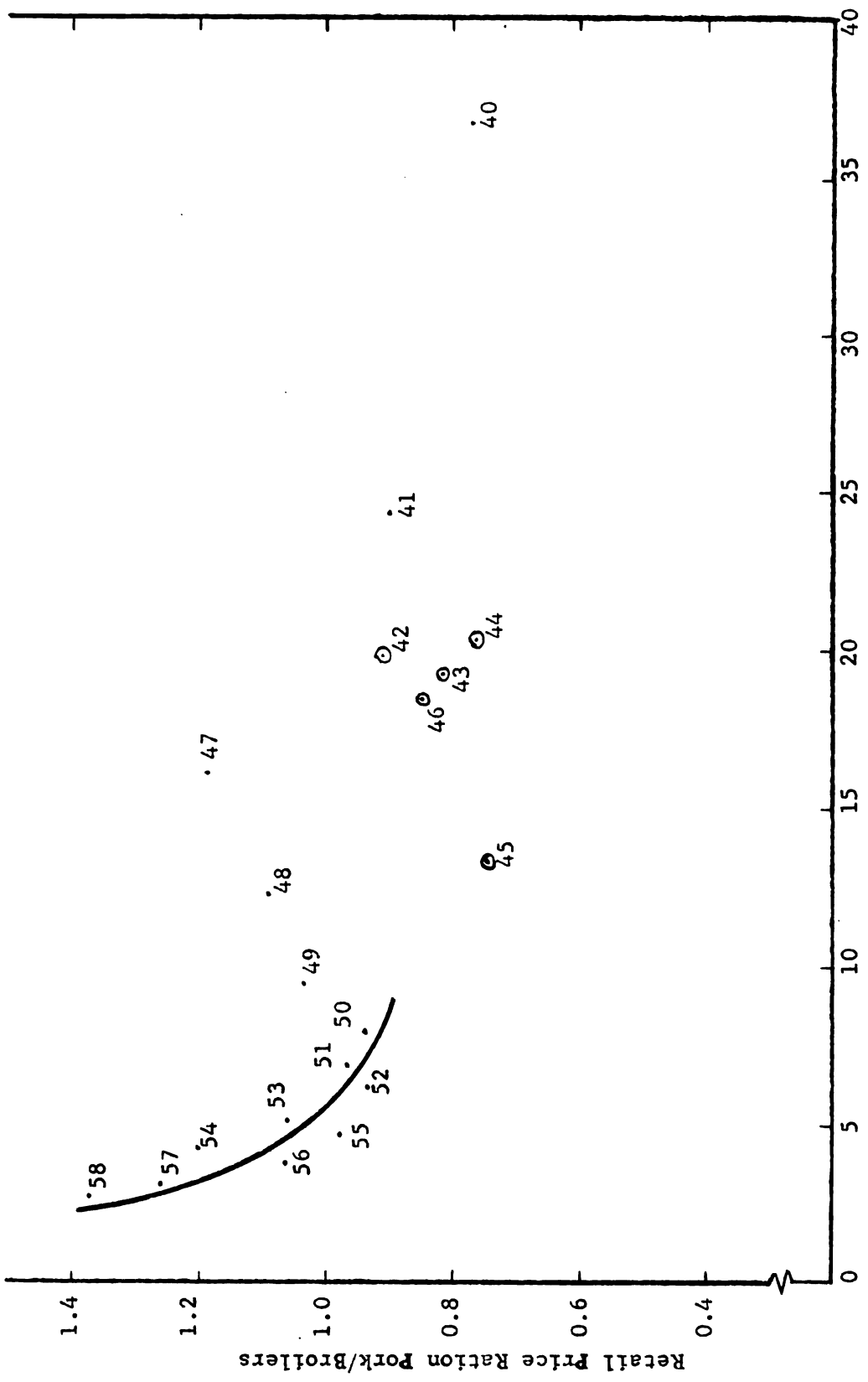


Figure 10. Demand for Pork Relative to Broilers in the United States, 1940 to 1958.

the curve indicates the existence of an inverse relationship between the ratio of the retail price of pork to broilers and the ratio of the per capita consumption of pork to broilers.

Demand for Beef Relative to Pork. The time series data for the retail price ratio of beef to pork and the per capita consumption ratio of beef to pork shown in Figure 11[4] indicate that the demand for beef has been increasing relative to the demand for pork.[5] Since continuous series of beef and pork retail prices are available for a longer period of time than were broiler prices, this diagram has been extended back to 1925 to show the changes in relative demand over a longer period of time. In the period from 1925 to 1958, with the war years deleted, two shifts and possibly three have occurred in the relationship between the ratio of the retail price of beef to pork and the ratio of the per capita consumption of beef to pork. Shifts in the relationship occurred between the years 1932 to 1934 and 1947 to 1950. It is questionable whether there has been a shift in the relationship since 1950 or whether the scattering of the observations indicate a single relationship with wide deviations. It is conceivable that one may consider two relationships for the period since 1950 with the separation occurring in 1954 to 1955; this is the situation shown in Figure 11 where the two lines of average relationship have been indicated by broken lines to indicate that they are questionable. However, the statistical analysis for the period 1950 to 1958 was based on the assumption that the relationship during the

[4]The years when price ceilings and rationing were in effect due to World War II have been indicated in Figure 11 by circles around the observations for those years.

[5]A similar diagram was published in the study by Shepherd et al. op. cit., p. 733; this diagram was discussed in Chapter III of this thesis. Since the study by Shepherd et al. was published, the price and consumption data have been revised so there are some differences in data included in the two diagrams.

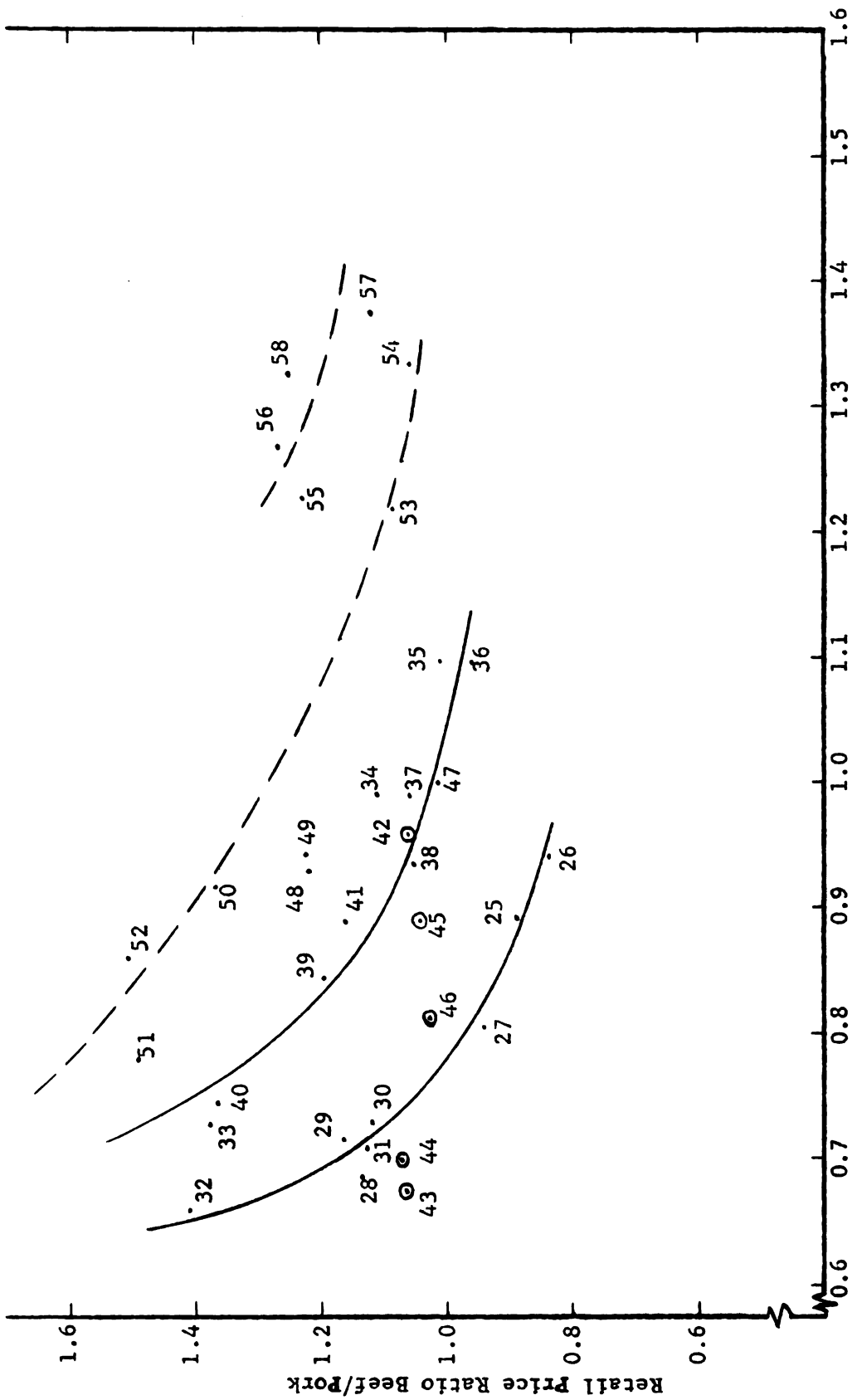


Figure 11. Demand for Beef Relative to Pork in the United States, 1925 to 1958

period was unchanged. Since the curves indicating the lines of average relationship have been shifting up and to the right, this gives some indication that the demand for beef relative to pork has been increasing over the period. The four lines representing the relationships between the retail price ratio and per capita consumption ratio slope down and to the right. The downward slopes indicate the existence of an inverse relationship between the price ratios and per capita consumption ratios of beef to pork.

Summary of the Graphic Results. Actual and relative time series data used in the graphic analysis indicate that prior to 1950 the relationships existing between retail price and per capita consumption of broilers were not clear. Only since 1950 has the relationship between retail price and per capita consumption for actual and relative data for broilers resembled anything like a demand curve and can be approximated by a single equation regression model. This analysis tends to indicate that the relationship between the price and quantity data in natural numbers is linear for the actual data and curvilinear for the relative data.

Regression Analysis

To obtain more precise estimates of some of the demand shifters, income and competing products will be included in the regression analysis. The estimates obtained from the regression analysis also provide a basis for making probability statements about the results providing the assumptions mentioned below are approximately satisfied.

To facilitate the discussion in this section a few comments on notation are in order. The dependent variables included in the regression analysis are:

Y_1 = per capita consumption of broilers in pounds

Y_2 = retail price of broilers in cents per pounds

Y_3 = relative retail price of beef to broilers

Y_4 = relative retail price of pork to broilers

Y_5 = relative retail price of beef to pork

The independent variables included in the analysis are:

X_1 = retail price of broilers in cents per pound

X_2 = retail price of beef in cents per pound

X_3 = retail price of pork in cents per pound

X_4 = relative per capita consumption of beef to broilers

X_5 = relative per capita consumption of pork to broilers

X_6 = relative per capita consumption of beef to pork

X_7 = per capita consumption of broilers in pounds

X_8 = per capita consumption of beef in pounds

X_9 = per capita consumption of pork in pounds

X_0 = per capita disposable personal income in dollars

and the u's are the unexplained residuals which are assumed to be normally and independently distributed with a uniform variance. Observations on each variable are in terms of annual data for the United States.

It was mentioned in Chapter IV that all models were fitted in both natural numbers and logarithms. Both of these were examined for closeness of fit, and one was selected on the basis of both the best fit to the data and the graphic analysis in the preceding section. Natural numbers were selected as the best fit for the demand models using actual data while logarithms were selected as the best fit for the relative demand models. Only the equation selected as the best fit for each model is included in this chapter; the other equations are included in

this chapter; the other equations are included in Appendix B. For each of the models presented in this chapter, the standard errors of the regression coefficients are included in parentheses below the regression coefficients. The adjusted coefficient of multiple determination ($\bar{R}^2$) and the standard error of estimate ($S\hat{y}$) are included with each model.

Demand for Broilers. Although it was indicated in the previous chapter that the author was more interested in predicting prices than quantities consumed, separate models using actual data have been developed using both price and quantity of broilers consumed as the dependent variable.

Consumption of Broilers. The per capita consumption of broilers was considered to be influenced by the retail price of broilers, retail price of beef, retail price of pork and income. The variables were fitted in the additive form as:

$$(1)\quad Y_1 = -8.29598 - \underset{(.06267)}{0.33612^{1}X_1} + \underset{(.02465)}{0.09128^{2}X_2} + \underset{(.04186)}{0.06793^{3}X_3} + \underset{(.00253)}{0.01885^{1}X_0}$$

$$\bar{R}^2 = .985 \qquad S_{\hat{y}} = .524$$

[1]Significant at the .01 level
[2]Significant at the .05 level
[3]Significant at the .10 level

Signs of the regression coefficients were consistent with expectations; therefore one-tailed tests were used for the test of significance. The coefficients of each of the variables included were significantly different from zero. These variables were associated with 98.5 percent of the variance in the per capita consumption of broilers.

The model shows an inverse relationship between the per capita consumption of broilers and the retail price of broilers and a positive relationship between consumption and the retail price of beef, retail

price of pork and income. The simple correlation between per capita consumption and retail price of broilers was -0.92, and, the correlation between per capita consumption and income was 0.96; correlation between per capita consumption and the other independent variables, retail price of beef (r_{2Y} = -.24) and retail price of pork (r_{3Y} = .26), was much lower. The intercorrelation between the retail price of broilers and income was -0.85; an intercorrelation of this magnitude would usually be expected to cause large standard errors of the regression coefficients and would provide sufficient evidence to question the validity of the regression coefficients as well as the elasticities calculated from these coefficients. Little can be said about the effects, if any, that the high intercorrelations will have on the estimates obtained from the model. However, in this case reasonably small standard errors were obtained for the regression coefficients in despite of the high intercorrelation.

The price elasticity of demand for broilers measured at the mean values was -1.29. It should be noted again that a demand curve which is linear in arithmetic form has a constantly changing elasticity of demand which is highest at the upper end and becomes lower with movement down the curve. At the upper end of the estimated demand curve for broilers the price elasticity of demand calculated from the 1950 data was -2.26, and at the lower extreme the elasticity of demand from the 1958 data was calculated to be -0.73. The high intercorrelation between the retail price of broilers and income provides sufficient evidence to question the validity of these estimates of price elasticities of demand. This model indicates that the demand for broilers

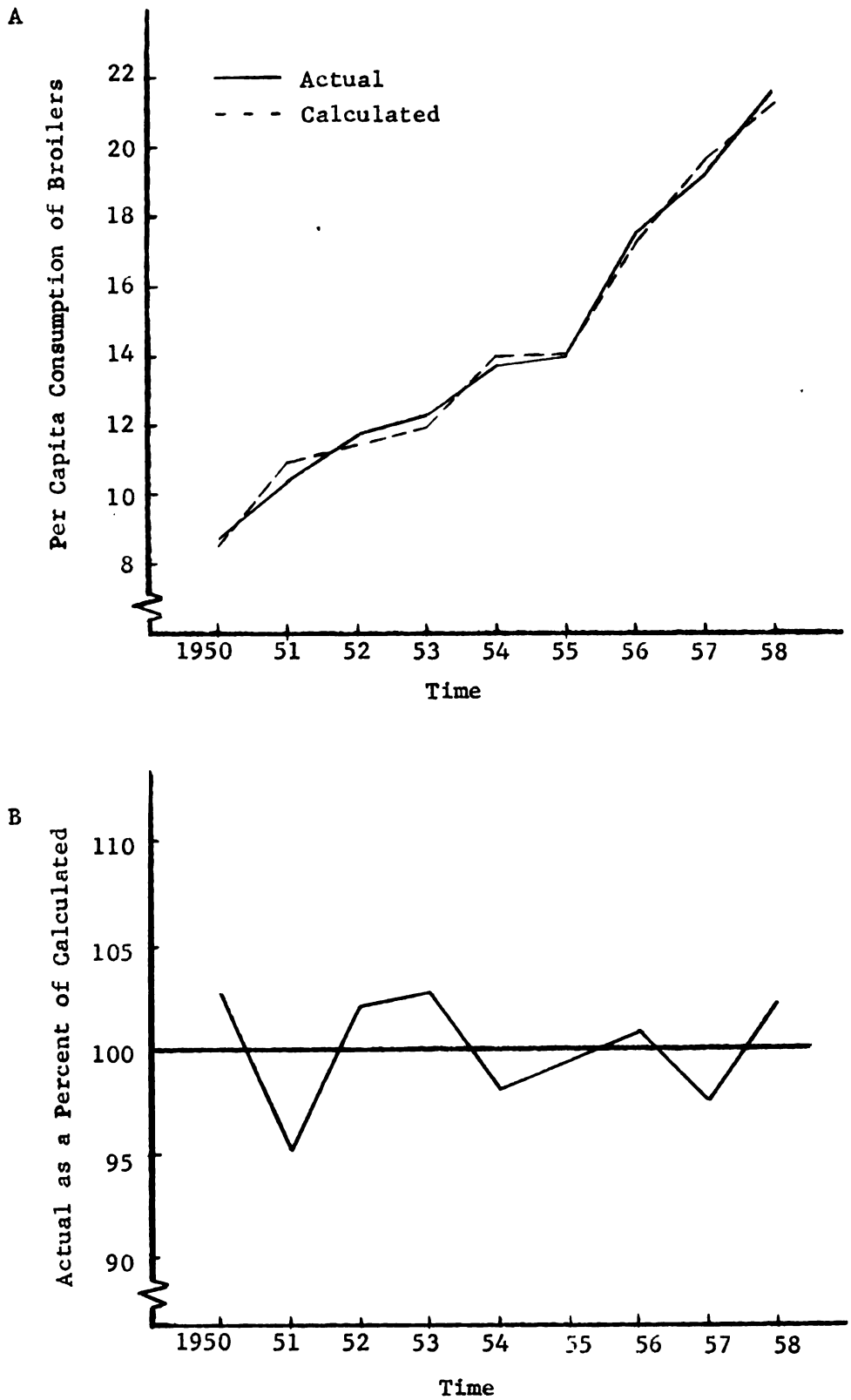
was highly elastic in the early fifties and has since decreased until now appears to be inelastic. This indicates that one must use elasticities with extreme caution and especially the estimates of elasticities calculated at the mean values. This especially applies to commodities, such as broilers, where there has been a secular trend in the price of the commodity over the period studied which would cause continuous movement in one direction along a demand curve.

The cross elasticity of demand for broilers at the mean values was 0.47 with respect to the price of beef and 0.28 with respect to the price of pork. This indicates that substitution exists between broilers and the two commodities and that broilers are in competition with each commodity. The model indicates that a ten cent increase in the retail price of beef would increase per capita consumption of broilers by 0.91 pounds while a ten cent increase in the retail price of pork would increase per capita consumption of broilers by 0.68 pounds.

The regression coefficient for income indicates that each $100 increase in per capita income increases per capita consumption of broilers by 1.88 pounds; the income elasticity of demand for broilers at the mean values as calculated from this coefficient was 2.11. However, this coefficient probably includes more than the influence of income. Income and time are highly correlated so one might expect this coefficient to include the influence of changing tastes as well as the influence of income. The validity of this coefficient is also questionable as a result of the high intercorrelation existing between income and the retail price of broilers.

Figure 12

Comparison of Actual and Calculated
Per Capita Consumption of Broilers



Estimates of the annual per capita consumption of broilers obtained from the equation are shown in Figure 12 along with the actual per capita consumption. The estimates indicate that a relatively close fit was obtained for the data. In all cases the direction of the year to year movement was correctly indicated. The model appears to give consistently close estimates for each year with the unexplained residuals between -0.54 and +0.47 pounds, or in a range of eight percent about the actual values. The largest percentage deviations occurred in the earlier years; however, this can be accounted for by the lower level of consumption in the earlier years. No pattern could be detected in the residuals, therefore, the assumption of randomness and independence was not unreasonable.

Price of Broilers. The price of broilers was considered to be a function of the per capita consumption of broilers, per capita consumption of beef, per capita consumption of pork and income. The model was fitted in the additive form as:

$$Y_2 = a_2 + b_{27}X_7 + b_{28}X_8 + b_{29}X_9 + b_{20}X_0 + u_2$$

where u_2 is the unexplained residual of Y_2. The results from the fitted equation were:

$$Y_2 = 46.22536 - \underset{(.73387)}{2.46345^{1}X_7} - \underset{(.17689)}{0.38287^{2}X_8} - \underset{(.28103)}{0.25425X_9} + \underset{(.02616)}{0.05567^{1}X_0}$$

$$\bar{R}^2 = .873 \qquad S_{\hat{y}} = 2.055$$

[1]Significant at the 0.5 level

[2]Significant at the .10 level

The signs of the regression coefficients for the per capita consumption of broilers and income were consistent with expectations, and the coefficients were significantly different from zero using a one-

tailed test. Since no expectations were formulated for the coefficients for the per capita consumption of beef and pork, two-tailed tests were used for the test of significance; the coefficient for per capita consumption of beef was significantly different from zero. The variables included in the model were associated with 87.3 percent of the variance occurring in the retail price of broilers in the period 1950 to 1958.

This model also indicate an inverse relationship between the price and per capita consumption of broilers; each one pound increase in the consumption of broilers results in a decrease in the price of broilers of 2.46 cents. The elasticity of demand for broilers calculated at the mean values was -1.56.

The model indicates that each $100 increase in per capita income increases the retail price of broilers by 5.6 cents per pound; however, this coefficient also reflects the changes in the tastes of the consumers over time which could not be separated from income.

The signs of the coefficients for beef and pork consumption were the same as the sign for broiler consumption; this would indicate that beef and pork were complementary with respect to broilers which is contrary to the results of the previous model when per capita consumption of broilers was considered to be a function of prices. The regression coefficient for the per capita consumption of beef indicates that a one pound increase in beef consumption results in a decrease of 0.38 cents in the price of broilers.

Each of the independent variables included in the model was highly correlated with the retail price of broilers; consumption of broilers was the highest (r_{7Y} =-.92) and was followed by income (r_{0Y} = -.85),

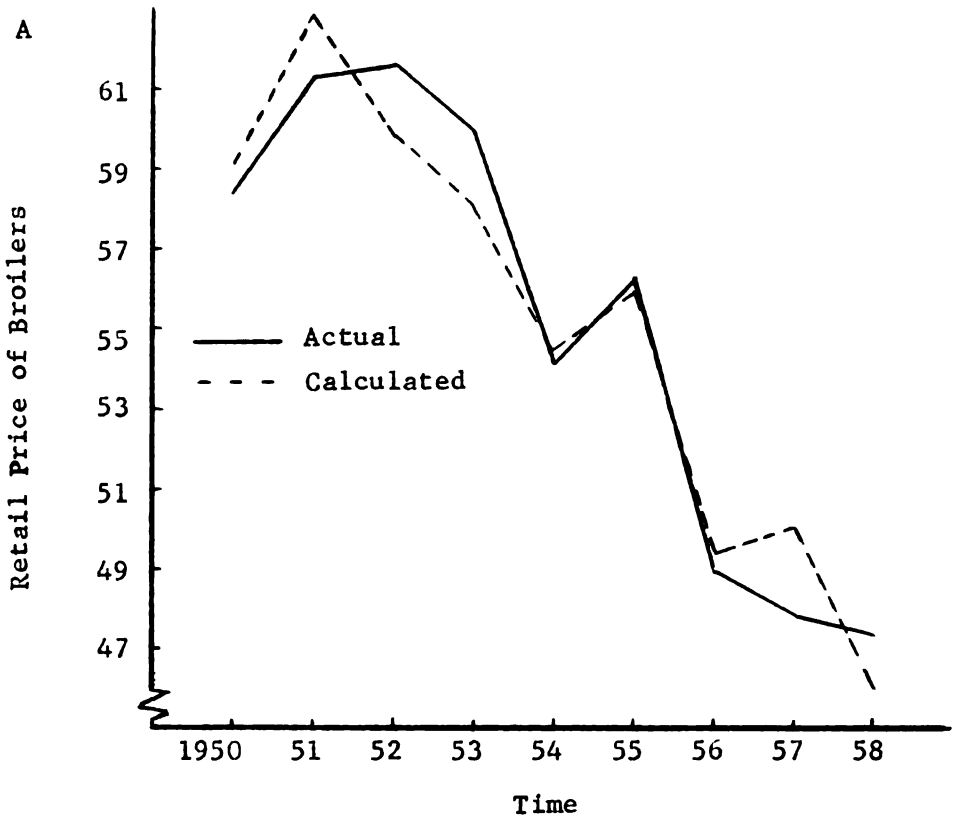
consumption of beef (r_{8Y} = -.79) and consumption of pork (r_{9Y} = .68). Per capita disposable income was highly correlated with consumption of broilers (r_{07} = .96) and consumption of beef (r_{08} = .84) while consumption of beef was also highly correlated with consumption of broilers (r_{87} = .75) and consumption of pork (r_{89} = -.77). These high intercorrelations are perhaps the cause of the high standard errors of the regression coefficients; the standard errors in this model are much larger than those obtained in theprevious model. Since all of the independent variables are highly intercorrelated, it is doubtful that the values for the regression coefficients and the elasticities calculated from them have any real meaning.

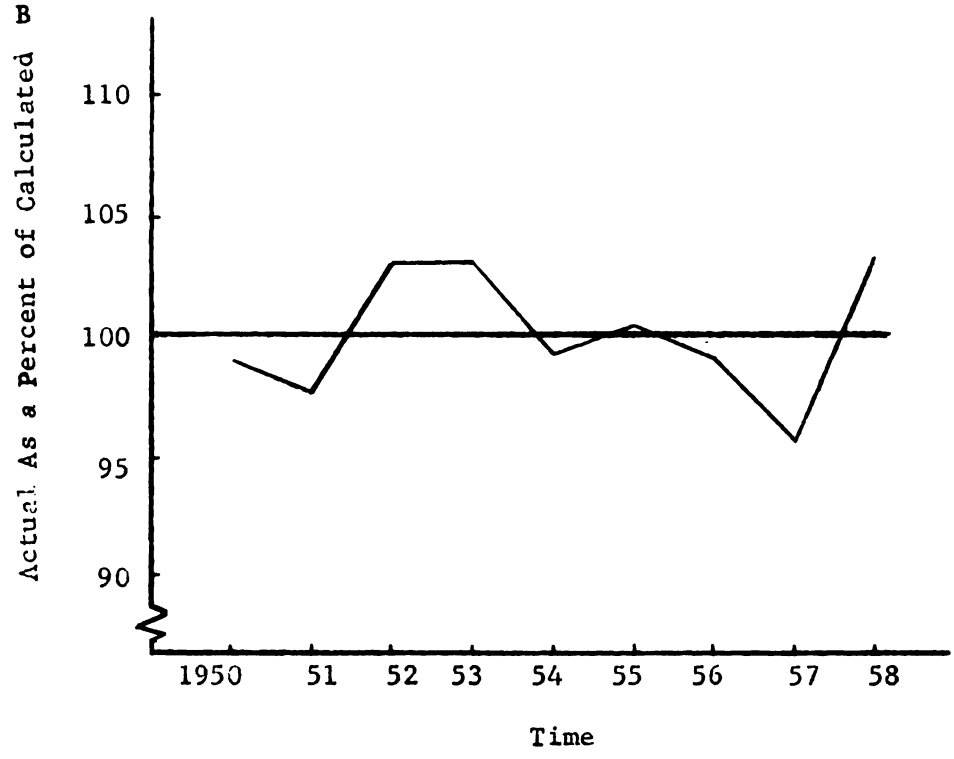
Estimates of the retail price of broilers obtained from the model were fairly close to the actual prices as can be seen in Figure 13. In all cases except two, 1951 to 1952 and 1956 to 1957, the direction of the year to year movement was correctly predicted. The unexplained residuals were between -2.21 and + 1.85 cents per pound; overestimates of the retail price were less than 4.5 percent while underestimates were less than 3.5 percent of the actual values. No pattern could be detected in the residuals; therefore, the assumption of randomness and independence was not unreasonable.

Comparison of the results from the two models presented above, where retail price and per capita consumption of broilers were each considered to be the dependent variable, reveals that both equations give relatively good fits to the data but give quite different coefficients and elasticities. The results of the two models indicate that the model using price as a

Figure 13

Comparison of Actual and Calculated
Retail Prices of Broilers





dependent variable involves higher intercorrelations among the independent variables. For this reason the model using quantity as the dependent variable probably is more meaningful for estimating elasticities. This is true even though one might consider the quantity available for consumption to be predetermined while price varies so as to clear the market.[6] The high intercorrelations do not appear to affect the predictive power of the models within the period studied but may affect forecasts for future periods if the highly intercorrelated independent variables become less intercorrelated.

Demand for Beef Relative to Broilers. The relative retail price of beef to broilers was considered to be influenced by the relative per capita consumption of beef to broilers, per capita consumption of pork and income. The variables were fitted in the multiplicative form as:

$$Y_3 = a_3 X_4^{b_{34}} X_9^{b_{39}} X_0^{b_{30}} u_3$$

where u_3 is the unexplained residual of Y_3. The results obtained from the model fitted in this form for the period 1950 to 1958 were:

$$(3)\quad \log Y_3 = 5.03131 - \underset{(.10419)}{0.91909^{1}} \log X_4 - \underset{(.22131)}{0.17680} \log X_9 - \underset{(.27486)}{1.21929^{1}} \log X_0$$

$$\bar{R}^2 = .920 \qquad S_{\hat{y}} = .015$$

[1]Significant at the .01 level

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[6]This is a relative and not an absolute argument. Since stocks of broilers are normally small, the quantities produced in any year will reflect prices in the previous years to the extent that fixed costs were incurred. However, it must be recognized that broiler production, unlike pork and beef production, can be varied to a considerable degree within a year.

The sign of the regression coefficient for the relative per capita consumption of beef to broilers was as expected, and the coefficient was significantly different from zero with a one-tailed test. No expectations were formulated concerning the coefficient for income; it was significantly different from zero using a two-tailed test. The per capita consumption of pork was not significantly different from zero. These variables were associated with 92 percent of the variance occurring in the relative retail price of beef to broilers during the period 1950 to 1958.

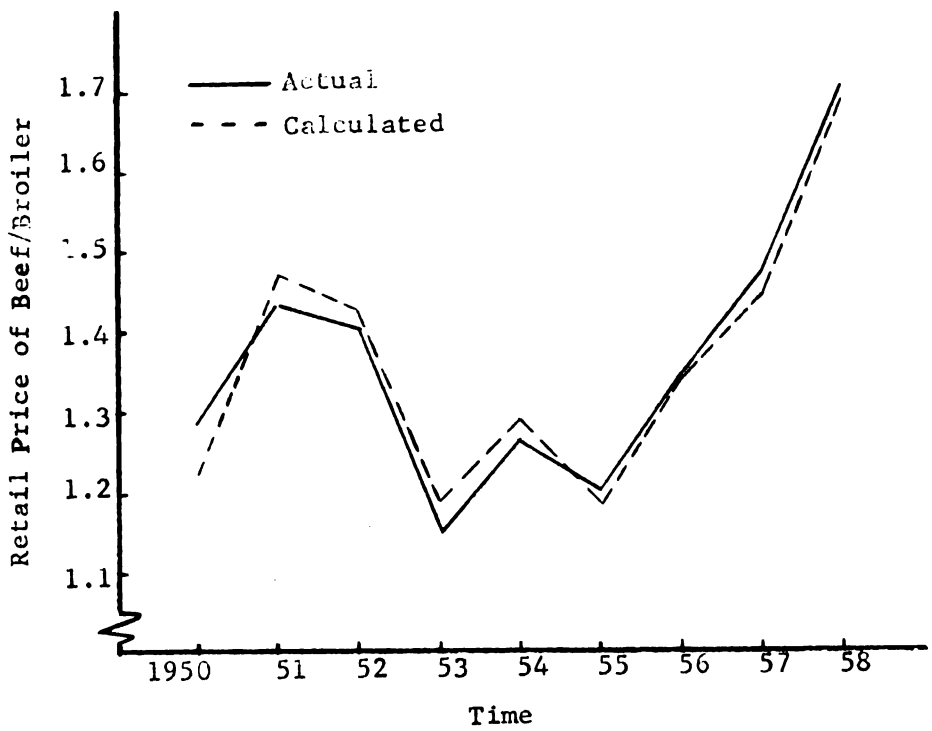
The regression coefficient for the relative per capita consumption of beef to broilers indicates an "elasticity of substitution" between the two commodities of -1.09 which is constant over the period. The income coefficient indicates that a one percent increase in income results in a 1.22 percent decrease in the relative retail price of beef to broilers; however, this coefficient also reflects changes in the tastes of consumers which could not be separated from income.

A simple correlation of -0.84 existed between the dependent variable, relative retail price of beef to broilers, and the relative per capita consumption of beef to broilers; simple correlations between the dependent variable and income ($r_{0Y} = .39$) and per capita consumption of pork ($r_{9Y} = -.11$) were considerably lower. Income was highly correlated with the relative per capita consumption of beef to broilers ($r_{40} = -.80$) and moderaterately correlated with per capita consumption of pork ($r_{90} = -.63$). These intercorrelations are not as high as those in the previous models but are perhaps high enough to reduce the reliability of the regression coefficients.

Figure 14

Comparison of Actual and Calculated Relative Retail Prices of Beef to Broilers

A



B

Estimates obtained from the model for the relative retail price of beef to broilers as shown in Figure 14, indicate that the function is a relatively good fit for the data. Year to year changes in the estimates were consistent with changes occurring in the actual price ratio; however, this is not very surprising in this case for changes between the annual observations were rather pronounced. The model underestimated the price ratio in the first year, overestimated the ratio for the next four years and then underestimated the ratio in the last four years; however, the number of observations is insufficient to support a statement that serial correlation exists among the residuals. The unexplained residuals were between -0.04 and +0.06 or in a range of less than nine percent of the actual values of the observations.

Demand for Pork Relative to Broilers. The relative retail price of pork to broilers was considered to be influenced by the relative per capita consumption of pork to broilers, per capita consumption of beef and income. These variables were fitted in the multiplicative form as:

$$Y_4 = a_4 X_5^{b_{45}} X_8^{b_{48}} X_0^{b_{40}} u_4$$

where u_4 is the unexplained residual of Y_4. The results obtained from this model for the period 1950 to 1958 were:

(4) $$\log \hat{Y}_4 = 7.87131 - \underset{(.12280)}{0.93811^{1}} \log X_5 - \underset{(.13194)}{0.10982} \log X_8 - \underset{(.47762)}{2.18357^{1}} \log X_0$$

$$\bar{R}^2 = .945 \qquad S_{\hat{y}} = .014$$

[1]Significant at the .01 level.

The regression coefficient for the relative per capita consumption of pork to broilers was negative as expected and was significantly different from zero using a one-tailed test, and the regression coefficient

for income was significantly different from zero using a two-tailed test. The coefficient for the per capita consumption of beef was not significantly different from zero. These three variables were associated with 94.5 percent of the variance occurring in the relative retail price of pork to broilers during the period 1950 to 1958.

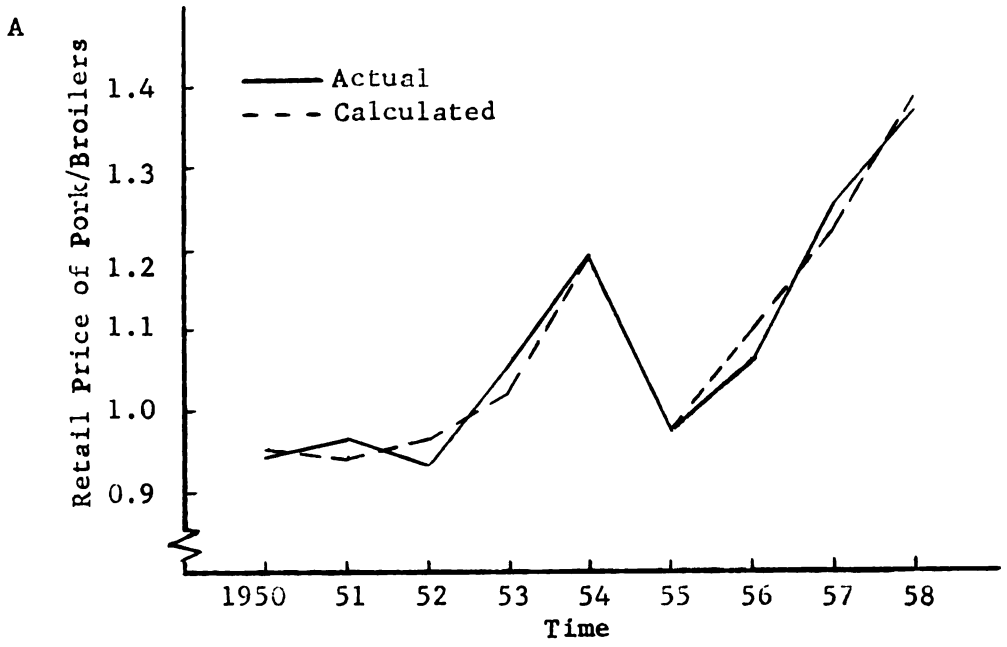
The regression coefficient for the relative per capita consumption of pork to broilers indicates the "elasticity of substitution" between the two commodities to be -1.07. The coefficient for income indicates that a one percent increase in income results in a 2.18 percent decrease in the relative retail price of beef to pork; it should be mentioned again that this coefficient also represents changes in the tastes of consumers over time which could not be separated from income.

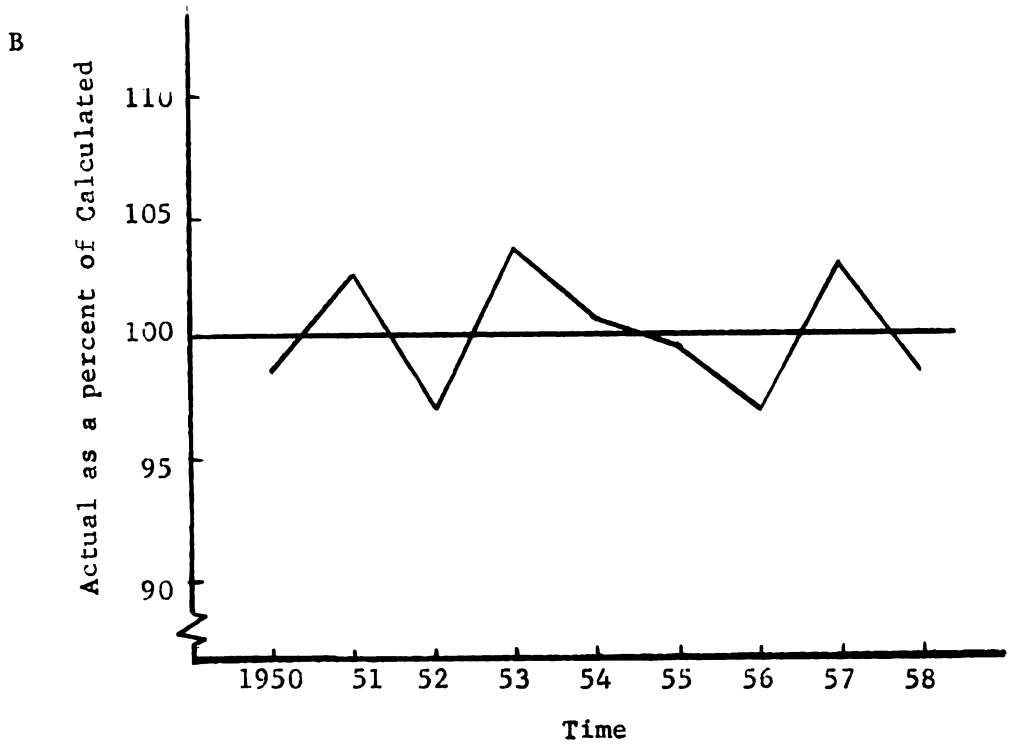
Each of the independent variables was substantially correlated with the relative price of pork to broilers; relative per capita consumption of pork to broilers ($r_{6Y} = -.89$) was negatively correlated and per capita consumption of beef ($r_{8Y} = .65$) and income ($r_{0Y} = .75$) were positively correlated. Income was highly correlated with relative per capita consumption of pork to broilers ($r_{50} = -.96$) and per capita consumption of beef ($r_{80} = .83$) while the per capita consumption of beef was correlated with the relative consumption of pork to broilers ($r_{58} = -.82$). In spite of the high intercorrelations the standard errors of the regression coefficients do not appear as high as one might expect; however, the high intercorrelations raise questions about the validity of the regression coefficients.

Estimates of the retail price ratio of pork to broilers, as shown in Figure 15, indicate that the predicted year to year changes between

Figure 15

Comparison of Actual and Calculated Relative Retail Prices of Pork to Broilers





the first three years were in the wrong direction. This should not be considered as a serious fault of the model for the changes occurring in the actual observations were small relative to changes in the ratio in other years and the estimates were relatively close to the actual values. In all other cases the direction of the year to year movement was correctly predicted. The unexplained residuals were between -0.036 to +0.037 or in a range of seven percent about their actual value. No pattern could be detected in the residuals; therefore, the assumption of randomness and independence was not unreasonable.

Demand for Beef Relative to Pork. The relative retail price of beef to pork was considered to be influenced by the relative per capita consumption of beef to pork, per capita consumption of broilers and income. The variables were fitted in the multiplicative form as:

$$Y_5 = a_5 X_6^{b_{56}} X_7^{b_{57}} X_0^{b_{50}} u_5$$

where u_5 is the unexplained residual of Y_5. The results obtained from the model for the period 1950 to 1958 were:

(5) $$\log Y_5 = -0.22350 - \underset{(.13081)}{0.79777}^{1} \log X_6 + \underset{(.27055)}{0.27601} \log X_7 + \underset{(.9330)}{0.01559} \log X_0$$

$$\bar{R}^2 = ,855 \qquad S_y^1 = .021$$

[1]Significant at the .01 level

The sign of the regression coefficient for the relative per capita consumption of beef to pork was negative which was consistent with expectations, and the coefficient was significantly different from zero with a one-tailed test. The other two variables were not significantly different from zero. The independent variables included in the model were associated with 85.5 percent of the variance occurring in the relative retail price of beef to pork.

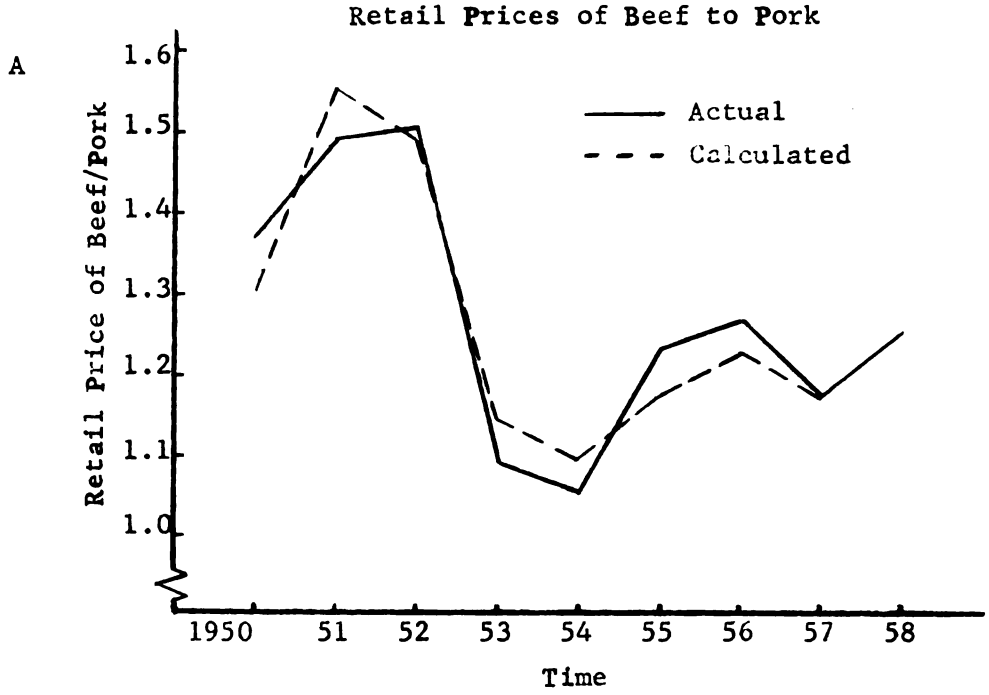
The regression coefficient for the relative per capita consumption of beef to pork indicates the "elasticity of substitution" between the two commodities to be -1.25.

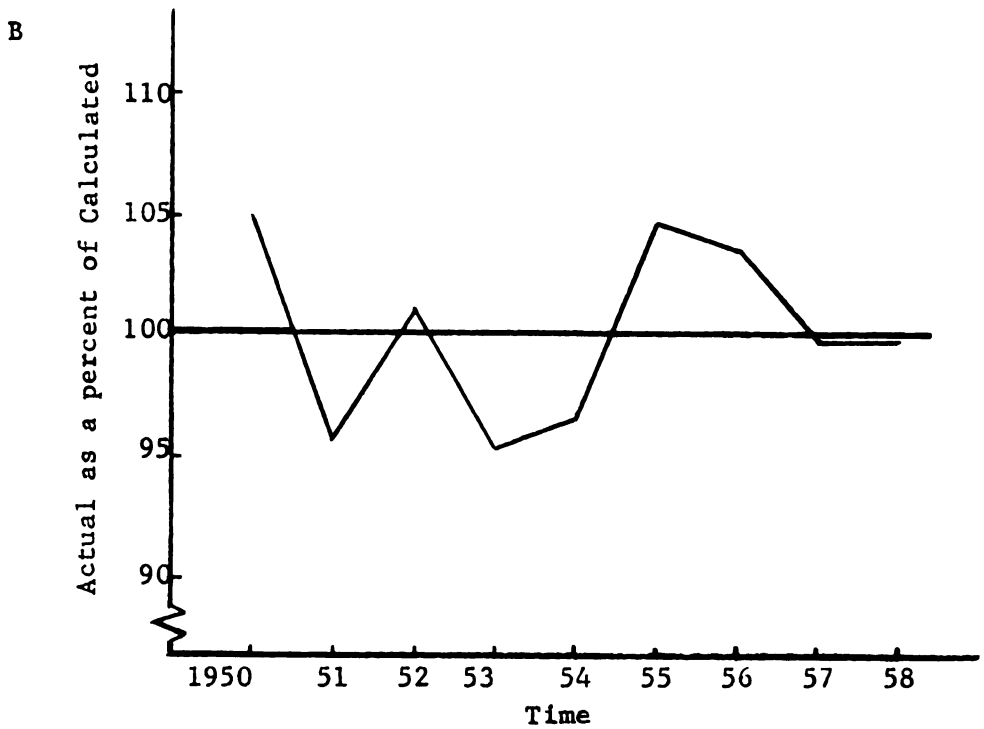
Each of the independent variables included in the regression equation was negatively correlated with the relative retail price of beef to pork; relative per capita consumption of beef to pork ($r_{6Y} = -.86$) being the most highly correlated was followed by income ($r_{0Y} = -.46$) and per capita consumption of broilers ($r_{7Y} = -.41$). Income was highly correlated with per capita consumption of broilers ($r_{70} = .98$) and relative per capita consumption of beef to pork ($r_{60} = .80$) while relative per capita consumption of beef to pork and per capita consumption of broilers were highly correlated ($r_{67} = .78$). The high intercorrelations perhaps point to the source causing the large standard error of the regression coefficient for income and cast doubt on the validity of the other coefficients.

Estimates of the relative retail price of beef to pork as shown in Figure 16, indicate that the model is perhaps the least effective estimating model included in the analysis; this does not mean to imply that the model is a poor estimator, but that it is not as effective as the other equations. The direction of the predicted year to year changes was consistent with the actual changes except in one case, 1952; the difference in the direction of the change may be related to the large overestimate for 1951. The residuals were between -0.068 to + 0.065 or in a range of ten percent about the actual values. The residuals do not appear to be inconsistent with the assumption of randomness, but they do cast doubt on the validity of the assumption that the relationship between

Figure 16

Comparison of Actual and Calculated Relative Retail Prices of Beef to Pork





the variables remained the same over the period 1950 to 1958; the residuals tend to support the relationships between the retail price ratios and the per capita consumption rations that were indicated by dashed lines in Figure 11.

Summary of Regression Results. Although relatively good fits were obtained from each model, the high intercorrelations between the independent variables caused questions to arise concerning the validity of the regression coefficients. This restricts any meaningful statements that could be made concerning the elasticities obtained from the coefficients; these high intercorrelations give reasons to emphasize the graphic as well as the regression results.

In the following chapter these results will be further developed and conclusions drawn as to their usefulness in predicting the future.

Chapter VI

SOME CONCLUDING REMARKS

The hypothesis stated in Chapter I was that the demand for broilers has been increasing relative to the demand for beef and pork. If this hypothesis can be accepted as being true, the increase in the relative demand for broilers could have resulted from changes in the demand for either or both of the commodities. Five possibilities were stated in Chapter V as reasons for the increase in the relative demand for broilers; they were: (1) the demand for broilers increased while the demand for beef and pork was decreasing, (2) the demand for broilers increased while the demand for beef and pork was constant, (3) the demand for broilers, beef and pork increased with the demand for broilers increasing faster, (4) the demand for broilers was constant while the demand for beef and pork was decreasing and (5) the demand for broilers, beef and pork decreased with the demand for beef and pork decreasing faster.

Results of the analysis were presented in the previous chapter; therefore, this chapter is more of an attempt to restate the more important results and to state the conclusions that can be drawn from the evidence indicated by the analysis.

Indications of the Analysis

Indications of shifts in demand that were observed in Chapter V and are presented in this section will be discussed with reference to two periods, the period prior to 1950 and the period 1950 to 1958.

Results of the analysis indicate that the demand for broilers relative to beef and pork did increase during the period 1940 to 1950. This is indicated by the relative data shown in Figures 9 and 10 where the

relationship between the retail price ratio and consumption ratio changed over the period. These diagrams were expressed in terms of beef and pork relative to broilers; since the changes occurring in the relationship between the retail price ratio and consumption ratio during the period were shifts to the left, this indicated that the demand for broilers increased relative to beef and pork. Further comparison of these two diagrams reveals that shifts in the relationships between the retail price and consumption ratios of beef to broilers and pork to broilers appear to have disappeared at about the same time. Since shifts in the average relationship between the retail price and per capita consumption of broilers (Figure 8) also ceased to appear at about the same time, this may be an indication that the demand for beef and pork was relatively stable during the period, at least when compared with the demand for broilers.

The analysis indicated that the demand for beef relative to pork increased in the period 1925 to 1958. This was indicated by the shifts which occurred in the relationship between the retail price and consumption ratios. Shifts in the relationship were not as continuous as the shifts occurring in the relative demand of beef and pork to broilers. This was indicated in Figure 11 where four lines of average relationship were drawn to show the relationship between the price and consumption ratios; since the lines of relationship more nearly resembled demand curves and tended to move up and to the right over time, this is an indication that the demand for beef relative to pork increased over the period studied. Since urban consumers ate more beef than farm people and the income elasticity of demand for beef was higher than the income

elasticity of demand for pork, Shepherd et al.[1] attributed the increase in demand for beef relative to pork mainly to increased urbanization and consumer incomes.

Since the demand for beef relative to the demand for pork increased during the period studied, this indicated that the demand for pork relative to broilers declined more during the period than the demand for beef relative to broilers.

Since the demand for broilers increased, the last two possibilities stated as reasons for the increase in the relative demand for broilers can be rejected. This analysis does not contain sufficient evidence to determine which of the remaining three possible reasons is responsible for the changes in the relative demand, but the increase in the demand for beef relative to pork does indicate that the demand for either beef or pork was changing. This analysis has examined only the relative demand for beef and pork and was not concerned with the absolute demand for either commodity; however, diagrams plotted from the actual data for beef and pork, which was the same data used to construct the relative data, indicate that the demand for beef was increasing over the period while the demand for pork was decreasing. From this it can be concluded that the increase in the relative demand for broilers resulted from an increase in the demand for broilers and an increase in the demand for beef which was less than the increase in the demand for broilers (Reason 3) and a decrease in the demand for pork (Reason 1).

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[1]Shepherd et al., op. cit., pp. 739-742.

The demand for broilers appeared to remain stable over the period 1950 to 1958. Both the graphic and regression analyses indicated that the relationship between the retail price and per capita consumption of broilers remained stable during the period. The graphic analysis indicated that the annual observations tended to move consistently down a single line of average relationship, and the close fits for the data obtained from the regression models further indicated that no changes occurred in the relationship during the period.

The graphic analysis indicated that the demand for beef relative to broilers appeared to remain relatively stable during the period 1950 to 1958, but the estimates obtained from the regression model give reason to question whether the relationship between the retail price and consumption ratios remained stable over the period. Residuals derived from the estimates indicated that the model underestimated the price ratio in the first year, overestimated the ratio in the next four years and then underestimated the ratio in the last four years. Since the relative quantity in the last four years was taken at a higher relative price than was predicted by the model, this could be an indication that the demand for beef increased relative to the demand for broilers during the latter years of the period. The graphic analysis did indicate that there was a tendency for the price ratio to increase in the latter years of the period, but this appeared to be an upward movement along the line of relationship rather than a change in the relationship.

The demand for pork relative to the demand for broilers appeared to remain stable since 1950. The graphic and regression analyses gave no indications that suggested any changes in the relationship between the retail price and consumption ratios of pork to broilers during the period.

The demand for beef relative to the demand for pork increased during the period 1950 to 1958. This was first noted in the graphic analysis in Chapter V where there appeared to be a shift in the relationship between the retail price and consumption ratios of beef to pork. The possibility of a shift occurring in the relationship was weakly supported by the residuals of the estimates obtained from the regression analysis.

The analysis indicated that broilers now compete with beef and pork on an aggregate level. This was shown in the actual demand equation for broilers where quantity consumed was considered to be a function of the various prices; in this model an increase in the prices of beef and pork resulted in an increase in the quantity of broilers consumed. This was also indicated by the retail price and consumption ratios of beef and pork to broilers where a change in the price ratio resulted in a change in the opposite direction in the consumption ratio.

The analysis indicated that prior to 1950 the demand for broilers increased relative to the demand for beef and pork while the demand for beef increased relative to the demand for pork. Since 1950 the demand for broilers and the demand for broilers relative to the demand for pork appeared to remain stable while the demand for beef relative to the demand for broilers and pork increased.

Some Reasons for the Changes in Demand

Shifts occurring in the actual and relative demand for broilers have resulted from changes in tastes and incomes of the consumers.

Consumers have acquired an increased taste or preference for broilers over time for per capita consumption of broilers increased from 2.0 pounds in 1940 to 21.7 pounds in 1958. Unless consumers had increased

their preference for broilers, it is extremely doubtful that per capita consumption of broilers would have increased by this amount as a result of changes in the price of broilers. Availability and improved quality of broilers at the retail outlets have probably been the two most important factors leading to the increased preference for broilers.

Increased production of broilers and the related vertical integration occurring in the industry have made available a larger and more continuous supply of broilers. In the early years of the broiler industry the housewife was never sure when she would find broilers or poultry meat available in the grocery store, This may have eliminated broilers or poultry meat from the diets of families where the housewife planned the family menu in advance of her grocery shopping. The housewife can now be sure that a supply of broilers is available at her local grocery store, and she can plan in advance to include broilers in the family menu.

Improved and standarized quality of broilers available at the retail outlets has permitted consumers to place a higher degree of reliability on the broilers which they view in the retail outlet and may have encouraged greater consumption of broilers by consumers. Improved quality of broilers at retail has resulted from younger and more tender meated birds, which are raised in confinment, and more careful handling of the birds during processing combined with faster transportation between the processing plants and the retail outlets.

The form of the product has changed over time as well as the quality of broilers. In the earlier years broilers were marketed as either New York dressed or ready-to-cook, but over the years processing

shifted to ready-to-cook broilers; this shift is indicated by the retail price series for broilers published by the Bureau of Labor Statistics and the United States Department of Agriculture. Retail prices for broilers are now reported only on a ready-to-cook basis whereas they were reported on New York dressed basis until 1953.

Retail outlets recognized the potential market for broilers and spent more effort to make the product attractive and eye-appealing to potential consumers. Broilers are now displayed in self-service displays along with competing meats where consumers can inspect the quality of broilers and other meats and can choose the meat which they desire.

Most of the changes discussed above mainly occurred prior to or shortly after 1950 and were perhaps the main reasons for the increase in the preference and demand for broilers with the price of broilers, which was increasing, being relatively unimportant. However, these changes along with other changes in the broiler industry which were discussed in Chapter I have not been as pronounced since 1950, and the consumer preference and demand for broilers now appears to be more influenced by the downward trend in the price of broilers. This is supported by the results of Chapter V for the analysis indicated changing relationships between price and consumption prior to 1950 and more stability in the relationships after 1950.

Possibly a high income elasticity of demand existed for broilers over the period studied. This probably resulted from the fact that chicken was once considered to be a luxury and was consumed almost entirely on Sunday. If the influence of preferences could have been

separated from the income coefficients in this analysis, it is believed by the author that the analysis would have still indicated a high income elasticity of demand for broilers.

Raskopf[2] found in Tennessee that per capita consumption of broilers for families living in the county averaged 2.5 pounds lower than for families living in cities or suburbs. Since urban families eat more broilers than families living in the country, this would indicate that the national trend toward urbanization caused an increase in the demand for broilers.

Although increased income and urbanization may have increased the demand for broilers, availability and quality of broilers are believed to be the most important factors causing the increased preferences for broilers. However, in the future it is expected that income will become a more important factor affecting the demand for broilers as quality becomes stablized.

Some Problems and Suggestions for Future Studies

Each of the models presented in this study contains sets of independent variables that were highly correlated with the dependent variable; in each model the independent variables were associated with 85 percent or more of the variance occurring in the dependent variable. Although each of the models presented in this study estimated the observations within the period studied, 1950 through 1958, with a high degree of accuracy, reliability of future predictations is questionable and will depend largely upon whether the independent variables remain as highly

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[2]Raskopf, Factors Affecting Per Capita Consumption of Broilers in Tennessee, p. 21.

intercorrelated in the future. High intercorrelations existing between the independent variables give sufficient reason to question the degree of reliability which one might place on the various regression coefficients and the elasticities computed from these coefficients; this reduces the usefulness of the regression models and especially the regression coefficients for those variables that were highly correlated with other independent variables included in the same equation. Should the independent variables included in the models become less intercorrelated in the future, predictions obtained from these models cannot be expected to exhibit as high a degree of accuracy as the estimates obtained during the period studied. The correlation between income and time in the original models was the highest of the intercorrelations existing in the models calculated for the analysis. Since income and tastes or preferences of the consumers were highly correlated over time, the income coefficients in the models after time was deleted would be expected to include the influence of changes in tastes because it was not possible to separate the influence of the two variables. If the regression coefficients of other variables do not represent the real influence of the variables on the level of demand due to the intercorrelations, then a change in the intercorrelations may result in poor estimates of the dependent variable.

Results of the graphic analysis indicate that data prior to 1950 are of little value in a demand study for broilers which uses the single equation approach. If a longer period of analysis is deemed necessary by future researchers in this area, then they will need to use simultaneous equations or delay their analyses until additional obser-

vations are available. Perhaps extension of this analysis to include the simultaneous equations approach with models for other meats would yield more realistic results in terms of the elasticities compared to the elasticities obtained in this study.[3] This study does provide useful information on the timing of shifts which have occurred in the relationships and should be of interest to future researchers constructing economic models in this area.

Since broilers have a shorter production period than most agricultural commodities and three or four batches of birds can be produced in one year with the same fixed facilities, future work on the demand for broilers could be extended to include an analysis of the demand for broilers for shorter time periods than the year used in this study. Shortening the length of the time period considered should reveal additional relationships that exist but have been lost in the analysis because annual estimates have been used.

Distributed lags were not considered in any of the models used in this analysis, but lagged variables may be considered to be relevant in future research. Perhaps there is a tendency for changes in consumption patterns to lag behind changes in income or to be based on anticipated income or perhaps a tendency for consumption in one period to be dependent on consumption in the past period. However, with the time period being one year it is possible that the effect of any lags may be quite small.

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[3] The study by Nordin, Judge and Wahby discussed in Chapter III is a possible beginning point for such a study.

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A P P E N D I C E S

APPENDIX A

DATA

Appendix Table 1

Commercial Broiler Production, Farm Chicken Meat Production and Gross Income from Commercial Broilers, United States 1934 to 1958*

Year	Farm Chicken Meat Production (million pounds)	Commercial Broiler Production (million pounds)	Gross Income from Broilers (million pounds)
1934	2,105	97	19
35	2,210	123	25
36	2,410	152	31
37	2,032	196	42
38	2,185	239	46
39	2,338	306	52
40	2,158	413	72
41	2,586	559	103
42	3,005	674	155
43	3,679	833	238
44	3,009	818	235
45	3,315	1,107	327
46	2,715	884	289
47	2,668	936	302
48	2,289	1,127	405
49	2,643	1,570	443
50	2,310	1,945	533
51	2,312	2,415	689
52	2,025	2,624	756
53	2,046	2,904	786
54	1,948	3,236	747
55	1,634	3,309	834
56	1,668	4,270	838
57	1,336	4,683	886
58	1,516	5,431	1,002

*Source: Chicken Meat Production: 1934 to 1956, Egg and Poultry Statistics Through 1957, Statistical Bulletin No. 249, AMS, USDA, May 1959, p. 80; 1957 and 1958, Chickens and Eggs, AMS, USDA, April 1959, pp. 7 and 9. Commercial Broiler Production and Gross Income from Broilers: 1934 to 1956, Egg and Poultry Statistics Through 1957, Statistical Bulletin No. 249, AMS, USDA, May 1959, pp. 16 to 17.

Appendix Table 2

Broilers: Farm Price, Retail Price, Farm Value and Farm Retail Spread, United States, 1940 to 1958*

Year	Farm Price (cents)	Retail Price (cents)	Farm Value (cents)	Farm-Retail Spread (cents)
1940	17.3	28.1		
41	18.4	30.2		
42	22.9	36.1		
43	28.6	41.5		
44	28.8	41.7		
45	29.5	43.1		
46	32.7	48.7		
47	32.3	51.1		
48	36.0	56.7		
49	28.2	53.8		
50	27.4	58.5	37.4	21.1
51	28.5	61.3	39.0	22.3
52	28.8	61.6	39.7	21.9
53	27.1	60.0	37.0	23.0
54	23.1	54.2	31.6	22.6
55	25.2	56.2	34.6	21.6
56	19.6	49.0	26.9	22.1
57	18.9	47.9	25.9	22.0
58	18.5	47.4	25.5	21.9

*Source: Farm Price: 1940 to 1957, Egg and Poultry Statistics Through 1957, Statistical Bulletin No. 249, AMS, USDA, May 1959, p. 22; 1958, Chickens and Eggs, AMS, USDA, April 1959, p. 17.
Retail Price: Poultry and Egg Situation, AMS, USDA, November 1958, p. 41.
Farm Value and Farm Retail Spread: L. R. Gray and William L. Mitchell, Marketing Spreads For Eggs and Frying Chickens In The United States and Selected Cities, AMS-296, AMS, USDA, January 1959, p. 21.

Appendix Table 3

Per Capita Consumption of Total Chicken Meat and Broilers, Ready-to-Cook Basis, United States, 1909 to 1958*

Year	Total Chicken (pounds)	Broilers (pounds)	Year	Total Chicken (pounds)	Broilers (pounds)
1909	14.7				
10	15.5		1935	13.1	0.7
11	15.6		36	13.7	0.8
12	14.9		37	13.6	1.1
13	14.5		38	12.7	1.3
14	14.5		39	14.1	1.6
15	14.4		40	14.1	2.0
16	13.8		41	15.4	2.8
17	13.3		42	17.7	3.2
18	13.3		43	23.0	4.1
19	14.2		44	20.4	3.9
20	13.7		45	21.6	5.0
21	13.4		46	19.4	4.1
22	14.2		47	18.1	4.3
23	14.6		48	18.3	5.5
24	13.7		49	19.6	7.1
25	14.3		50	20.6	8.7
26	14.2		51	21.7	10.4
27	15.2		52	22.1	11.7
28	14.6		53	21.9	12.3
29	14.3		54	22.8	13.7
30	15.7		55	21.4	13.9
31	14.1		56	24.6	17.5
32	14.4		57	25.6	19.2
33	14.7		58	28.5	21.7
34	13.5	0.5			

*Source: Total Chicken Meat: 1909 to 1955, Supplement for 1956 to Consumption of Food in the United States, 1909-52, Agriculture Handbook No. 62, AMS, USDA, September 1957, p. 13; 1956 and 1957, Supplement for 1957 to Consumption of Food in the United States, 1909-52, Agriculture Handbook No. 62, August 1958, p. 16; 1958, Poultry and Egg Situation, AMS, USDA, November 1958, p. 39.
Broilers: Data for per capita consumption of broilers were not available prior to 1934; 1934 to 1939, Calculated from data in Delmarva-Maryland-Delaware Broiler Statistics and related data ... 1934-57, p. 45; 1940 to 1957, Egg and Poultry Statistics Through 1957, Statistical Bulletin No. 249, AMS, USDA, May 1959, p. 8; 1958, Calculated from the data in Poultry and Egg Situation, AMS, USDA, November 1958, p. 39.

Appendix Table 4

Data for Variables in Regression Equations*

Year	Relative Retail Prices: Beef Broilers Y_3	Relative Retail Prices: Pork Broilers Y_4	Relative Retail Prices: Beef Pork Y_5	Retail Prices: Beef X_2	Retail Prices: Pork X_3
				(cents)	(cents)
1925			.882	30.7	34.8
26			.842	31.4	37.3
27			.940	32.8	34.9
28.			1.137	37.4	32.9
29			1.163	39.2	33.7
30			1.117	36.2	32.4
31			1.128	30.0	26.6
32			1.412	24.9	17.6
33			1.378	21.5	15.6
34			1.110	23.3	21.0
35			1.010	30.5	30.2
36			.960	28.6	29.8
37			1.062	32.5	30.6
38			1.051	28.7	27.3
39			1.194	29.5	24.7
40	1.050	.769	1.366	29.5	21.6
41	1.043	.901	1.158	31.5	27.2
42	.970	.911	1.064	35.0	32.9
43	.872	.817	1.068	36.2	33.9
44	.820	.765	1.072	34.2	31.9
45	.777	.745	1.044	33.5	32.1
46	.873	.848	1.029	42.5	41.3
47	1.209	1.188	1.018	61.8	60.7
48	1.328	1.088	1.220	75.3	61.7
49	1.271	1.037	1.226	68.4	55.8
50	1.289	.942	1.368	75.4	55.1
51	1.439	.966	1.490	88.2	59.2
52	1.406	.933	1.506	86.6	57.5
53	1.152	1.058	1.088	69.1	63.5
54	1.264	1.196	1.057	68.5	64.8
55	1.201	.975	1.232	67.5	54.8
56	1.347	1.063	1.267	66.0	52.1
57	1.474	1.257	1.173	70.6	60.2
58	1.709	1.367	1.250	81.0	64.8

*Data for variables Y_1 and X_7, the per capita consumption of broilers, and variables Y_2 and X_1, the retail price of broilers, were given in previous tables (per capita consumption in Appendix Table 3 and retail price in Appendix Table 2) and are not included in this table.

Source: Retail Price of Beef: 1925 to 1957, Livestock and Meat Statistics, 1957, Statistical Bulletin No. 230, AMS, USDA, July 1958, p. 271; 1958, Supplement for 1958 to Livestock and Meat Statistics, Supplement for 1958 to

Appendix Table 4 - Continued

Data for Variables in Regression Equations

Year	Relative Per Capita Consumption		
	Beef / Broilers X_4	Pork / Broilers X_5	Beef / Pork X_6
1925			.891
26			.941
27			.805
28			.687
29			.714
30			.730
31			.711
32			.661
33			.728
34			.991
35			1.099
36			1.093
37			.989
38			.935
39			.845
40	27.450	36.750	.747
41	21.750	24.429	.890
42	19.125	19.906	.961
43	13.000	19.244	.676
44	14.256	20.385	.699
45	11.880	13.320	.892
46	15.024	18.488	.813
47	16.186	16.186	1.000
48	11.473	12.327	.931
49	9.000	9.535	.944
50	7.287	7.954	.916
51	5.394	6.914	.780
52	5.316	6.188	.859
53	6.309	5.163	1.222
54	5.847	4.380	1.335
55	5.899	4.806	1.228
56	4.880	3.851	1.267
57	4.406	3.203	1.376
58	3.710	2.797	1.326

Statistical Bulletin No. 230, AMS, USDA, June 1959, p. 133.
Retail Price of Pork: 1925 to 1957, Livestock and Meat Statistics, 1957, Statistical Bulletin No. 230, AMS, USDA, July 1958, p. 272; 1958, Supplement for 1958 to Livestock and Meat Statistics, Supplement for 1958 to Statistical Bulletin No. 230, AMS, USDA, June 1958, p. 133.
Per Capita Consumption of Beef: 1925 to 1956, Livestock and Meat Statistics, 1957, Statistical Bulletin No. 230, AMS, USDA, July 1958, p. 283; 1957 and 1958, Supplement for 1958 to Livestock and Meat Statistics, Supplement for 1958 to Statistical Bulletin No. 230, AMS, USDA, June 1959, p. 138.

Appendix Table 4 - Continued

Data for Variables in Regression Equations

Year	Per Capita Consumption		Per Capita Disposable Personal Income
	Beef X_8	Pork X_9	X_0
	(pounds)	(pounds)	(dollars)
1925	59.5	66.8	
26	60.3	64.1	
27	54.5	67.7	
28	48.7	70.9	
29	49.7	69.6	
30	48.9	67.0	
31	48.6	68.4	
32	46.7	70.7	
33	51.5	70.7	
34	63.8	64.4	
35	53.2	48.4	
36	60.5	55.1	
37	55.2	55.8	
38	54.4	58.2	
39	54.7	64.7	
40	54.9	73.5	
41	60.9	68.4	
42	61.2	63.7	
43	53.3	78.9	
44	55.6	79.5	
45	59.4	66.6	
46	61.6	75.8	
47	69.6	69.6	
48	63.1	67.8	
49	63.9	67.7	
50	63.4	69.2	1,369
51	56.1	71.9	1,473
52	62.2	72.4	1,520
53	77.6	63.5	1,582
54	80.1	60.0	1,582
55	82.0	66.8	1,660
56	85.4	67.4	1,727
57	84.6	61.5	1,782
58	80.5	60.7	1,786

Per Capita Consumption of Pork: 1925 to 1957, Livestock and Meat Statistics, 1957, Statistical Bulletin No. 230, AMS, USDA, July 1958, p. 284; 1958, Supplement for 1958 to Livestock and Meat Statistics, Supplement for 1958 to Statistical Bulletin No. 230, AMS, USDA, June, 1959, p. 138.
Per Capita Disposable Personal Income: 1950 to 1957, Supplement for 1957 to Consumption of Food in the United States, 1909-52, Supplement for 1957 to Agricultural Handbook No. 62, AMS, USDA, August 1958, p. 29; 1958, Poultry and Egg Situation, AMS, USDA, November 1958, p. 41.

APPENDIX B

Alternative Regression Equations

Demand for Broilers

Consumption of Broilers

$$\log \hat{Y}_1 = -6.22661 - \underset{(.19495)}{0.86070^{1}}\log X_1 + \underset{(.11439)}{0.28873^{2}}\log X_2 + \underset{(.15013)}{0.23322^{3}}\log X_3 + \underset{(.23569)}{2.4680^{1}}\log X_0$$

$$\bar{R}^2 = .989 \qquad S_{\hat{y}} = .014$$

Price of Broilers

$$\log \hat{Y}_2 = -3.05852 - \underset{(.31175)}{0.85963^{2}}\log X_7 - \underset{(.25511)}{0.38821}\log X_8 - \underset{(.40976)}{0.28316}\log X_9 + \underset{(1.12356)}{2.18956^{3}}\log X_0$$

$$\bar{R}^2 = .817 \qquad S_{\hat{y}} = .020$$

Demand for Beef Relative to Broilers

$$\hat{Y}_3 = 4.95471 - \underset{(.05373)}{0.23867^{1}}X_4 - \underset{(.00891)}{0.00779}X_9 - \underset{(.0048)}{0.00110^{3}}X_0$$

$$\bar{R}^2 = .746 \qquad S_{\hat{y}} = .085$$

Demand for Pork Relative to Broilers

$$\hat{Y}_4 = 4.60063 - \underset{(.08014)}{0.20981^{2}}X_5 - \underset{(.00541)}{0.00595}X_8 - \underset{(.00088)}{0.00125}X_0$$

$$\bar{R}^2 = .707 \qquad S_{\hat{y}} = .084$$

Demand for Beef Relative to Pork

$$\hat{Y}_5 = 1.72476 - \underset{(.11833)}{1.00641^{1}}X_6 + \underset{(.01266)}{0.01771}X_7 + \underset{(.00042)}{0.00028}X_0$$

$$\bar{R}^2 = .925 \qquad S_{\hat{y}} = .044$$

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[1]Significant at the .01 level.
[2]Significant at the .05 level.
[3]Significant at the .10 level.