START

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

**UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.**
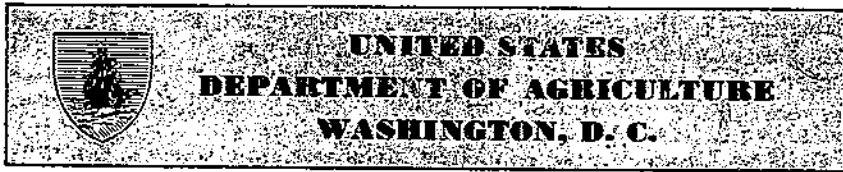
The Analysis of Demand for Farm Products[1]

By KARL A. FOX, *Head, Division of Statistical and Historical Research, Bureau of Agricultural Economics*

SUMMARY AND CONCLUSIONS

This bulletin presents, in terms of simple diagrams, demand-supply structures for a number of farm products. These diagrams have been found helpful in deciding whether consumer demand equations for various products are statistically measurable and, if so, whether single-equation or simultaneous-equation methods are required. Basic problems of analysis of demand by both methods are outlined, and many statistical demand equations for 1922–41 are presented and discussed. The stability and reliability of some of these demand equations during 1942–51 are examined.

[1] Submitted for publication, May 15, 1953.

The diagrams and relationships discussed in this bulletin must be interpreted in the light of its objectives. The relationships discussed are those appropriate to analyses of annual average prices and annual total consumption for the country as a whole in years for which prices are not influenced materially by price supports. They do not necessarily apply to short-run or local marketing situations.

The best forecast of the value of a given economic *variable* can usually be obtained by a single-equation least-squares analysis in which that variable is used as the dependent and the other relevant factors as independent variables. The coefficients of such an equation will not necessarily correspond to familiar economic concepts such as elasticities of supply or demand.

But research workers are often interested in obtaining best estimates of precisely such economic or "structural" relationships as elasticities of demand. In some cases, unbiased estimates of these relationships can be obtained only by solving a system of simultaneous equations.

In order to show that a single least-squares demand equation gives unbiased estimates of the elasticity of demand for a given farm product, it must usually be shown that the production moving into marketing channels, consumer income, and in some cases, supplies of its competing products are not measurably affected by the price of the commodity during the marketing season. This bulletin indicates many practical cases in which unbiased estimates of elasticities of demand can be obtained by single-equation methods.

Disposal income of consumers is not influenced to a statistically measurable extent by changes in price or consumption of any individual farm product, nor is it influenced to any significant extent by those for groups of commodities, such as all livestock products. Of course, it is realized that farm prices as a whole, as reflected in farm income, make a significant contribution to total consumer income.

In many cases it is clear that supply or production for an entire year is determined mainly by prices in a period prior to the time of harvest or marketing, or by weather and other noneconomic factors. Such cases include most annual crops and production of hogs and turkeys prior to World War II. Supplies of continuously produced commodities such as eggs, milk, and commercial broilers would fall into this category if time units shorter than a year were used. Annual production of other commodities such as beef, veal, and lamb and of some of those just mentioned can be shown to be largely unaffected by price during the marketing period in most years. Extreme circumstances, such as application or removal of price controls, have disrupted this situation at times.

Logically, consumption usually depends upon current price. For many commodities, however, consumption for a marketing year is highly correlated with production which, in turn, is not significantly affected by price during the period of marketing. This is apparently true for most livestock products (except dairy products and animal fats and oils), feed grains and hay, vegetables for fresh use, and some fruits. For commodities having two or more major end uses in the domestic market or for which changes in demands for export and storage are important, valid single-equation measurements of the coefficients of elasticity may sometimes be obtained by deriving a statistical relation for each of the separate outlets. This approach is

especially usable if price is determined mainly by an effective price-support program, so that consumption becomes in effect the dependent variable, or when the price in this country is determined chiefly by conditions in the world market. In the latter case, the world price (say at Liverpool) may be expressed as a function of world supply and world demand. This has been done in certain analyses based on prewar years for wool, cotton, and wheat.

Certain practical problems are involved in any attempt to measure elasticities of demand or other structural coefficients by statistical means. In those cases in which the simultaneous-equations approach appears to be required, these problems frequently are magnified because of the greater complexity of the analysis. For example, it is hard to find and construct meaningful and continuous series on foreign prices and foreign incomes or other measures of foreign demand for much of the period since 1933. Estimates of production in certain countries, such as China and the Soviet Union, may be inaccurate and in some cases they are unavailable. Good estimates of production and exports may exist for the major exporting and importing countries. However, construction of a supply or consumption series based on a limited list of countries artificially excludes the effect of import demand and export supplies in omitted countries.

Lack of published retail price series on a sufficiently detailed basis may prevent the estimating of consumer-demand relationships for some products. Data on retail inventories of processed fruits and vegetables are generally incomplete, and representative wholesale or f. o. b. price series for many processed commodities can be obtained only if one has access to records of large processors and distributors. Veal and mutton also are among the commodities for which no adequate retail price series exist.

Domestic consumption in the sense of final purchases at retail is imperfectly known for some fats and oils and their products, for sugar, for cotton goods, and for processed fruits and vegetables. In addition, some consumption series, like that for fluid milk and cream or for the quantity of wheat fed to livestock, are estimated as residuals and include in themselves any error which may exist in the final production estimate or in other major utilization components. For other items, such as fresh vegetables, the reported estimates of production are incomplete, and the accuracy of consumption estimates based on them, although including allowances for unreported production, is unknown.

If the level of error in reported series attributable to lack of data or incomplete reporting can be estimated, least-squares regression coefficients and equations can be corrected for biases that arise from these factors.

In many cases, information available to the investigator will not lead him unerringly to a unique set of equations (if a simultaneous system is required) or a unique set of variables in any case. Problems of the degree of aggregation that should be used often are considerable, and the choice made will affect the final coefficients and the interpretations placed upon them.

In certain cases information obtained from previous knowledge or research concerning some of the coefficients in a complete demand-supply structure may be used to obtain estimates of some of the other

coefficients. For example, a cursory inspection of series on wheat prices and on the domestic food use of wheat indicates that the elasticity of final consumer demand is extremely small—probably somewhere between zero and —0.1. If the United States price has been on a support basis, a demand curve for exports of wheat from this country might be calculated, using the United States farm price of wheat as an independent variable and using world production of wheat outside this country (and possibly the total number of dollars expended by foreign countries for all of our goods and services) as other independent variables. When the price of wheat is well above the price of feed grains, the demand for wheat for feed is fairly inelastic. When the price of wheat is close to or a little below the price of feed grains, this demand is highly elastic. From these various pieces of information, a partly synthetic demand structure which has considerable explanatory value can be determined for this country's wheat. Such structures embody the judgments and intuitions of commodity specialists in a quantitative and reproducible form and serve to crystallize any forecasting or policy interpretations which are based upon them.

Elasticities of demand for most livestock products, using retail prices and domestic consumption as variables, range between —0.5 and —1.0. If demand elasticities at the farm price level are derived from these, they center around —0.5. Elasticities of demand at the farm level with respect to total supply or production are greater than the elasticities derived from domestic consumption, as the effects of changes in production on prices received by farmers are softened by adjustments in foreign trade and in stocks. Most of the demand elasticities at the farm price level for selected crops also are less than unity, and a few are between zero and —0.5. For most farm crops, revenue could be increased, at least in the short run, by cutting back production or consumption. The substitution effects set in motion by programs directed to such an end over longer periods cannot readily be inferred from these estimates of demand elasticity based on year-to-year changes. Only a few of the crops for which analyses were run show elasticities of demand greater than one in absolute value.

Two of the major analyses of demand for livestock products were projected through 1942 to 1950. The addition of "excess cash reserves of consumers" to disposable income apparently improved the estimates. But even after allowing for this factor, a lag in adjustment of consumer demand to the sharp changes in price and income of 1946–48 appeared to be required. Similar extensions for the analyses dealing with crops indicate that, with the exception of potatoes during the period for which price supports were in effect, most of the prewar analyses applied reasonably well in the postwar years. This was true even for items like corn and other feed grains for which prices in some years were considerably affected by Government programs.

These results offer encouragement as to the continued applicability of many analyses of demand based on prewar data. It is not surprising that demand equations for staples like apples, onions, and sweetpotatoes have not changed greatly in terms of year-to-year responses. Nor is it surprising to find unchanging relationships within the feed-grain and hay economy, given certain levels of livestock production and prices. The changes that have taken place in consumer demand for livestock products evidently do not affect the equations that

measure demand by livestock producers for feed concentrates and hay. However, more detailed analysis is needed of changes in price and consumption relationships both during and after World War II than is given in this bulletin.

Despite these encouraging results, demand equations derived for a particular time period cannot be extrapolated with confidence into later time periods without a careful appraisal of possible changes in their demand-supply structures during the intervening years. Statistical analysis of demand is an adjunct to other sorts of specialized and detailed knowledge rather than a substitute for it. Under favorable conditions it enables us to summarize much of this information in a simple and usable form and to make forecasts or interpretations within approximately known margins of error.

INTRODUCTION

As a statement of economic principle, the modern view that, in general, a "system" of equations must be analyzed simultaneously to ascertain the underlying relationships between price, production, and consumption of agricultural commodities is not a novel one. The real advance made lies in the development of a statistical theory (and computational procedures) which should enable us to "identify" and measure the several relationships involved in such a system. The difficulty of separating a demand from a supply curve when price and quantity are determined simultaneously was described by Working (37)[2] in 1927, but not until 1943 was an adequate procedure available for measuring each curve when supply is influenced by current prices.

However, modern econometric theory recognizes a special case in which a single least-squares equation gives an unbiased estimate of the demand curve. Minor departures from this case may be handled satisfactorily by single-equation methods; major departures in general require the simultaneous fitting of two or more equations, if the object is to obtain unbiased estimates of elasticities of demand and similar structural coefficients. If interest centers on predicting the value of one variable from given values of other variables and if elasticities of demand are not required, single least-squares equations are useful, even when the basic structure involves simultaneous equations.

In attempting to appraise the extent to which demand functions for agricultural commodities can properly be derived by single-equation methods, demand-supply structures for specific farm products are presented graphically, and the practical meaning and statistical implications of these structures are discussed. Statistical analyses of the factors that affect price and consumption are presented for a number of products for which the single-equation approach is apparently applicable, based on data for 1922–41. A few simple simultaneous-equation systems are also presented.

Some disturbances and apparent changes in prewar demand relationships, which were reflected in demand relationships during and after World War II, are discussed and the value for forecasting of some of the prewar demand functions under postwar conditions is appraised.

---

[2] Italic numbers in parentheses refer to Literature Cited, p. 88.

DEVELOPMENT OF STATISTICAL ANALYSIS OF DEMAND

That this study may be placed in proper perspective, some of its theoretical and empirical forerunners are outlined. The statistical derivation of "demand curves" is a development of the present century. Aside from the pioneer attempts of Benini (4), Moore (27, 28), and one or two others, applied work in this field did not get under way until after World War I. Considering the effect of economic and other upheavals upon the continuity of research, it is not surprising that, in 1953, certain major questions remain unsettled concerning methodology and that the number of generally accepted results is limited.

Statistical analysis of demand was late in developing because of its dependence upon both economic and statistical theory which were previously unrelated and also upon the scope and accuracy of published economic data.

The requisite economic theory for analyzing demand was available at an early date. In 1838, Cournot (8) stated the economic theory of demand in a form that lent itself to numerical applications and suggested that "it would be easy to learn, at least for all articles to which the attempt has been made to extend commercial statistics, whether current prices are above or below" the value that would maximize gross revenue from sales. However, 50 years went by before statistical concepts that were even imperfectly adapted to analysis of demand became available. Not until the 1890's was the theory of correlation elaborated, and it was several years later before it was applied for the first time to relationships between price and quantity.

Discussion of the slowness of development of economic data and particularly of continuous time series relating to production, consumption, and income, would take us too far afield. In this country, such series on national income and on consumption of food date from the 1930's. In the 1920's analysis of agricultural prices was seriously hampered by inadequate data, and prior to World War I agricultural data were even more limited both in scope and in accuracy. Nevertheless, it was evident to Moore (28) that "the most ample and trustworthy data of economic science" were official statistics.

In the 1920's, economists in the United States Department of Agriculture and in the State agricultural colleges made many analyses of relationships between price and quantity of farm commodities. These studies were intended to provide information by means of which farmers could adjust their plans for production and marketing. Although the rate of publication of analyses of agricultural prices slowed down considerably after about 1933, the results of the earlier period have been modified and extended.

Demand analyses of some sort now exist for aggregates such as all farm products, all foods, food livestock products, meat animals and meats, and for many individual products. Analyses of supply or response of acreage to price have been made for potatoes, cotton, flaxseed, milk, hogs, eggs, chickens, and other products.

Persons doing applied work in demand analysis may be divided into three groups, although, in 1953, the lines between them are less rigid than they were a year or two earlier. The first group carries on in the tradition of Moore, using the single-equation least-squares ap-

proach and relying upon judgment to cope with the various pitfalls that have been stressed by other groups. Some analysts use the short-cut graphic method, developed and popularized by Bean (3), as a supplement to, or a substitute for, mathematically derived least-squares regression equations. The second group supplements the least-squares approach with the application of bunch-map analysis to select "useful" variables and to detect high intercorrelation among independent variables. The third group, which centers around the Cowles Commission at the University of Chicago, uses a multiple-equation approach and takes explicit account of the so-called "identification problem." The methods used by these three groups were largely developed in three successive decades.

Henry L. Moore was the principal founder of the first and earliest of these groups. His books (27, 28) furnished inspiration for much of the analysis of agricultural prices that was carried on in the United States during the 1920's.

By the end of the 1920's, leaders of this group had recognized and suggested solutions for several major problems of the single-equation least-squares approach. Holbrook Working (38) pointed out that the curves which could be approximated with agricultural data then available were demand curves of dealers rather than consumers. He called attention also to the fact that errors or disturbances in independent variables gave a downward bias to least-squares regression coefficients. Elmer Working (37) gave an account of what is now called "the identification problem." Henry Schultz (30) calculated weighted regression coefficients to allow for the presence of errors in explanatory variables. Recognition of sampling errors and tests of significance by price and demand analysts came at the end of the decade. This subject was treated by Ezekiel in his book (10) on correlation analysis, published in 1930. Schultz's article (31) on the standard error of a forecast appeared in the same year, but it had to some extent been anticipated by Working and Hotelling (39) in 1929.

The two monuments of the first group are Ezekiel's *Methods of Correlation Analysis* (10) and Schultz's *The Theory and Measurement of Demand* (32). Schultz's applied work belongs with this group, although some of his theoretical chapters go beyond the usual scope of its interest.

The second group relies upon methods developed by Ragnar Frisch (15, 16) from 1929 to 1934. Frisch realized that spurious results could be obtained because of the combined (and unrecognized) effect of random errors in the data and high intercorrelation among explanatory variables. He believed that such results were often obtained in practice. To cope with this problem, Frisch developed his method of "statistical confluence analysis by means of complete regression systems." This technique was used extensively by Tinbergen (34) in analyzing business cycles and by Stone (33) and Prest (29) in analyzing price-consumption relationships.

The third group, which became active in the last decade, is largely identified with the Cowles Commission. The first major article dealing with the simultaneous-equations approach was published by Haavelmo in 1943 (18). The main feature of this approach is its emphasis upon the simultaneous determination of interdependent

relationships. Analysts of the previously discussed groups frequently used two or more equations to indicate an equilibrium solution, such as the determination of price by the intersection of a supply and a demand curve, but in their studies each curve was determined separately. Tinbergen (34) calculated many equations which were theoretically interdependent, but his method of fitting assumed that each was statistically independent.

This third group has its theoretical monument in Cowles Commission Monograph No. 10, Statistical Inference in Dynamic Economic Models (22). The introduction to the simultaneous-equations approach by Marschak, together with material included in Girshick and Heavelmo (17), Koopmans (21), and Klein (20, ch. I), is particularly helpful toward an understanding of the economic and statistical assumptions on which the approach rests. Much effort has gone into the simultaneous equations approach. But its applications have so far been limited in number,[3] and the areas in which it is superior to other methods have not been clearly defined. Its basic assumption is that "economic data are generated by systems of relations that are, in general, stochastic, dynamic, and simultaneous" (22). A frequently used model of this type assumes (1) that some of the variables within the system are determined simultaneously by the several relationships involved, (2) that a random "disturbance" or residual term is attached to each equation, in contrast to functional relationships which are assumed to hold exactly without error, and (3) that lagged values of some variables are involved. However, there are certain cases, particularly in analysis of agricultural prices, in which simultaneity is of limited importance. In such cases it is doubtful whether the elaborate procedures of the Cowles Commission will improve or even change the results of the single-equation approach within the limits of sampling error.

A THEORETICAL FRAMEWORK FOR ANALYSIS OF DEMAND

In any modern econometric investigation, four major steps are involved: (1) Specifying the system of relationships that is believed to have produced the observed data; (2) ascertaining whether these relationships can be identified for purposes of statistical analysis; (3) making the statistical analysis; and (4) interpreting the results.

The first requires a knowledge of economic theory and of the particular relationships that hold for the commodity under consideration. In Cowles Commission terminology, it involves specifying the "model," that is, the system of equations and the variables involved in each equation. Diagrams of the supply-demand structure, several of which are presented in this bulletin, serve the same purpose as an econometric model and are useful in helping nonmathematicians to understand the nature of the interrelationships involved.

For a complex set of simultaneous equations, the second is essentially a problem for mathematicians. In simple cases, certain criteria can be used to ascertain whether a particular set of relationships can be identified and whether a set of simultaneous equations is required

---

[3] Johnson (19, pp. 56–71 and 109–111) gives an example that can be rather easily followed by applied commodity analysts.

to yield valid estimates of the various coefficients involved, or whether equally reliable results can be obtained by the single-equation approach. These criteria are discussed in the section that follows. In the present state of economic theory, there usually is room for differences of opinion concerning at least some of the variables that belong in a complete model. Investigators are inevitably tempted to discard or add enough of these controversial variables to make a particular equation, and the model as a whole, identifiable. This problem is recognized by Klein (20, p. 10) in the following footnote:

The reader must not get the impression that economic theory is called upon at this moment in order to achieve identification. Economic theory is called upon to provide the true structure of the systems of equations. The parameters (or coefficients) of the true system may or may not be identifiable. However, if we fail to get an identified system because certain variables have been omitted from the equations or because the equations are not true, we must use economic theory to improve the equations until they do represent the truth. If the truth permits identification of the parameters, we may proceed with statistical estimation.

The third involves statistical problems which are largely outside the scope of this bulletin. Some of these are discussed in Fox (13); others are covered in standard textbooks that deal with statistics or price analysis.

Certain considerations that are involved in analyzing the supply-demand structure for a particular commodity or group of commodities are discussed in this report.

WHEN CAN THE SINGLE-EQUATION METHOD BE USED?

If the purpose of an analysis is to estimate the expected price associated with given values for such variables as size of crop and consumer income, the best answer can be obtained by a least-squares regression with price dependent and other variables independent. If the purpose is to estimate the elasticity of demand and other structural coefficients, this equation may not give an unbiased estimate. It will do so if, and only if, current supply and other independent variables are not measurably affected by price during the marketing period. These conditions are approximately met for many farm products. If they are not met, a system of simultaneous equations is needed if valid estimates of the several coefficients of interest to economists and commodity analysts are to be obtained.

The two diagrams shown in figure 1 illustrate the meaning of these criteria. Each shows the demand-supply structure for a certain type of perishable crop. In the upper diagram, all of the crop is assumed to be sold in a single outlet. Watermelons make a good example. The lower diagram assumes that part of the crop is sold in the fresh market and part in processed form. It further assumes that the farm or local market price is identical in the two outlets and that the retail price for either form is not significantly affected by the retail price or consumption of the other form. This situation may apply approximately to consumption of table grapes in fresh form or for making wine and other alcoholic beverages. In each diagram, total supply is assumed to be unaffected by the price during the harvesting season.
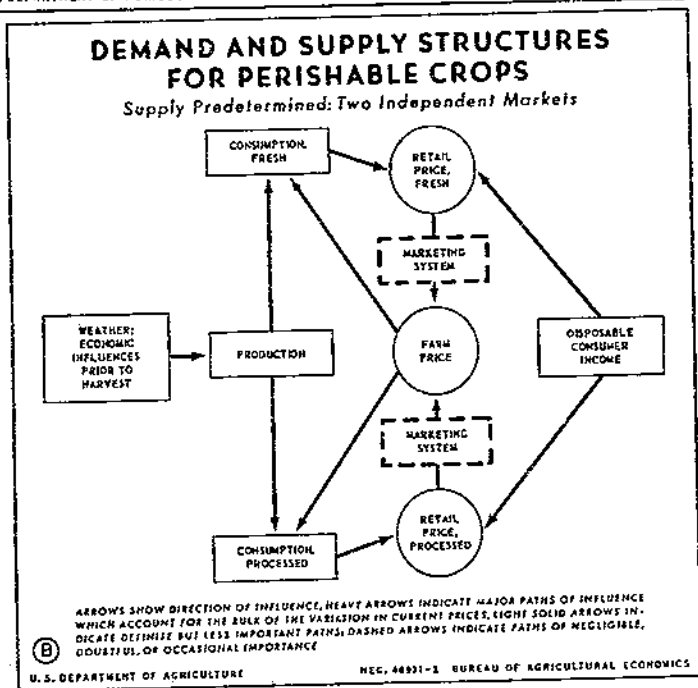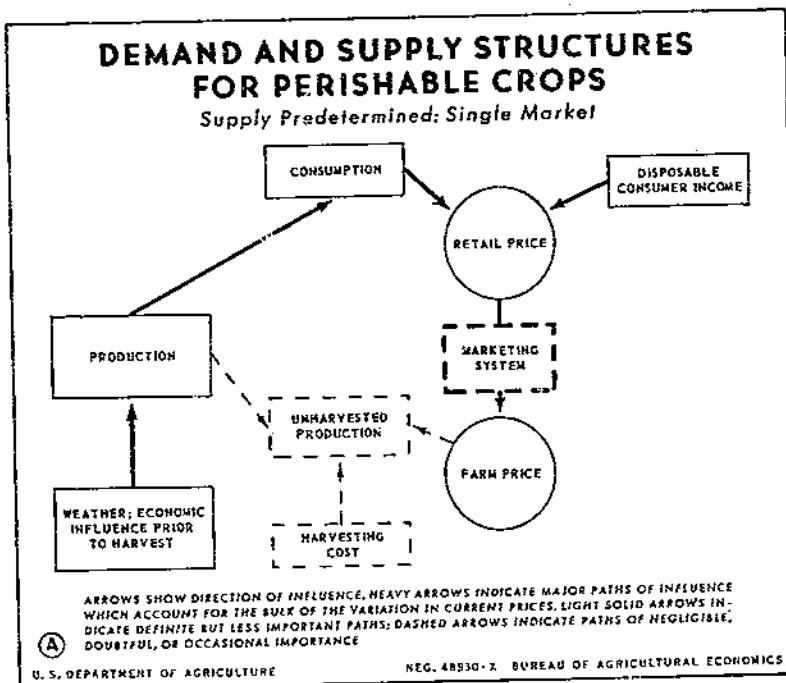
FIGURE 1.

In the situation illustrated by the upper diagram, if under usual price conditions all of the crop is harvested, a single-equation approach can be used to estimate the elasticity of demand and related coefficients. In this instance, retail price would ordinarily be considered to be determined by production (or consumption) and consumer income. Variations in the retail price not explained by these two factors would result partly from errors of measurement in the price series used and partly from effects of other real but minor factors not included in the equation. If the partial correlation between price and consumption is very high, consumption can be treated as the dependent variable without greatly affecting elasticity and other estimates. Prices at the local market or farm level can then be estimated from a simple equation relating farm to retail prices.

But when prices of certain crops decline below costs of harvesting, much of the crop is left in the field. In such cases supply is determined partly at least by current price. If this occurs in significant degree, a system of equations involving separate supply and demand functions may need to be solved simultaneously.

In the lower diagram, all production is assumed to be harvested and marketed for use in either fresh or processed form. If interest is centered mainly on the factors that determine the farm price, they can be estimated from a single-equation in which price is the dependent variable and production and consumer income are used as independent variables. The supply-price coefficient obtained from this equation, if converted to an elasticity-of-demand coefficient by the usual formulas, would represent an average of the elasticities in the fresh and processed market. Single equations likewise could be used to measure the interrelationships between consumption, price, and income in either the fresh or processed market, *given the amount that moved through each of these outlets.* However, a simultaneous system of equations would be needed to estimate the relative proportion of the crop that could be expected to move through each outlet in any given year. Such a system would at the same time yield a measure of the different price and income elasticities of demand prevailing in each outlet.

In deciding whether the single-equation or the simultaneous-equations approach is applicable for any given commodity, several questions must be answered. As this study is concerned with demand, identification and measurement of the demand relationships are emphasized. Problems involved in ascertaining the factors that affect supply, or in measuring other relationships that may enter into the complete supply-demand structure, are considered only to the extent that they are instrumental in isolating the demand function. To justify the use of the single-equation least-squares approach in estimating elasticity of demand and similar coefficients, the following questions must be answered:

1. *Is supply of the given commodity affected by current price?*—If the answer to this question is "yes," there is implied the existence of a second "structural" equation in which supply is expressed as a function of average prices during the marketing season in addition to cer-

tain other relevant variables.[4]   Hence, the alternative to treating supply as a "predetermined" variable (with or without certain minor adjustments) is the simultaneous fitting of both a supply and a demand curve.

Whether supply is unaffected by price during the marketing period depends to some extent upon the market level at which supply is defined.   This in turn depends upon the point in the production and marketing chain at which the demand relation is estimated.   In general, the quantity of a crop ready for harvest is determined (1) by economic factors which operated before planting time and in stages of growth during which yield-influencing practices or materials may have been applied; and (2) by noneconomic factors such as weather, insects, and other natural hazards.   Similarly, the number of animals on farms at the beginning of a marketing period is unaffected by current price.

As mentioned above, the quantity of a crop actually harvested or marketed may be affected by prevailing prices during the marketing period in some cases.   Individual producers may leave quantities unharvested if current market prices fall below the costs of harvesting and transporting the crop to market.   In a few cases, producers may be able to control the total quantity harvested in response to the price situation that exists at harvest.   In these cases, the quantity harvested is determined jointly or simultaneously with the current price.   If the actions described are taken in only a few abnormal years, harvested production in the remaining years may still be treated as a predetermined variable.

2. *Is consumption of a given commodity significantly affected by current price or by the demand for export or storage?*—Suppose the supply of a given commodity entering the marketing system is not affected by the current market price.   Suppose further that the marketing system passes on this supply in a routine way, so that, except for normal wastes and losses in the marketing process, the supply that reaches consumers is exactly equal to that marketed by farmers.   In this case, consumption is not determined by prices during the marketing period; it can be used as an independent variable in a least-squares demand function.

If consumption is not exactly equal to farm supply, because of change in stocks or because of existence of foreign trade, cases that are more complicated will arise.   Theoretically, the existence of imports suggests one or more supply curves for producers or dealers in the countries from which imports are obtained; the existence of exports denotes the presence in a complete model of the demand curves

---

[4] The word "predetermined" is used frequently in the remainder of this bulletin to avoid repetition of cumbersome phrases.   A variable is predetermined with respect to a given demand-supply structure if its current value is not affected by current values of other variables in the same structure.   In other words, its value is determined by forces operating *prior to* the current time period, by factors *outside* the demand-supply structure in question, or by both together. A variable that is predetermined in this sense can be used as an independent variable in a least-squares demand function (or in the "reduced form" equations of a simultaneous model) to arrive at unbiased estimates of structural coefficients.   A variable that is not predetermined ordinarily leads to biased estimates of such coefficients if treated as an independent variable in least-squares equations.

of one or more foreign countries. If domestic stocks change significantly, in addition to the demand curve for final consumption, a demand curve for storage holdings exists. Thus, in a strict sense, it is clear that if foreign trade or changes in stocks are important, a multiple-equation model is required.

However, suppose the changes in stocks and in net trade are both small relative to observed changes in consumption and that domestic consumption, accumulation of stocks, and net exports move in the same direction in response to changes in supply. In such cases, changes in domestic consumption can be estimated with considerable accuracy on the basis of changes in supply. If supply is predetermined, consumption also can probably be treated as predetermined under such conditions.[5]

3. *Is consumer income significantly affected by changes in price or consumption of the given commodity?*—If the answer to this question is "yes," an equation explaining consumer income as a function of certain other variables would be required in a complete model for the commodity.

Disposable personal income is affected directly or indirectly by prices and production of all goods and services in the economy. In a complete model of the entire economic system, disposable income would be regarded as a simultaneously determined variable. For any given commodity, however, the question involved is the extent to which disposable income is influenced by variations in the consumption and price of the commodity in question.[6]

The most important individual farm products, such as beef, pork, and fluid milk, are equivalent in retail value to only 2 or 3 percent of disposable income. Variations in the supply of any one of these could hardly account for more than 2 or 3 percent of the total variation in disposable income, particularly after allowing for the relative stability of production of the major agricultural products. The fact that elasticities of consumer demand for such items as pork and beef appear to be not far from unity tends to restrict the income effects that otherwise might flow from these commodities. These considerations suggest that disposable income can be treated as an independent variable in statistical analyses of demand for farm products, either singly or in moderately large groups. In fact, even in the Girshick-Haavelmo (*17*) multiple-equation analysis of the demand for all food, the income equation was fitted independently by the method of least squares.

4. *Is the supply of any competing commodity affected by the current price of the given commodity?*—Considerations that affect the answer to this question are identical with those involved in answering question 1. If the answer is negative or approximately so for all closely competitive items, their supplies can be included as independent

variables in a least-squares demand equation, with the price of the given commodity as the dependent variable.

5. *Is more than one major domestic outlet available for the given commodity?*—If so, separate equations are needed to measure the demand in each outlet. Separate equations also are needed to measure the relation between farm and retail prices, and some assumption regarding the level of farm prices for products moving into each outlet needs to be made. If a substantial part of the supply could move into either outlet, fitting these equations simultaneously should yield valid estimates of the various coefficients, given sufficiently accurate data. For some crops, however, varieties grown for processing and those grown for fresh use differ. In such cases, each variety can be considered as a separate commodity, and the single-equation approach can be used for each, provided the other considerations noted above permit its use.

If each of these four questions can be answered in the negative, a statistical demand function fitted by least squares should approximate the "true" or structural demand function. If an analyst has serious reservations on any of these questions, it may be necessary to fit a set of simultaneous equations. Although, in the latter case, the use of a single equation may yield a useful forecasting device under certain circumstances, the result cannot be clearly interpreted as a function of demand which reflects the behavior of certain specified economic groups.

Factors That Cause Changes in Consumer Demand [7]

The basic unit in analysis of consumer demand is the individual consumer or, at most, the individual family or spending unit. Each family has certain characteristics which are actually or potentially important in relation to its consumption of foods. These may be grouped into (1) the basic food habits of its members and (2) measurable characteristics such as income, financial commitments, and initial pattern of expenditures; number of members employed and their occupations; total number of persons in the family, and their ages and sex.

During any given period, basic changes may occur because of deaths or births, or grown sons and daughters may leave the home to establish new families. Some of these changes are influenced significantly by economic conditions and profoundly by mobilization for war.

Economic characteristics also change during any given time period. The income of each working member of the family from his original job may change owing to changes in basic wage rates, average hours worked per week, or weeks worked per year. If he does not work for wages, his salary or income from professional services, interest, or rents may change. He may change his occupation in a way that will influence his consumption of food. Or, he may retire, which will mean changes both in income and in way of life that will influence his own consumption of food and that of the larger spending unit (if any) to which he belongs. An additional member of the family

---

[7] This section was drafted originally in December 1950. The author's conception of consumer behavior closely parallels the "going concern" concept outlined in Bilkey (5, particularly pp. 33–45 and pp. 65–66).

may take a job, with resulting changes in his own pattern of living and in that of the spending unit as a whole.

A family may take on new financial obligations or liquidate old ones. New obligations may decrease current expenditures for food and retirement of obligations permits them to increase. The decision to take on new obligations is influenced by economic considerations (including anticipated increases in personal income, in prices of durable goods, or in both) and, in national emergencies, by anticipations of future shortages. In a free economy, patterns of expenditure and consumption are influenced to some extent by changes in relative prices, apart from anticipations as to future price movements of durable or storable commodities.

When the country's resources are fully mobilized, direct restraints may be placed on some normal activities and expenditures. These restraints involve a reduction in the flow of satisfactions the family derived (or would have derived) from them. Consumer durable goods provide mobility, entertainment, and other values, or they reduce the time and energy spent on household tasks. When these goods are unavailable, the effect goes beyond a simple release of cash. People try to obtain substitute satisfactions from goods and services the supply of which can be maintained or increased. Deprivation of leisure through a longer work week builds up similar pressures. Disruption of community ties as families move to centers of defense industry, and of family ties as members enter the Armed Forces, also affects the balance of feasible satisfactions and expenditures. All of these factors may express themselves as disturbances or shifts in the demand relationships which had prevailed in the peacetime economy.

The quantity of any food demanded (in the economic sense) by a particular family depends chiefly upon these variables: (1) Price of the given commodity; (2) prices of a few closely competing commodities; (3) retail prices of other consumer goods and services; (4) family income; (5) liquid assets held; (6) fixed commitments and (7) various other characteristics of the family, such as number, age, and sex of each person, and occupations of working members. A demand equation containing all of these variables still would be subject to minor disturbances in normal times because of more remote economic variables, and to major or episodic disturbances in times of mobilization or war.

In terms of national totals and averages, fairly good data are available on consumption and on the first four listed items from about 1920 on, so far as most major food products are concerned.[8] Data on liquid assets and fixed commitments of consumers are limited for years before 1939. Other characteristics, such as age and sex distribution of the population, change slowly; data concerning others, such as occupational distribution before World War II, are limited and little is known as to the effects of changes in these attributes upon the demand for particular foods. For this reason, the final three items cannot be included in statistical analyses of demand for the pre-World War II period. They may not have varied sufficiently from 1922 to

---

[8] National totals and averages inevitably omit certain information which could be obtained from data for individuals, including information on distribution of income, distribution of liquid assets, and the relation between these two distributions.

1941 (the period on which most of the analyses presented in this bulletin are based) to cause significant shifts in the total demand for individual farm products. However, some of them changed drastically enough during and after World War II to affect seriously the accuracy of forecasts based on prewar relationships. In addition, price control and rationing destroyed the usual significance of some of the variables during the war.

In passing from demand equations for individual families to those for the total population, price rather than consumption should be placed in the dependent position in those cases in which the single-equation approach is applicable. Individual consumers adjust their purchases to the array of market prices which they must pay. For the nation as a whole, total production of farm products is more likely to be the given or predetermined variable, with the market price adjusting to it. If, in addition, consumption also can be assumed as essentially predetermined, then single-equation methods are applicable.

Time-series data on prices paid by consumers usually represent prices in retail stores. Restaurants and institutions account for an appreciable fraction of the total consumption of food. Sizable quantities of dairy and poultry products, hogs, fruits, and vegetables are consumed on the farms that produce them. Relative prices of individual foods may differ greatly in these outlets and may be partly responsible for the varying patterns of consumption in restaurants, on farms, and in urban homes. On the other hand, time-series data on consumption of food relate to total domestic consumption. Prices of a given food and its competitors in retail stores, therefore, are not a perfect measure of the array of market and imputed prices which induce the observed changes in consumption of food. This qualification may be of some significance in periods of rapid changes in the proportion of total food consumed on farms or in restaurants.

The list of variables that affect consumer demand includes "closely competing commodities." However, certain foods, notably fats, oils, and sugar, are used mainly as ingredients in food combinations. In most cases, the fat or sugar accounts for only a minor part of the cost of the complete "dish" and the proportions in which these ingredients are used are affected very little by changes in price.

There is some evidence in the national statistics of a stable "technical coefficient" connecting consumption of butter plus margarine with that of bread. Thus, the drop in consumption of butter from 1940 to 1950 may have resulted almost as much from a drop in consumption of bread as from an increase in use of margarine. Similarly, salad oils go with salads; their use has increased roughly in line with the increase in consumption of salad vegetables.

Sugar is used with many foods. Large quantities go into confections, soft drinks, ice cream, sweetened condensed milk, bakery products and jams and jellies, and into canned and preserved fruits. Large quantities are also used in coffee, tea and cocoa, on breakfast cereals, and on fresh fruits and berries. In each of these uses, each individual tends to use sugar in a fixed ratio to the main ingredient.

In analyses of the demand for edible fats and oils or for sugar it would be logical to include as a variable consumption of foods with which these commodities are customarily used. Both price and income elasticities of demand for sugar, given certain levels of con-

sumption of foods in which it is used, are probably smaller than is implied by time-series analyses which omit the "completing goods."

Foods compete with one another in terms of their positions in the menu, the time needed for their preparation, and other factors. The fact that different foods, such as beans, cheese, eggs, and fish, are equivalent sources of protein does not necessarily lead to economic competition among the foods. To the extent that custom and time needed for preparation make eggs a breakfast and meat a dinner item, the two compete very little. If the number of significant regression coefficients obtained is any criterion, short-run competition and substitution among foods are limited, except within groups such as meat and poultry or canned fruits. At lower market levels, competition within the fats and oils and the feed concentrates groups is also important. But there are no reasons for regarding all food as a homogeneous total, as is implied in some published analyses.

The list of variables presented does not specifically include lagged values of price, consumption, income, or other factors. That it takes time for consumers to adjust their purchase patterns in response to changes in price and income is generally recognized. Hence, during a period of time too short to permit a "final" adjustment, the rate of consumption at the end will depend to some extent upon the rate at the beginning of the period. Partly for this reason, first differences (changes from one year to the next) are used in most of the statistical analyses in this bulletin, as this formulation depends upon both previous and current-year values of all variables.

However, it cannot be assumed that the adjustment always takes place within a single year. Effecting a given reduction in use of an important item in the menu may take longer than for one of casual interest and infrequent purchase. Also, small adjustments for a major commodity might be completed within a year, whereas large adjustments would require more time. Thus, consumption responses calculated during a period when year-to-year changes in price are moderate may not apply accurately to a period such as 1946–49, when such changes were violent.

There is also a possibility that the elasticities of consumer demand depend upon the level of consumption in the preceding period. Thus, a given price stimulus might have less effect in increasing consumption above a previous record than in increasing it from an average or normal level.

The annual production cycle for most farm products and the importance of variations in weather mean that identical conditions of supply and price seldom continue for more than a year at a time. The fact that most consumers shop for food at least once a week creates a presumption that adjustments to moderate changes in price and income essentially are completed within the year. The author's analyses of demand in terms of first differences of annual data have generally left little room for important effects owing to lagged first differences.

Much remains to be learned as to the role of lagged variables (or "inertia") in determining consumer demand. Similarly, much is unknown concerning the shape of consumer demand curves, and the range beyond which linear relationships (either arithmetic or logarithmic) may seriously misrepresent consumer behavior.

The Marketing System

During the 1940's, it became standard practice in the Bureau of Agricultural Economics to use disposable personal income as the "demand shifter" in analyses, regardless of whether the commodity prices involved were measured at the consumer or retail level or at the local market or wholesale levels. The practice of using local market prices as the dependent variable implicitly assigned a passive role to the entire marketing system. As marketing charges (including processing and transportation charges as well as trade margins) absorb from 30 to 85 percent of the retail dollar on different farm products, and average about 50 percent for food products as a group, this implicit assumption should not go unexamined.

At each point at which a commodity changes ownership, a demand schedule confronts a supply schedule, conceptually at least. Each transfer means that someone has decided to sell and someone has decided to buy at the given price. Concrete factors such as changes in costs of labor and materials, freight rates, brokerage fees, and other items, enter into the supply equations along with anticipations as to changes in the opposing demand equation. The demand from processors and dealers depends upon what they believe they can realize on their subsequent sales, allowing for anticipated changes in their internal costs. Behind each factor that consciously enters into these behavior equations lie other factors that are responsible for changes in individual elements of marketing costs.

Dwelling upon these points pushes us back into the morass (so far as statistical measurement is concerned) of general equilibrium theory. We must work within the limitations of our data—those which exist and those which we may reasonably hope to acquire. At best, this usually forces us to combine data for all buyers (or all sellers) who operate at the same market level in a given marketing channel. Often we find that time-series data exist for only a few of the more important market channels and levels. We must then decide how elaborate a hypothesis concerning the behavior of the actual marketing system can be tested with such data. We are seldom able to quantify all the important relationships.

Empirically, farm and retail prices of most foods have behaved as though they were related to each other by (1) certain fixed charges (costs of processing, transportation, and containers) and (2) certain percentage markups, particularly in wholesale and retail distribution. Both groups of factors may be affected by technological and institutional changes. For example, the spread of self-service chain stores and supermarkets may have led to a downtrend in average percentage markups, both retail and wholesale, during the last 25 years, other factors being equal. Or per unit labor and material requirements in processing, transportation, and handling may have declined because of increasing efficiency.

An alternative hypothesis is that, on an annual average basis, all marketing margins change directly with costs of marketing. If farm prices rose sharply relative to costs of marketing, a fixed percentage markup would bring substantial windfall profits to food distributors. But competition between existing distributors and the actual or potential entrance of new firms can speedily eliminate such windfalls.

If this happens, percentage markup factors are reduced on most items until the supply and demand for marketing services are again in equilibrium.

Empirical representation of this hypothesis would require a combination of specific items of cost of marketing to go with each year's observations as to farm and retail prices. Failing this, the marketing margin could be treated as an index of the *prices* of goods and services consumed in the marketing process, with appropriate base-period weights. A further adjustment factor or index would be needed to reflect changes in efficiency, or inputs per unit of product marketed.

Each of these hypotheses represents the marketing system as transmitting consumer demand to the farm price level in a very simple way. Neither representation requires simultaneous determination of demand functions at both farm and retail levels. They imply that the demand relationship should be measured at the final consumption level—either retail or wholesale. The relation between farm and retail or wholesale prices can then be measured by a simple regression equation. Alternatively, we might say that dealer demand at the farm level is equal to the consumer demand curve at retail, *minus* the supply curve for marketing services. The second hypothesis implies a perfectly horizontal supply curve for marketing services within the relevant range of quantities marketed, while the first implies a downward sloping supply curve for marketing services, as a fall in retail price associated with increased marketings would lead to a decrease in marketing charges.

Other forms of the supply function for marketing services may exist in various food-processing or marketing industries. Occasionally a bottleneck situation is found, in which farm-to-retail price spreads suddenly become very large. Examples are the hog glut of 1943–44 and the cotton-mill bottleneck of 1947–48, both of which resulted in unusually wide margins for the services involved.

Analysis of shorter-run fluctuations in price may require more complicated models of the marketing system. Fluctuations in inventories, which are frequently accompanied by fluctuations in price spreads at different market levels, indicate divergent anticipations among different groups of dealers. In general, it seems likely that anticipation plays an important part in changes in farm prices during any period that is short relative to the normal transit and storage life of a particular product. However, analyses based on annual observations suggest that the simpler model of the marketing system is applicable in most studies that involve time periods of a year or more.

ESTIMATING DEMAND AT THE LOCAL MARKET LEVEL

In the preceding section it was suggested that domestic consumer demand for many food products is transmitted through the marketing system in a way that can be approximated by a simple empirical formula—that is, that the annual average farm price is a simple function of the domestic retail price.

In practice, several distinctive domestic demands may exist for a given product. Corn is used for feed and seed, for dry-processing into cornmeal, for wet-processing into starch, corn sirup, and corn oil, and for the manufacture of alcoholic beverages. Demand for corn

as feed includes a reservation demand on the part of the original producer as well as the demands of dealers in mixed feed and of farmers in feed-deficit areas.   Thus, for some purposes, domestic demand must be broken down into its component parts.

The export market is important for some of the major crops grown in the United States, notably wheat, cotton, and tobacco.   When international trade was relatively free, it was possible to speak of an export-demand function for certain of our products.   However, in more recent years Government controls of various types have affected foreign trade in some commodities to such an extent that statistical measurement of the export-demand function is impossible.

DEMAND FOR DOMESTIC USE OR STORAGE

If the farm price can legitimately be regarded as equal to the retail price minus marketing costs. domestic demand at the farm level is strictly a derived demand.   The relevant marketing cost may be the marginal rather than the average cost of providing marketing services. Even if constant percentage markups (and therefore windfall profits or losses) are assumed at some distribution levels, demand at the farm level can be treated as a simple derived demand.

Demand for a *storable* commodity at the farm level involves speculative elements or anticipations.   Futures markets, hedging operations, and Government loan rates and resale provisions also are involved.   At any particular time, farmers have reservation demands for their storable crops, which depend upon price anticipations.   During the marketing season as a whole these aspects may "wash out" fairly well; average marketing margins may approximately equal marketing costs.

Farmers also may be regarded as having reservation demands for perishables, in that they may vary their home consumption and also the amount of waste or unharvested production as the price of the product varies.   Demand for use in farm homes may be consolidated with demand by nonfarm consumers.   But quantities wasted or unharvested probably should be taken into account in any concept of supply that is used.

If two or more distinct domestic uses exist for the same commodity, an equal number of derived demand curves exist at the farm level, with equilibrium in the competitive case involving equal farm prices in each use.[9]   If the product is closely held by a producer's organization, different prices may be charged in different outlets.   Farm-level demand for cotton in industrial uses may be regarded as transmitted from demands of final purchasers via chains of technical coefficients (representing such ratios as pounds of cotton per automobile tire produced) with or without price substitution between cotton and other fibers.   If some part of a basically perishable commodity is processed, a chain is created through which anticipations and fluctuations in inventories enter into the determination of farm prices at harvest.

---

[9] For certain items, such as milk for fluid use versus milk for use in manufactured products, farm prices may not be equal.   However, this can be assumed to reflect certain marketing services, such as more careful cooling and handling, rendered by farmers.   Prices "at the cow" should be identical.

Demand for feed grains presents certain complications, as the grains may either be sold as such or fed to livestock on the farm where produced. As it may be some time before the livestock are sold, the feeding use implies anticipations as well as at least direct costs (other than those for feed) of converting the marginal quantities of grain into different livestock products. The lag-times differ for each livestock product, and the marginal net-revenue curves may differ also.

DEMAND FOR EXPORT

Demands of consumers in other countries may also be traced back through tariffs, transportation, and merchandising charges to a derived demand at the United States farm level. Export demand for our farm products is influenced by production, income, and other factors in each importing and each exporting country; also by changes in ocean freight rates, import duties, quotas, and fluctuations in exchange rates. For clear thinking, the total export-demand function in any given year should be built up by combining the relevant demand functions for each importing country, and taking account of contract or other arrangements with other exporting countries.

During the last 40 years disturbances in international trade have been so frequent and so drastic that "average aggregate export-demand curves" derived by statistical methods in many cases are misleading. To the extent that stability is found over a considerable period, such curves might be derived simultaneously with domestic demand curves.

Realistic analysis also must recognize differences in varieties and end-use characteristics of cotton, tobacco, or wheat produced in different countries. An increase of a million bales in the supply of Egyptian cotton might not affect the "world" (Liverpool) price of cotton grown in this country in the same way as would an increase of a million bales in the supply of cotton grown here. Thus, if the Liverpool prices of each type of cotton were treated as dependent variables, treating supplies of different cottons as distinct independent variables would have some advantages. However, allowances would need to be made in the equations for such competition among varieties as may exist.

TOTAL DEMAND AS A SINGLE-EQUATION MODEL

Suppose that the United States average farm price of a commodity is assumed to be a function of (1) its total supply or disappearance, (2) a measure of domestic demand, and (3) a measure of foreign demand. If the relative quantities exported and domestically consumed are fairly stable and a relevant measure of foreign demand can be found, such an equation, fitted by least squares, might have value for forecasting. The regression coefficient of price upon total supply would represent a combination of similar coefficients from each of the structural demand functions, domestic and foreign. If the structural coefficient in either demand function changed over time or if changes occurred in the relative quantity exported, or both together, the coefficient in the forecasting equation would be expected to change over time.

For some commodities that are important in international trade, a statistically valid single equation may exist in which the world price is expressed as a function of world supply and world demand, both regarded as independent variables. Such a function can be fitted by least squares. If the commodity is quite homogeneous, the United States farm price then can be derived from the world price by subtracting intervening costs.

ECONOMIC FACTORS THAT AFFECT SUPPLY

In considering economic factors that affect supply and their effect on econometric models of the supply-demand structure, several cases should be distinguished. One such case would involve discontinuous production, such as characterizes practically all crops, at least in a given producing area. Discontinuous production results in certain statistical simplifications, as no arbitrary element is involved in dividing production between successive years or other periods of time.

Distinctions need to be made between perishable and storable crops when the flow of farm marketings is considered. If a crop cannot be stored on the farm the time distribution of marketings by farmers is determined by the timing of actual production, that is, by the maturing or ripening of the crop. Of course, a cooperative organization may provide storage facilities, so that the distribution over time of marketings from farmer *ownership* can be varied to some extent.

If crops, such as most grains, are storable on the farm, the time of marketing is subject to a good deal of voluntary control by farmers. It is influenced by anticipations of future prices and, in the case of feed grain, it depends also upon anticipations of profit from feeding the grains to livestock, for which a sizable time lag before marketing occurs. If a product is customarily carried over on farms from one harvest season to the next, selection of time units for measuring the effects of supply upon price becomes somewhat arbitrary. For example, Foote (*11*) makes one set of price analyses for corn for November to May, during which time nothing is known as to the prospects for the next crop. A separate analysis is made for prices of corn from June through September, with the stocks of old-crop corn on July 1 and the new-crop production of oats and barley as supply factors, in addition to early season estimates of the coming corn crop.

A second major class of cases includes commodities for which the production process on a given farm is continuous throughout the year, although it may undergo seasonal fluctuations. Milk and eggs are perhaps the best examples of continuous production. In the continuous production case, the division of price and production into separate units of time is always arbitrary to some extent. The seasonal characteristics of the commodity may help in the selection of reasonable units of time. An empirical principle is to select the time period which maximizes the variation in changes in production between the successive time units. For example, if most decisions that affect the size of laying flocks are made in late fall and winter, beginning the production year for eggs immediately after most of these decisions have been made has some advantage. Sometimes the marketing year may be started when stocks are smallest. Usually production will then have passed its seasonal low and will again be approaching equality with current consumption on its way toward its seasonal peak.

Some commodities, like hogs, are marketed throughout the year, but from a practical viewpoint the production process is discontinuous. For example, farmers in some producing areas raise only one crop of hogs a year and the crop is generally farrowed in late spring. Breeding decisions for the spring pig crop are ordinarily made during September-December of the preceding year when the size and quality of the corn crop is established. In such areas the change in numbers of spring pigs farrowed is directly related to the change in production of corn. In areas in which both spring and fall crops of pigs are produced on the same farm, decisions concerning fall farrowings are made largely from March through June and are still based mainly on production of corn in the preceding autumn. Hence, production of spring and fall pigs taken separately can be treated as substantially predetermined variables, and the time distribution of the subsequent marketings of hogs is also largely predetermined. It is true that marketings can be advanced or postponed by 2 or 3 weeks, and that late marketings from the fall pig crop and early marketings from the spring pig crop overlap to some extent.

Production of broilers is continuous in a sense, but it can be varied rather considerably on less than 16 weeks' notice—the time required to accumulate and hatch eggs and to raise the chicks to market weights. If a time unit of 16 weeks or less is used, current production may be regarded as predetermined. Therefore, an analysis of prices of broilers in terms of total annual production and annual average prices may prove misleading, as several complete supply-price responses may occur in the 12 months.

Production of cattle is also continuous so far as the enterprise is concerned and this is partly true for sheep. However, production and marketing practices provide some forecasting relationships, on the basis of which marketings of some classes of these livestock may be regarded as largely predetermined. But as Breimyer (6) points out, decisions of farmers to increase or decrease their breeding herds are potentially flexible. As pointed out on page 11, unless supply can be assumed to be predetermined, a system of simultaneous equations is required in most cases for valid estimates of the elasticity of demand and similar coefficients.

PROBLEMS OF AGGREGATION

The combination of distinct items into a single group is a universal feature of demand analyses based on time series. This process is known as aggregation. The types of aggregation involved in a typical analysis of demand include the following:

(1) Aggregation of individual consumers, farmers, processors, or distributors within a given marketing or producing area;
(2) Aggregation of commodities;
(3) Aggregation of firms at different levels in the marketing system;
(4) Aggregation of transactions from different time periods; and
(5) Aggregation of marketing or producing areas.

Considerable aggregation is necessary to reduce to manageable proportions the number of variables in most economic problems. Aggregation is also forced on research workers because the cost of collecting accurate current data for small marketing or producing areas is prohibitive. However, some analyses at the national level are more highly aggregated than is required by available data. Discussions in

Outlook and Situation reports of the Bureau of Agricultural Economics are carried on at a lower level of aggregation (that is, in greater detail) than are most published statistical analyses. This suggests that a more formal consideration of the relationships of national aggregates to subaggregates, and even to individual firms and consumers, would be worthwhile.

The basic unit underlying market data is the individual transaction of a particular firm or individual with respect to a strictly defined commodity. Suppose that information had been tabulated on purchases of every commodity (narrowly defined) by every family for a considerable period of time. These billions of individual transactions would need to be aggregated in economically meaningful ways. The principal ways of aggregation are briefly discussed.

AGGREGATION OF INDIVIDUAL CONSUMERS, FARMERS, OR MARKETING AGENCIES

Suppose that a demand equation were available for a given commodity for each spending unit in the economy. Market demand then could be regarded as the sum of such demand equations for all spending units. Even if the equations for individual families were unchanged over time, the coefficients that indicate the effect of price and of income on consumption in the market-demand equation would not necessarily be constant over time. They would be constant (1) if the distributions of family incomes and prices paid did not change during the time period considered, or (2) if all prices and all incomes changed in fixed proportions, or (3) if the correlations between (a) price and the regression coefficient of consumption on price and (b) income and the regression coefficient of consumption on income were zero for the array of individual family equations at each point in time. In the last case, the market price and income coefficients would be simple averages of the corresponding coefficients of the individual family-demand equations. (In other cases, they are assumed to be weighted averages.) One of these cases is more or less presupposed when a linear aggregative demand equation is fitted to average prices and per capita (or per family) consumption and income data for the United States for a period of years.

Small variations in the price and income coefficients in the market-demand equation from year to year would not be serious when fitting a statistical demand function. However, cross-section studies of family purchases of food at different times suggest that the income coefficient may be noticeably affected by major shifts in distribution of income. This may come about largely through changes in the demand equations of those families whose incomes change radically. Also, food preferences of some individuals change over time in response to factors other than price or income.

Similar considerations apply to aggregate demand or supply equations for other groups—farmers, processors, or distributors. The possibility that the coefficients of the equations are conditioned by the particular average levels and distributions assumed by the independent variables during the period analyzed should always be borne in mind.

AGGREGATION OF COMMODITIES

At the consumer level, a commodity such as beef is a collection of distinct cuts and grades, some of them closely competitive with re-

spect to a given end use and others wholly noncompetitive in that use. Obviously, there is also competition among end uses. For example, high prices for steak mean that some consumers serve more hamburger or stew and less steak. The basic units from which the aggregative demand equation for beef is derived may be regarded as the demand equations for particular cut-and-grade combinations, for particular end uses, by individual families. The statistical problems involved are similar to those discussed in the preceding section.

AGGREGATION OF FIRMS AT DIFFERENT LEVELS IN THE MARKETING SYSTEM

Farm products typically pass through two or more hands on the way from farms to consumers. At each point at which title is transferred, a demand curve confronts a supply curve. For products that pass through independent wholesale and retail establishments after processing, the marketing process involves four aggregate supply curves (those of farmers, processors, wholesalers, and retailers) and four aggregate demand curves (those of processors, wholesalers, retailers, and consumers). Changes in inventories, both planned and unplanned, may occur at any or all of the three levels in the marketing system. Further complicating the situation are the varying degrees of vertical integration—retail food chains buy direct from farmers or processors, and, in some cases, consumers buy direct from farmers.

Short-period analysis of prices for storable commodities can be highly complex, partly because of the potential importance of fluctuations in inventories relative to adjustments in final consumption. Leads and lags in recognition of changed situations and reactions to them at different market levels are also involved. The practice of hedging reflects the difficulty of forecasting changes in prices of storable commodities over periods that are relatively short compared with their normal transit, storage, processing, and distribution lives.

Lack of data on inventories at different market levels, or even on total nonfarm inventories, for many farm products is responsible for some of the unexplained residuals in the statistical demand curves for these products. Estimates of consumption are commonly based on distribution by primary processors. In some cases they are based upon the quantity initially processed, for example, consumption of cotton by domestic mills. Reports on stocks in cold storage and other facilities suffer from varying degrees of incompleteness. Thus, when primary disappearance is used as a substitute for consumer purchases in a consumer demand function, differences arising from changes in inventories should result (1) in unexplained residuals, (2) in biases in the regression coefficients, or (3) in both. If changes in inventories are independent of the explanatory variables, particularly retail price, the full amount of these changes should appear in the residual term. If changes in inventories are correlated with changes in retail prices, the residual term is smaller but the regression of consumption upon retail price is biased.

AGGREGATION OF TRANSACTIONS FROM DIFFERENT TIME PERIODS

All of the statistical demand curves presented in this bulletin are based on annual observations. In some cases the price variable used

is a weighted average; in others it is a simple average of monthly prices. It seems probable that either or both of these annual average prices may be influenced by the *time distribution* of marketings and purchases within the year as well as by annual totals.

If the demand curve is the same in all months of a given year, the weighted average price is lower than the simple average price. Also, in general, the weighted average price and the simple average price behave differently. In 1 or 2 cases the 1937–38 recession caused weighted average prices to change in the opposite direction from simple average prices between the 2 calendar years.

More complicated relationships may be involved in aggregation over time. Thus, each coefficient in the consumer demand curve may vary from month to month according to a definite seasonal pattern. In addition, as Foytik (*14*) suggests, the coefficients of the demand curve for a week or a month may be influenced by the levels of price, purchase, and income variables in one or more preceding weeks or months. The quantitative importance of these intraseasonal factors for analyses based on annual data must be studied for individual commodities and time periods. Lack of accurate data on consumption for periods shorter than a year limits our ability to establish significantly different consumer demand curves for different months, or to demonstrate serial dependence of their coefficients upon earlier values of price, consumption, and income variables.

AGGREGATION OF DIFFERENT PRODUCING OR MARKETING AREAS

If a perfectly homogeneous commodity is marketed uniformly throughout the year in each producing area, the only new element introduced by aggregation over producing or marketing areas is the distribution of transportation charges between producers and consumers. If all transportation *rates* between pairs of points are constant, the average cost of transportation per unit in any year depends upon the geographic distribution of production relative to that of effective demand. Such variations would affect somewhat a regression relationship between average farm prices and average retail prices for the Nation as a whole, provided at least one of these averages was based on current-year weights. This is generally true of the published series on average farm prices for the country as a whole. When production of a commodity is concentrated in 2 or 3 widely separated areas, variations in relative production may cause significant variations in the margin between average farm and retail prices.

If we set out to reconcile a demand analysis based on national averages with analyses of farm prices in individual States, many more complications may arise. Consumer demand for the same generic commodity, potatoes for instance, may differ widely as among varieties and qualities grown in different States. The seasonal pattern of marketings may differ from State to State. The grade distribution in each State may vary from year to year relative to those in other States. Thus an explanation of geographic price differentials usually involves commodity, quality, and seasonal influences as well.

Enough has been said to indicate some of the problems of aggregation that are always present in the statistical analysis of demand. If

the coefficients of demand curves for all elements in the aggregate are identical, the regression coefficient has structural significance. But if the coefficients differ widely among the various elements, the regression coefficients obtained for the aggregate depend partly upon the relative variability of the different elements of the aggregate during the period for which the equation is fitted. An aggregative analysis for "all food" might be misleading, whereas an analysis for "all beef" might be relatively impervious to the variations in the grade composition of the beef supply that may reasonably be expected.

If the elements of an aggregate are sufficiently dissimilar, separate equations should be computed for relatively similar subdivisions of the aggregate as a whole.

DEMAND FOR LIVESTOCK PRODUCTS, 1922–41

Supply-demand structures for livestock and their products differ in certain respects from those for crops. In this section, diagrams of the major forces that influence production, consumption, and price are presented for each major livestock product. Implications of these diagrams as to methods required to estimate elasticities of demand and similar coefficients are emphasized, using the theoretical concepts developed in the preceding section. Statistical and analytical evidence bearing on the extent to which certain factors are predetermined (as defined in footnote 4, page 12) is presented when possible. In those cases for which the single-equation approach appears to be valid, analyses of factors that affect demand are presented, together with equations showing normal relations between farm and retail prices. In two cases, results from simplified systems of simultaneous equations are compared with the least-squares demand equations.

When possible, the analyses are based on data for 1922–41. In a later section, results are extrapolated into the post-World War II period, and reasons for discrepancies between actual and predicted values are discussed. Most analyses are based on year-to-year changes (first differences). In general, the interwar relationships for these analyses appear to hold reasonably well in the postwar period.

Supply-demand structures for meat animals and meats are considered first. Pork, beef, veal, lamb, and mutton together account for some 30 percent of the retail value of domestic farm food products, and meat animals account for a similar percentage of total cash receipts to farmers from marketings of farm products. In terms of dollar value, these commodities make up by far the most important subgroup of farm commodities. Characteristics of supply and demand differ for each of the meat-animal species, and hence each type is considered separately.

Figure 2, and all similar diagrams in the following pages, must be interpreted in the light of the special objectives of this bulletin. The directions of influence shown by the arrows are those appropriate to analyses of annual average prices and annual total consumption for the country as a whole for years in which prices are not influenced materially by price supports. On an annual basis, the total quantity of a perishable food offered to consumers is largely determined by the quantity produced and retail prices adjust themselves to the supply available for consumption. Competition between marketing agencies

for the privilege of processing and distributing the available supply tends to bring yearly average farm prices into line with those at retail.

These directions of influence do not necessarily apply to short-run or local marketing situations even for perishable products. For example, at any given time a retailer sets a price on each product and his customers adjust their purchases and consumption to that price. Or a wholesaler may be sufficiently dominant in a locality to establish a price for some days or weeks which serves as a basing point for local retailers and indirectly determines local consumption. It would be possible to construct a demand and supply diagram representing any given short-run or local situation, and the directions of influence might well differ from those which apply to the annual and national average relationships for the same commodity.

Even on an annual basis, the demand and supply structure for a commodity might be diagrammed differently for different purposes. Consumption and prices of pork might be broken down between different cuts; the marketing system could be elaborated into processing, transportation, and distributing agencies; total consumption of pork could be separated into (1) consumption on farms from farm slaughter, (2) consumption in restaurants, and (3) home consumption based on commercial slaughter. Similarly, figure 2 could be expanded to show factors which lie behind "disposable consumer income" or "number of sows bred in preceding year," although these variables are taken as given for the purpose at hand. Many of the arrows would be reversed if prices were determined chiefly by a government support program.

Thus, figure 2 is simply one member of a class of diagrams which might be described as demand and supply structures for pork. *It is useful primarily as a basis for selecting variables and methods of analysis for the measurement of demand on an annual and national average basis, using data of the sort that are generally available from published sources. This observation applies to all similar diagrams in this bulletin which relate to specific commodities.*

HOGS AND PORK

Figure 2 shows a diagram of the major factors that enter into the supply-demand structure for hogs and pork. As in similar diagrams included in this bulletin, heavy arrows represent major influences that are relevant to the statistical measurement of demand equations for this commodity group, lighter arrows represent minor influences, and dashed arrows indicate those of negligible, doubtful, or occasional importance. In each case, the many forces that enter into or affect the marketing system are included within a single dash-bordered box. Since, in this bulletin, the major factors that affect demand for farm products are emphasized, discussion of the relationships that operate within the marketing system is considered to be outside its scope. In each diagram, prices are shown within circles and other factors within boxes.

FACTORS THAT AFFECT SUPPLY

Production of pork obviously is a direct function of the number of hogs slaughtered, their average weight, and the percentage yield

THE DEMAND AND SUPPLY STRUCTURE FOR PORK

ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE
WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS IN-
DICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE,
DOUBTFUL, OR OCCASIONAL IMPORTANCE

U. S. DEP.IRTMENT OF AGRICULTURE   NEG. 48936-X   BUREAU OF AGRICULTURAL ECONOMICS

Figure 2.

of pork per hog. Year-to-year variations in production of pork result mainly from changes in the number of hogs slaughtered.

The number slaughtered in any given year is determined mainly by the number of sows bred in the preceding year. For example, hogs marketed from September to March were born 6 to 9 months previously, from sows bred 10 to 13 months previously. About June 22, when the size of the spring pig crop is known, a forecast can be made of the number of hogs that will be slaughtered from September to March. Similarly, about December 22, when the size of the fall pig crop is known, the approximate number of hogs that will be slaughtered from April to August of the following year can be forecast.

The average age at which hogs are marketed can be varied by a few weeks according to how much they are forced during raising and feeding, and by perhaps a week or two according to the exact time chosen for marketing. For example, economic influences current toward the end of a marketing season may determine whether more spring pigs than usual will be carried over into the period for marketing fall pigs, or whether more fall pigs will be marketed early, along with spring pigs. Variations in average marketing dates are directly related to the average weight per hog slaughtered, as late marketings mean heavy weights, early marketings light weights. Variations in the number of gilts saved for breeding mean opposite variations in the number slaughtered currently. These factors influence production of pork relatively little in most years.

The nature of available official data means that calendar-year estimates of pork consumption must be used in deriving a consumer demand equation. This unit splits the marketing season for spring pigs. However, the logical basis for considering that calendar-year production of pork is predetermined, or nearly so, rests on the 10 to 13 months required for gestation and feeding to market weight, plus a decision-making interval before actual breeding.

The relevant statistical question in this connection is, "What proportion of the variation in calendar-year production of pork is associated with factors known or determined before January 1 and with noneconomic variables operating during the current year?" For this purpose, production of pork can be considered to be determined by some or all of the following variables:

Spring pig crop, previous year;
Fall pig crop, previous year;
Breeding intentions for current spring pig crop—that is, number of sows to farrow (reported in previous December)—multiplied by actual number of pigs saved per litter, which depends mainly on natural conditions, including weather, at farrowing;
Supply of corn, previous year;
Hog-corn price ratio, preceding September–December;
Production of corn, current year; and
Short-term expectations regarding price trends which could affect age and weights at marketing.

The first three variables accounted for more than 93 percent of the variation in production of pork during 1924–41. The report of breeding intentions reflects the influence of other variables such as supplies of feed grain and relative prices of hogs and corn, current and anticipated. Supplies of feed on January 1 relative to numbers of livestock

also affect production of pork because of their influence on average slaughter weight and yield of pork per hog. The current year's production of feed grains, which depends primarily on weather, could be introduced as an additional factor which may influence the weights at which hogs are marketed during the latter part of the calendar year and the number of gilts saved for breeding purposes after January 1.

From this analysis it appears that in 1924–41 variations in calendar-year production of pork were about 95 percent predetermined. The explanation of production is not significantly increased by including the current price of hogs or pork.

RELATION BETWEEN PRODUCTION AND CONSUMPTION

Exports and changes in stocks of pork and pork products (excluding lard) normally are small. In terms of year-to-year changes, 93 percent of the variation in consumption of pork during the calendar-years 1922–41 was associated with variation in the quantity of pork produced. When both variables were expressed in millions of pounds dressed weight, the regression equation was as follows:

$$Q = 50.2 + 0.752\,S$$
$$(0.05) \tag{1}$$

where Q is consumption, S is production, and the number in parentheses is the standard error of the regression coefficient. Thus, a 1-million-pound change in production normally was associated with an 0.75-million-pound change in consumption.

As 95 percent of the variation in production of pork during the interwar period was apparently predetermined, it appears that at least 88 percent (0.95 times 0.93 times 100) of the variation in consumption of pork was predetermined. Alternatively, consumption of pork could have been expressed directly as a function of the variables used to explain production of pork. When this was done, 90 percent of the variation in consumption of pork was associated with the known predetermined factors affecting production. In this instance, the bias that may result from treating consumption as a predetermined variable and using the single-equation approach is probably small.

RESULTS FROM SIMULTANEOUS- AND SINGLE-EQUATION MODELS

The example that follows helps to picture the biases that might be involved in neglecting a possible simultaneously determined supply equation for pork. If a simultaneous supply equation exists, the following model can be used. (In the usual terminology of simultaneous equations, addition of random disturbance terms would transform these into structural equations.)

$$\text{Demand: } p = b_1\,q + b_2\,y \tag{2}$$
$$\text{Supply: } q = b_3\,p + b_4\,z \tag{3}$$

where p is price, q is consumption, y is consumer income during the current year and z is the estimate of production that would be arrived at based on predetermined variables alone. Each variable is expressed in terms of deviations from its mean. If the variables are in logarithmic

form, b_1 is the reciprocal of the elasticity of demand and b_3 is the elasticity of supply. Equation (2) fitted directly by least squares gives an unbiased estimate of the elasticity of demand if, and only if, b_3 is zero.

A study of the reduced-form equations indicates that the significance of b_3 depends upon whether the net regression of q on y differs significantly from zero after allowing for the effects of z. On an intuitive basis this is not obvious. The actual analysis showed that this coefficient, and hence the elasticity of supply, did not differ significantly from zero. This may reflect in part the offsetting influence of feeding to heavier weights and the withholding of breeding stock with a rise in demand.

When the coefficients in equations (2) and (3) were determined simultaneously by the method of reduced forms, the following results were obtained : [10]

$$\text{Demand:} \quad p = -1.14\,q + 0.90y \tag{2.1}$$
$$\text{Supply:} \quad q = -0.07\,p + 0.77z \tag{3.1}$$

When these equations were fitted by the single-equation least-squares method, assuming that b_3 is equal to zero, results were obtained as follows. The standard errors of the regression coefficients are indicated by the numbers within the parentheses.

$$\text{Demand:} \quad p = -1.16q + 0.90y \;;\; R^2 = .97 \tag{2.2}$$
$$\quad\quad\quad\quad (0.07)\quad (0.06)$$

$$\text{Supply:} \quad q = (0) + 0.84z \;;\; r^2 = .90 \tag{3.2}$$
$$\quad\quad\quad\quad\quad (0.07)$$

It is apparent that the differences between the two sets of coefficients are small in relation to the standard errors of the regression coefficients as determined by the least-squares approach.

---

[10] The reduced form of equations (2) and (3) is derived as follows:
Substitute the right-hand side of equation (3) for the q in equation (2), obtaining an expression for p in terms only of the predetermined variables, y and z:

$$p = \left(\frac{b_2}{1 - b_1 b_2}\right) y + \left(\frac{b_1 b_4}{1 - b_1 b_2}\right) z. \tag{4}$$

Similarly, substitute the right-hand side of equation (2) for the p in equation (3), obtaining

$$q = \left(\frac{b_2 b_3}{1 - b_1 b_2}\right) y + \left(\frac{b_4}{1 - b_1 b_2}\right) z \tag{5}$$

As y and z are predetermined variables, equations (4) and (5), each fitted by least squares, should give unbiased estimates of their respective coefficients, which are combinations of the structural coefficients. These equations prove to be

$$p = 0.97y - 0.96z \;;\; R^2 = .92 \tag{4.1}$$
$$\quad\quad (0.10)\quad (0.11)$$

$$q = -0.06y + 0.84z \;;\; R^2 = .91 \tag{5.1}$$
$$\quad\quad\quad (0.06)\quad (0.07)$$

An estimate of b_1 is obtained by dividing the coefficient of z in equation (4.1) by the coefficient of z in equation (5.1), giving $b_1 = -1.14$. An estimate of b_3 is derived by dividing the coefficient of y in equation (5.1) by the coefficient of y in equation (4.1), giving $b_3 = -.06$. (The value of $-.07$ in equation (3.1) was based on unrounded data). As the coefficient of y in equation (5.1) is nonsignificant, the estimate of b_3 does not differ significantly from zero.

OTHER QUESTIONS INVOLVED IN ASCERTAINING WHETHER THE SINGLE-EQUATION METHOD CAN BE USED

(1) The extent to which consumer income appears to be affected by changes in price and consumption of individual agricultural products was discussed in a general way on page 13. Some evidence relative to this point as applied to pork is now presented. During the interwar period, less than 2 percent of the year-to-year variation in disposable income was associated with changes in the retail value of the consumption of pork. The total retail value of consumption of pork during 1922–41 was equal to 2.6 percent of disposable income. In percentage terms, the average year-to-year variations in consumption of pork and in disposable income were about the same. These facts suggest that variations in consumption of pork, operating through prices and expenditures for pork and competing products, affected consumer income negligibly. Hence, consumer income may be taken as predetermined with respect to the demand-supply structure for pork.

(2) About 86 percent of the year-to-year variation in farm prices of hogs during 1922–41 was associated with corresponding variations in the retail price of pork. In a more detailed study, the factors that may account for the 14 percent of variation that is unexplained might be explored. These factors may include peculiarities of the marketing structure, inventory changes, differences in methods of construction and weighting of farm and retail price series, and, to a minor extent, errors of measurement in the basic price data. However, it is unlikely that these factors would require a simultaneous fitting of marketing margin and consumer demand equations.

Short-run imperfections in relationships between retail and wholesale prices in a single city are discussed in McCallister, Poats, and Jones (25, pp. 3–12). Annual prices for the entire country may show similar imperfections to a limited extent.

(3) The price of lard affects the price of hogs to some extent at any given time. Had it been determined that the price of hogs during the marketing year significantly affected current production of pork, an equation dealing with factors that affect the price of lard might have been needed as a part of the required system of simultaneous equations relating to the supply-demand structure for pork. As the effects of current prices of hogs on production of pork have been shown to be negligible from a statistical viewpoint, factors that affect the price of lard need not be measured simultaneously with those that affect the price of pork.

The several considerations that enter into the decision as to whether the single-equation or the simultaneous-equations method should be used in determining the elasticity of demand for a single commodity have been discussed in detail for pork. For other commodities, only those aspects which might be expected to operate differently are considered.

Results from equations based on the diagram shown in figure 2 are discussed later. The equations for the several types of meat are discussed together to permit ready comparison of the coefficients obtained for the several items and those obtained for all meat considered as a single commodity group.

CATTLE AND BEEF

A simplified diagram of the supply-demand structure for beef is shown in figure 3. This is similar to the diagram for hogs.

THE DEMAND AND SUPPLY STRUCTURE FOR BEEF

ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS INDICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE, DOUBTFUL, OR OCCASIONAL IMPORTANCE

U. S. DEPARTMENT OF AGRICULTURE   NEG. 48937-X BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 3.

FACTORS THAT AFFECT SUPPLY

Beef, as distinct from veal, is produced from maturer cattle of heavier weight. Hence, production of beef during a given calendar year must come chiefly from animals in existence as of January 1. Numbers of cattle on farms as of January 1 by age, sex, and type are published each year. Marketings of male beef cattle, particularly steers, are affected only slightly by current prices in any one year. Marketings of heifers and cows are more subject to economic decisions based on current prices, and particularly to decisions to expand or contract the

breeding herd and the scale of the beef-cattle enterprise. Despite this qualification, the number of cattle on farms as of January 1 sets the general level of cattle slaughter for the succeeding calendar year and is substantially correlated with it.

The yield of beef per animal slaughtered is influenced by range and pasture condition during the current and preceding calendar years and also by supplies and prices of feed grains in both years. The economic factors responsible for the yield of beef per head in a given year are mainly determined before January 1.

If the statistical approach used for pork is applied to beef, about 85 percent of the variation in production of beef can be explained by variables measured or existing at the beginning of the calendar year or before, supplemented by noneconomic factors that operate during the calendar year. For example, the ratio of calves to cows is influenced to some extent by weather and disease but only slightly by economic considerations.

RELATION BETWEEN PRODUCTION AND CONSUMPTION

During 1922–41, more than 98 percent of the year-to-year variation in domestic consumption of beef was associated with variations in production of beef. As with pork, consumption of beef can be related to the predetermined and noneconomic variables used in the explanation of beef production. When this is done, the same percentage for consumption as for production—85 percent—is apparently predetermined. The remaining 15 percent may be partly owing to (1) random errors in the several variables, (2) independent decisions of cattle producers not directly influenced by current prices of beef and cattle, and (3) other predetermined variables not included in the above analysis. If the latter two factors are at all significant, the bias introduced by using consumption of beef as an independent variable in a single-equation least-squares demand function should be less than 15 percent.

RESULTS FROM SIMULTANEOUS- AND SINGLE-EQUATION MODELS

The elasticity of beef production with respect to current price was expected to be negative and to differ significantly from zero. Therefore, it seemed desirable to compare results from a simultaneous-equations model and a single-equation model for beef cattle, even though the differences in a similar comparison for hogs were nonsignificant. The structural equations for beef cattle, given below, are somewhat more complicated than those for hogs.

$$\text{Demand}: \ p = b_1 \ q + b_2 \ y + b_3 \ w \tag{6}$$
$$\text{Supply}: \ q = b_4 \ p + b_5 \ z, \tag{7}$$

where p and q are retail price and consumption of beef, y is consumer income, z is an estimate of production of beef based wholly on predetermined variables, and w is production of meats other than beef. The value of w is assumed to be unaffected by the price or consumption

of beef.[11] Corresponding to the analysis for pork, the single-equation approach is valid for fitting equation (6) only if b_4 in equation (7) does not differ significantly from zero.

In the simultaneous-equations terminology, these equations are over-identified. Hence, the standard method of deriving a unique estimate of b_4 is laborious. However, an analysis involving reduced-form equations indicates that b_4 does not differ significantly from zero. Even if b_4 is assumed to equal zero, two approaches are possible: (1) Equations (6) and (7) can be estimated simultaneously, using the method of reduced forms; or (2) equation (6) can be fitted directly by the least-squares method. The demand equations derived by these two methods, as shown below, are designated as equations (6.1) and (6.2), respectively. The standard errors of the regression coefficients are shown for the equation derived by the method of least squares.

$$p = -0.96q + 0.82y - 0.43w$$
$$p = -1.00q + 0.88y - 0.52w$$
$$(0.12) \quad (0.06) \quad (0.39)$$

Although the differences between these equations are larger than those between the equations for pork, they do not exceed one standard error of the least-squares regression coefficients.

OTHER CONSIDERATIONS

1. On the basis of the demonstration for pork, disposable consumer income can be treated as an independent variable in the consumer demand function for beef. The chief competing commodity is apparently pork, production of which is largely predetermined. Production of some other meats and of poultry also seems to have been largely predetermined under the conditions of 1922–41.

2. During 1922–41, 91 percent of the year-to-year variation in prices of beef cattle was associated with corresponding variations in the retail price of beef. In a more detailed study the reasons for the unexplained variation might be further explored.

3. Figure 3 indicates that changes in the farm price of cattle ready for slaughter influence to some extent the prices received by farmers for feeder or grass cattle. The margin between prices of feeder and

[11] Production of other meats, w, is included in the beef analysis and excluded from the pork analysis on empirical rather than logical grounds. The regression coefficient between the price of beef and the supply of other meats is highly significant, as evidenced by equations (6.1) and (6.2). However, in a parallel analysis, the least-squares regression of the price of pork upon the supply of other meats was −0.01 (±0.14), and the other coefficients in equation (2.1) were changed only in the third decimal place by the addition of this variable. Thus, the regression coefficient between the price of pork and the supply of other meats was nonsignificant, and estimates of the price of pork would have been affected very little by the inclusion of the latter variable.

The asymmetrical nature of these results is opposed to both theory and common sense. As an experiment, the author fitted least-squares demand equations for pork and beef subject to the condition that the cross-regressions of price upon supply of the competing commodity be identical. While a similar condition might be incorporated in a complete simultaneous-equations model including demand and supply functions for both pork and beef, this is not standard procedure.

slaughter cattle is influenced by prices of corn and other feed concentrates. However, most of the feeder cattle to be slaughtered in a given calendar year move to feed lots during late fall and early winter of the preceding year. The current farm price of corn is largely a function of corn production in the preceding autumn and of the condition and production of corn during the current year. All of these are largely determined by weather. Apparently, under normal conditions, current farm prices of cattle have only relatively small influence upon production of beef for the current year and the bias involved in not formally attempting to separate the supply curve from the demand curve is also relatively small.

However, pronounced trends in prices within a given year have two opposite effects, which sometimes tend to equalize each other. Rising prices, for instance, result in feeding all slaughter stock to heavier weights, adding to the beef output per head; but they also encourage producers to hold back both feeder and breeding stock, thus decreasing the number of cattle slaughtered. On occasion the extra withholding can be substantial.

Under such circumstances, a system of simultaneous equations (assuming adequate data available on which to base them) would be superior as a forecasting mechanism to the single-equation approach. This system would involve separate demand equations for (1) cattle for immediate slaughter, (2) cattle for further feeding, and (3) cattle for replacement or expansion of breeding herds.

CALVES AND VEAL

The supply-demand structure for veal is shown in figure 4. Veal is largely a byproduct of the dairy industry. Male and female calves are born in roughly equal proportions, but only a fraction of the males are of prospective value in connection with the dairy enterprise. In general, it does not pay to feed dairy cattle for slaughter to heavy weights, and most of the male calves (as well as some heifers) are slaughtered at an early age. Parenthetically, the dairy enterprise also supplies a considerable part of the output of beef, as dairy cows are sold for slaughter when their productivity declines to unprofitable levels and heifers held as prospective replacements are sold when their productivity becomes doubtful.

In addition to the veal produced from dairy calves, there is a considerable volume of meat from calves of beef breeding slaughtered at heavier weights than veal calves. This meat is considered as veal in some terminology and is reported as veal in all statistics of meat production.

Approximately 87 percent of the year-to-year variation in production of veal can be explained in terms of measurable predetermined or noneconomic variables. Figure 4 suggests that the remaining 13 percent may be owing mainly to nonmeasurable predetermined variables. Also, more than 99 percent of the year-to-year variation in consumption of veal is associated with corresponding changes in production of veal. Lack of an adequate retail price series for veal prevents determination of the marketing-system equation.

THE DEMAND AND SUPPLY STRUCTURE FOR VEAL

ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS IN-DICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE, DOUBTFUL, OR OCCASIONAL IMPORTANCE

U. S. DEPARTMENT OF AGRICULTURE   NEG. 48936-X BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 4.

Sales of heifer calves for slaughter are influenced to some extent by current and recent prices of milk cows and of milk and butterfat and anticipations of future prices for these items. However, these prices are not affected by the price or consumption of veal. Similarly, the output of "veal" from beef herds may be affected considerably by current and anticipated prices of beef cattle but only a little by prices of veal. Thus, in obtaining a demand equation relating to veal, the single-equation approach appears to be valid.

LAMB AND MUTTON

Figure 5 shows a simple diagram of the demand-supply structure for lamb. About 88 percent of the variation in number of lambs slaughtered during a given calendar year was associated with variations in number of sheep on farms at the beginning of the year. Average weights of lambs slaughtered are influenced to some extent by noneconomic factors such as weather and the condition of range and pasture. From 1922 to 1941 nearly 97 percent of the variation in production of lamb can be explained in terms of predetermined or noneconomic variables. Some 98 percent of the year-to-year variation in consumption of lamb was associated with corresponding variations in production of lamb. Thus in turn perhaps 95 percent of the consumption of lamb appears to have been explained by predetermined variables.

Eighty-five percent of the year-to-year variation in the farm price of lambs in 1922–41 can be explained by corresponding variations in the retail price of lamb and the price of wool. A sizable quantity of wool is obtained from the fleeces of slaughtered lambs, although most of the wool produced in the United States is obtained from mature sheep. The number of lambs slaughtered in any particular year apparently reacts only slightly to the current farm price of lambs. However, the cumulative effect of prices of lambs and wool over time in relation to prices of competing products, such as beef cattle, influences considerably the longer-run changes in numbers of sheep on farms and in production of lamb.

TOTAL MEATS AND MEAT ANIMALS

Figure 6 is a logical aggregation of the demand-supply structures for the four individual meats depicted in figures 2 through 5.

As production of individual meats is largely predetermined, total production of meat is largely predetermined also. During 1922–41, 95 percent of the year-to-year variation in consumption of meat was associated with variations in production of meat. Hence, the least-squares regression of retail prices of meat on consumption of meat is not likely to be seriously biased. The effects of prices of livestock products during the marketing year upon the current production of meat are relatively small except in abnormal years such as 1951. Although consumers spend from 5 to 6 percent of their disposable income for all meat (valued at retail prices), the effect of variations in consumption and prices of meat upon disposable income is still insignificantly small relative to errors of measurement in the published income series.

THE DEMAND AND SUPPLY STRUCTURE FOR LAMB

LAMB CONSUMPTION

RETAIL PRICE OF LAMB

DISPOSABLE CONSUMER INCOME

EXPORTS

CHANGE IN STOCKS

SUPPLY OF OTHER MEATS, POULTRY MEAT

LAMB PRODUCTION

MARKETING SYSTEM

WEIGHT OF LAMB PER HEAD SLAUGHTERED

NUMBER OF LAMBS SLAUGHTERED

FARM PRICE OF LAMBS

SHEEP ON FARMS JANUARY 1

PRICES OF LAMBS AND WOOL PRECEDING YEAR

PRICE OF WOOL

WORLD SUPPLY AND DEMAND FOR WOOL

ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS IN-DICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE, DOUBTFUL, OR OCCASIONAL IMPORTANCE

U. S. DEPARTMENT OF AGRICULTURE   NEG. 48939-X   BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 5.

FIGURE 6.

A more detailed analysis would raise a question as to whether supplies of poultry meat (particularly commercial broilers) and of fish can be regarded as predetermined variables. Production of broilers and of some types of fish in any given year may be influenced to some extent by supplies and prices of meat. Quantitatively, these commodities are not so important as red meats.

RESULTS OF STATISTICAL ANALYSES FOR MEAT AND MEAT ANIMALS

Data included in tables 1 to 3 are reproduced from an article published by the author in July 1951 (12). The analyses were developed in general conformity with the methodological viewpoint set forth in the present bulletin.

The data used in the statistical analyses are time series of annual observations for 1922-41. Unless timing of production and marketing indicate a different seasonal break, the observations refer to calendar years. Most of the series are based on official estimates of the Bureau of Agricultural Economics. But disposable consumer income during 1929-41 is from the published series of the Department of Commerce,

and retail price indexes and individual prices are in some cases based on data of the Bureau of Labor Statistics. In a few cases the official data were adjusted for the effects of specific programs, chief of which was the diversion program for beef during the drought-induced cattle liquidation of 1934. Virtually all quantity and income variables were placed on a per capita basis.

The series were converted to logarithms, and regression equations were fitted to first differences of these—that is, to year-to-year changes in each series rather than to deviations from the average for 1922–41 as a whole. Some of the reasons for this are as follows: (1) The logarithmic form was chosen primarily on the ground that price-quantity relationships in consumer demand equations were more likely to remain stable in percentage than in absolute terms when major changes occurred in the general price level. If the 1922–41 relationships are to be tested or applied under current conditions this is important. Incidentally, when logarithms are used, flexibilities of price and elasticities of demand are indicated directly by the regression coefficients, so that the results for different commodities can be compared directly without adjustments for differences in their original units of measure; (2) First differences were used partly because the question to which much of the agricultural outlook work of the Bureau of Agricultural Economics is addressed, "How will demand and price conditions in the next marketing season differ from those now existing?", logically requires an answer in terms of year-to-year change. Further, they improve reliability of the estimates in some cases by substantially reducing such intercorrelation of variables as is associated with shared trend and major cycle patterns in the variables proper. They also reduce the extent of extrapolation involved when interwar analyses are applied to postwar years.

Table 1 presents the major statistical coefficients from certain equations that apply to all meats and to each type of meat. In each case, the equations were fitted by the usual least-squares method. Equations relating prices of meat to production of meat and consumer income reflect total demand, including demands for export and storage. For this reason, the regression coefficients do *not* represent the reciprocals of consumer demand elasticities. Within the range of 1922–41 experience, the analyses for meat based on *consumption* are believed to approximate closely consumer demand equations.

Table 2 presents the results from some regression equations of farm prices upon retail prices. They are fitted independently of the consumer demand equations in accordance with the discussion given on pages 18–19. These regressions are empirical approximations for 1922–41, and the logarithmic form was chosen primarily so that regression coefficients for different commodities could be readily compared.

Table 3 shows results from analyses which express farm prices as functions of production or consumption and disposable income. The forecasting accuracy of these equations would be affected both by changes in consumer behavior and by changes in the marketing system. In general, these equations are less informative than the two separate sets of regressions, results from which are shown in tables 1 and 2.

TABLE 1.—*Meat: Factors affecting year-to-year changes in retail prices, United States, 1922–41*

Commodity	Coefficient of multiple determination [1]	Effect on price of 1-percent change in—					
		Production or consumption [2]		Disposable income [2]		Supply of competing commodities [2]	
		Net effect [3]	Standard error	Net effect [3]	Standard error	Net effect [3]	Standard error
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Production: [4]							
Pork	0.92	−0.85	0.09	0.93	0.10		
Beef	.96	−.83	.09	.83	.05	[5]−0.38	0.05
Lamb	.91	[6]−.34	.15	.78	.07	[5]−.40	.11
All meat	.98	−1.07	.07	.86	.07		
Consumption: [7]							
Pork	.97	−1.16	.07	.90	.06		
Beef	.95	−1.06	.12	.88	.06	[8]−.52	.09
Lamb	.94	[8]−.50	.14	.78	.06	[5]−.65	.14
All meat	.98	−1.50	.08	.87	.03		

[1] Represents the percentage of total year-to-year variation in retail price during 1922–41 which was "explained" by the combined effects of the other variables.

[2] Per capita basis.

[3] Regression coefficients from analyses based on first differences of logarithms. Can be used as percentages without serious bias for year-to-year changes of as much as 10 or 15 percent in each variable.

[4] Analysis for which quantity variables are production.

[5] Production per capita, all other meats.

[6] Probably understates true effects of changes in production or consumption upon price.

[7] Analyses for which quantity variables are consumption.

[8] Consumption per capita, all other meats.

PRICE-QUANTITY RELATIONSHIPS USING RETAIL PRICES

Two sets of relationships are shown for meat. During the early and middle twenties the United States exported as much as 800 million pounds of pork in a year. The export market tended to cushion the drop in prices of meat when slaughter of hogs increased. As total production of meat was fairly stable to begin with, small absolute changes in exports, imports, and cold-storage holdings, substantially reduced the percentage fluctuations in consumption of meat. From 1922 to 1941, consumption of meat changed only about 70 percent as much from year to year as did production of meat.

The first set of price-quantity coefficients for meat indicates that a 1-percent increase in production of meat caused a decline of little more than 1 percent in the average retail price of meat. Increases of 1 percent in production of pork or beef were associated with declines of less than 1 percent in their retail prices, and the net effect of production of lamb and mutton upon the price of lamb was even smaller.

In any period of mobilization the total civilian supply of meat is subject to control. The second set of analyses for meat is more relevant under such circumstances. A 1-percent decrease in per capita consumption of meat was associated with an increase of 1.5 percent in its average retail price. A 1-percent change in consumption of pork alone was associated with an opposite change of about 1.2 percent in its retail price. A 1-percent increase in consumption of beef was associated with slightly more than a 1-percent decrease in its retail price, if supplies of other meats remained constant. If the supply of other meats also increased 1 percent, the price of beef tended to decline another 0.5 percent.

Some of these equations take specific account of production of other meats in explaining the retail price of a given meat. Apparently prices of beef are strongly influenced by supplies of other meats, and chiefly by pork. Prices of lamb also are markedly affected by supplies of other meats. The simple correlation between year-to-year changes in prices of lamb and beef during 1922–41 ($r^2 = 0.67$) was almost the same as that between prices of lamb and pork ($r^2 = 0.65$). It seems likely that part of the apparent influence of pork upon the prices of lamb operates indirectly through the price of beef. Per capita production of beef and pork during 1922–41 were of the same order of magnitude (roughly 60 pounds per capita) while production of lamb and mutton was only a tenth as large. Apparently the price of lamb tended to some extent to follow prices of the two primary meats.

A similar equation gave a nonsignificant price flexibility for pork with respect to supplies of other meats. This coefficient would be expected to be negative and significant. The fact that production of beef and lamb was much less variable from year to year than production of pork makes it difficult to establish the actual effect of supplies of beef and lamb upon prices of pork.

RELATIONSHIPS BETWEEN FARM OR LOCAL MARKET AND RETAIL PRICES

Equations relating farm prices to retail prices, the results of which are shown in table 2, involve certain problems. Official calendar-year prices for meat animals are averages of monthly prices *weighted* by farm marketings. *The Marketing and Transportation Situation* (*35*) uses simple averages of monthly farm prices, with some adjustments to improve the comparability of the retail- and farm-price series used. The differences between the two series are significant in some years. Marketings of cattle are heavy during the last 4 months of the year. Slaughter (hence production of beef) is above average during these months. More important, farm prices reflect the heavy sales of feeder cattle from the range States to farmers and feeders in the Corn Belt. The average prices of these unfinished animals are lower than the average prices of finished cattle sold for slaughter. The difference between weighted and unweighted prices of cattle is large enough to change the signs of the first differences between years such as 1929–30 and 1937–38. The downturns in 1929 and 1937 are evident in the weighted farm prices, but not in the unweighted farm or retail series. (Observations are calendar-year

averages in each case.) The analyses in table 2 are based on un-weighted averages at both the farm and retail levels.

TABLE 2.—*Meat animals: Relationships between year-to-year changes in farm price and retail price, United States, 1922–41*

Commodity	Coefficient of determination [1]	Effect on farm price of 1-percent change in—			
		Retail price		Other factors	
		Net effect [2]	Standard error	Net effect [2]	Standard error
Meat animals:		*Percent*	*Percent*	*Percent*	*Percent*
Hogs (1)	0. 86	1. 75	0. 17		
Hogs (2)	. 87	1. 35	. 44	[3] 0. 23	0. 29
Beef cattle	. 91	1. 74	. 14		
Lambs	. 85	1. 06	. 18	[4] . 26	. 05
All meat animals	. 91	1. 57	. 12		

[1] Represents the percentage of total year-to-year variation in farm price during 1922–41 that was associated with the combined effects of the other variables.
[2] Regression coefficients from analyses based on first differences of logarithms.
[3] Wholesale price of *lard* at Chicago. Coefficient not significant owing to high intercorrelation ($r^2 = .85$) between retail price of pork and wholesale price of lard.
[4] United States average farm price of *wool*.

For meat animals as a group, flexibility of the farm price during 1922–41 was 1.57 times that at retail. The farm price of hogs was 1.75 times as flexible as the retail price of pork. However, prices of lard were highly correlated with prices of pork on a year-to-year change basis and the *wholesale* value of lard was equal to 15 percent or more of the value of live hogs. After allowing for the effects of changes in prices of lard, the *net* flexibility of hog prices with respect to the retail price of pork was probably less than 1.75. The equivalent farm value of "Good" grade beef ("Choice" grade under the present definition) was 1.74 times as flexible as the retail price. However, these farm-retail price flexibilities which are stated in percentage terms are not independent of the absolute level of farm prices, if the marketing margin contains substantial items of cost which are fixed in absolute rather than percentage terms.

Wool accounts for a significant fraction of the total value of lambs sold for slaughter. A recently shorn lamb of given quality brings a lower price than one with a heavy fleece. The price of wool significantly affects the price received by farmers for lambs.

Beef cattle have byproducts of some value, such as hides and tallow. The value of these byproducts is undoubtedly reflected in market prices to some extent and enters into the calculations of processors. But it is not always possible to measure these relationships from analyses based on time series.

FACTORS THAT AFFECT FARM OR LOCAL MARKET PRICES

Table 3 summarizes relationships between farm prices, production and disposable income. In most cases the effect of a 1-percent change in production per capita is associated with more than a 1-percent change in the farm price. There is some indication that from April to September the price of hogs is less sharply affected by changes in production of pork than during the heavy marketing season from October to March.

For most of these items, the response of farm price to changes in disposable income is more than 1 to 1. These coefficients ranged from 1.1 for lambs to 2.1 for the October-March analysis for hogs. The income response for all meat animals was 1.43.

As in table 1, production of other meats significantly affected the prices of beef cattle, calves, and lambs.

TABLE 3.—*Meat animals: Factors affecting year-to-year changes in farm prices, United States, 1922–41*

Commodity	Co-efficient of multiple determination [1]	Effect on farm price of 1-percent change in—					
		Production [2]		Disposable income [2]		Supply of competing commodities [2]	
		Net effect [3]	Standard error	Net effect [3]	Standard error	Net effect [3]	Standard error
Meat animals:		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Hogs:							
Jan.–Dec	0. 82	−1. 54	0. 26	1. 63	0. 28		
Oct.–Mar	. 81	−1. 52	. 26	2. 08	. 28		
Apr.–Sept	. 69	[4]—. 99	. 25	1. 50	. 37		
Beef cattle	. 90	−1. 19	. 23	1. 27	. 13	[5]−0.40	0. 15
Veal calves	. 93	— . 82	. 16	1. 30	. 10	[5]— .75	. 16
Lambs	. 87	−1. 50	. 31	1. 09	. 15	[5]— .70	. 24
All meat animals	. 88	−1. 60	. 26	1. 43	. 15		

[1] Represents the percentage of total year-to-year variation in farm price during 1922–41 that was explained by the combined effects of the other variables.
[2] Per capita basis.
[3] Regression coefficients from analyses based on first differences of logarithms.
[4] Probably understates true effect of production on price.
[5] Production of other meats per capita.

EGGS

Sales of eggs accounted for more than 70 percent of the total cash receipts from the poultry enterprise in 1922–41. Before World War II commercial production of broilers was relatively small and most chicken meat came from farm flocks which were kept primarily for production of eggs.

Figure 7 shows a simplified diagram of the demand-supply structure for eggs. It should be remembered that during 1922–41 produc-

THE DEMAND AND SUPPLY STRUCTURE FOR EGGS

EGG CONSUMPTION

RETAIL PRICE OF EGGS

DISPOSABLE CONSUMER INCOME

EGG EXPORTS

CHANGE IN STOCKS

EGG PRODUCTION

MARKETING SYSTEM

AVERAGE NUMBER OF LAYERS DURING YEAR

AVERAGE NUMBER OF EGGS PER LAYER

FARM PRICE OF EGGS

NUMBER OF HENS AND PULLETS ON FARMS JANUARY 1

"TREND": IMPROVEMENT IN GENETIC QUALITIES AND PRODUCTION PRACTICES

PRICES OF POULTRY FEEDS

SUPPLIES OF FEED CONCENTRATES, NUMBERS OF GRAIN-CONSUMING LIVESTOCK

WEATHER

ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS IN-DICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE, DOUBTFUL, OR OCCASIONAL IMPORTANCE

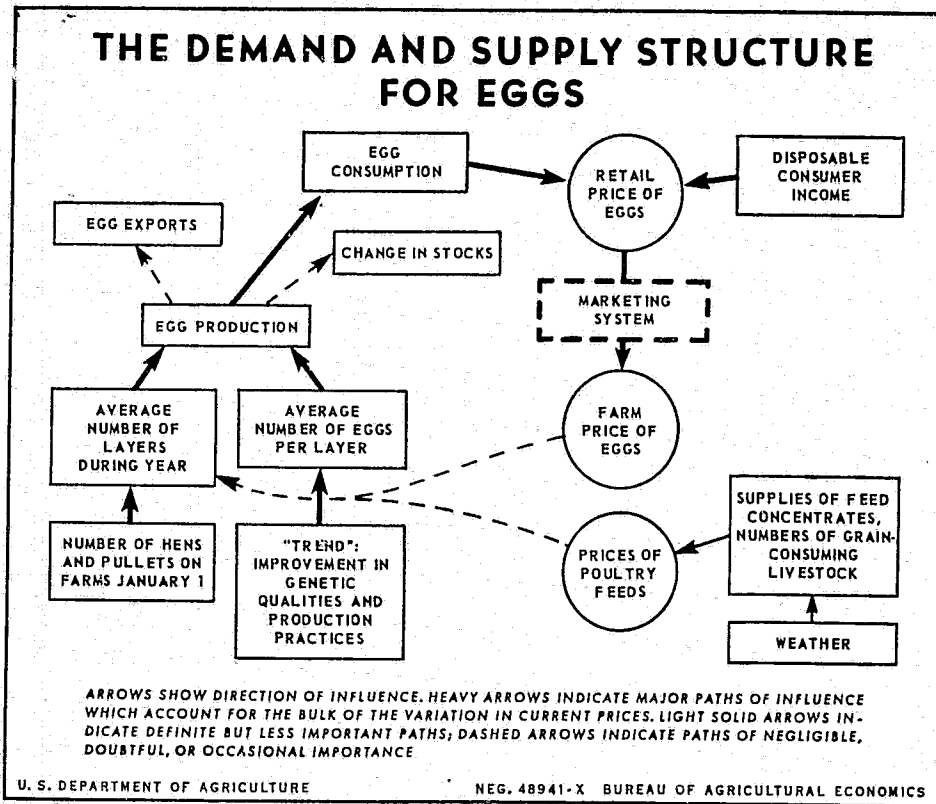U. S. DEPARTMENT OF AGRICULTURE   NEG. 48941-X   BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 7.

tion of eggs was one of the more stable agricultural production variables. The average variability (standard deviation) of year-to year changes in production of eggs amounted to 3 or 4 percent. With this limited basic variability, it seems likely that 10 percent or more of the observed year-to-year variation in the number of eggs produced comes simply from errors of measurement, even though the measurement error is small compared with the total quantity of eggs produced.

Production of eggs is strongly affected by seasonal factors, although less so now than in 1922–41. Although the short incubation and growing periods for chickens makes it theoretically possible to expand production of eggs within a 6-month period, the hatching of chicks for replacement of farm flocks is generally concentrated in spring. Culling of hens and replacing them with young pullets is concentrated in the last half of the year. In addition, there has been a strong (and curvilinear) uptrend in production per layer because of improved genetic qualities and of improvement in the feeding and management of poultry. About 85 percent of the variation in production of eggs, after the estimated error component is subtracted, is associated with variations in the average number of layers on farms January 1 and the trend in production per bird. Changes in supplies of feed during the current year may also affect production of eggs through their influence on the management of the flock.

Despite the strong seasonal pattern in the egg-producing enterprise, production of eggs probably responds to some extent to relative prices of eggs and of poultry feeds in the early part of the current year. For example, more than 17 percent of the variation in production of chickens during 1922–41 was associated with variations in the egg-feed price ratio early in the calendar year.

About 97 percent of the observed variation in consumption of eggs (in terms of original values) was associated with changes in production of eggs. (In terms of first differences, the degree of association is 80 percent.) Because of the method of derivation, errors of measurement in production of eggs would affect consumption equally.

Coefficients for the analysis on eggs given in table 4, based on production, are adjusted for the effects of an estimated measurement error in the egg-production series. Similar adjustments would be appropriate in an analysis based on consumption of eggs.

FARM CHICKENS AND BROILERS

The diagram in figure 8 could have been simplified for 1922–41 by excluding items relating to commercial broilers. Figure 8 is more representative of the situation as it existed in the early 1950's, when almost half of the total supply of chicken meat was produced by commercial broiler enterprises.

Production of farm chickens is influenced to some extent by economic variables which operate during a given calendar year, and more especially by the relative prices of eggs and poultry feed during the early months of the year. However, the price of poultry feed is established primarily by the quantity of feed grains produced in the preceding year (and to some extent in the autumn of the current year) relative
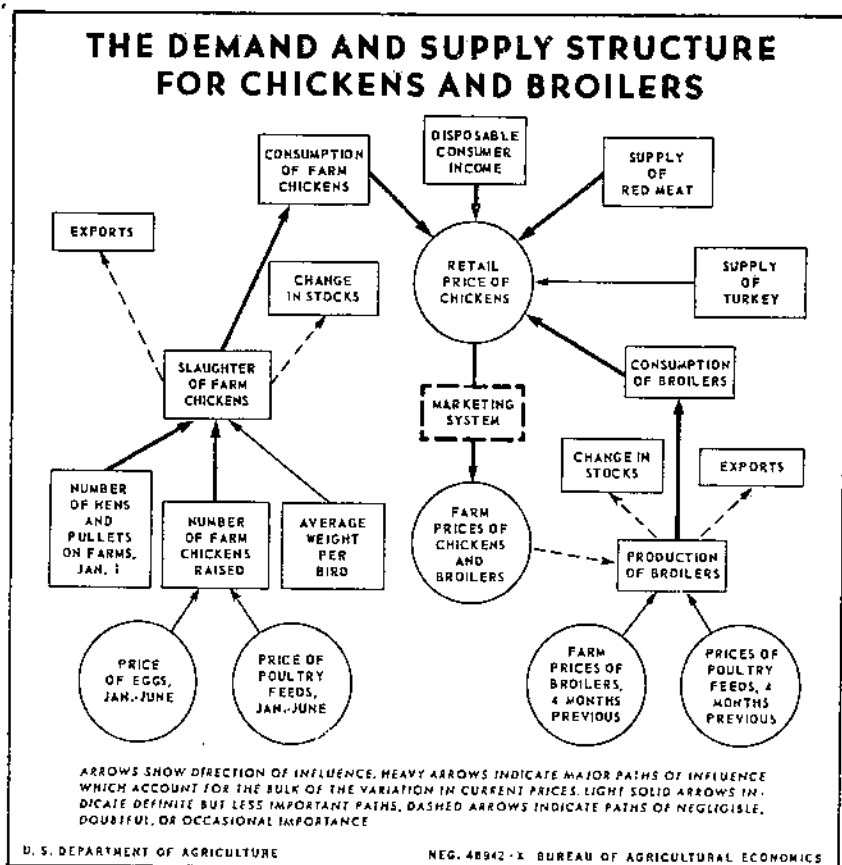
FIGURE 8.

to production and average prices of livestock. Demand for feed for chickens is only a fraction of the total demand for livestock feed. Similarly, as no measurable short-run competition in demand between eggs and chickens is found, the price of eggs may be regarded as uninfluenced by current slaughter of chickens. The number of hens and pullets on farms on January 1 is highly correlated with slaughter of chickens during the ensuing calendar year.

If prices of eggs and of poultry feeds in the early months of the calendar year are treated as predetermined variables, 69 percent of the observed variation in total slaughter in million pounds dressed weight of farm chickens can be explained by predetermined or noneconomic variables. About 88 percent of the variation in consumption of farm chickens during 1922–41 was associated with changes in slaughter of chickens (in terms of first differences), but the errors of measurement in the two series were not independent.

Unpublished studies of supply responses in production of chickens have attributed no importance to the price of farm chickens, as

chickens on farms are raised mainly for production of eggs. The more significant variables have been prices of eggs and of poultry feed. Hence, figure 8 indicates no effect of chicken meat prices upon current production of chickens.

Production of commercial broilers differs considerably from production of farm chickens. Broiler enterprises are highly specialized. They buy all or almost all of the feed they need. The producers' margin of profit is clearly discernible, and responses to relative prices of broilers and feed are relatively swift and sharp. Eggs hatch in about 3 weeks and chicks reach marketable weights as early as 9 weeks thereafter. Production of broilers can respond considerably to prices or other factors in 3 or 4 months. To some extent, the broiler enterprise serves as a balance wheel for the total poultry-meat industry.

If sufficiently accurate statistics for a long enough time were available, production of broilers could be treated as a predetermined variable by using time periods of 4 months or less. Figure 8 suggests that to understand the factors which determine prices of both broilers and farm chickens a simultaneous-equations system would be required conceptually, even though such a system cannot be fitted statistically until more data are accumulated.

TURKEYS

Figure 9 shows a similar demand-supply diagram for turkeys. Particularly during 1929–41 (no adequate data are available before 1929), turkeys fell into a simple pattern from the standpoint of estimation of statistical-demand equations. During this period approximately 90 percent of all turkeys produced were marketed from October to December. Turkey poults were hatched in spring and the number raised was influenced by such factors as profitability of production during the preceding year and the current level of feed prices. In 1929–41 the conditions of turkey production were such as to establish it as a predetermined variable.

In terms of original data, 98 percent of the variation in consumption of turkeys during 1929–41 was associated with variations in production. (In terms of first differences, the degree of association was 86 percent.) Again, the errors of measurement in the two series are not independent. The errors of measurement in consumption probably are sufficient to impart a significant downward bias (in absolute value) to the regression of turkey prices upon turkey consumption. Under pre-World War II conditions, consumer income, the supply of red meats, and the supply of chickens could be regarded as not measurably influenced by consumption or prices of turkeys during the same marketing year.

The increase in production of Beltsville Small White turkeys in the early fifties probably increased the intensity of competition among turkeys, chickens, and commercial broilers. For all types of poultry meats, development of the frozen-food industry tends to spread out the previous seasonal peaks in consumption. Possible effects of these factors must be kept in mind when proceeding from prewar analyses to current applications.

THE DEMAND AND SUPPLY STRUCTURE FOR TURKEYS
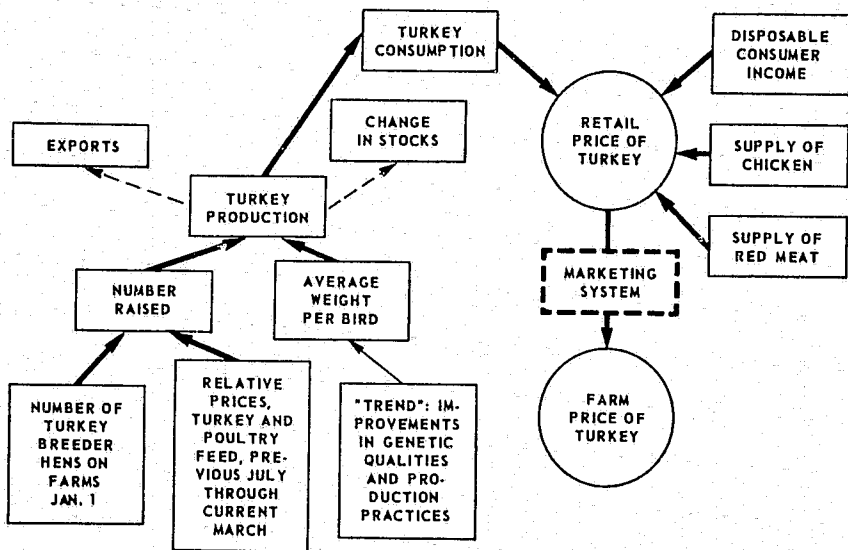
TURKEY CONSUMPTION

DISPOSABLE CONSUMER INCOME

CHANGE IN STOCKS

RETAIL PRICE OF TURKEY

SUPPLY OF CHICKEN

EXPORTS

TURKEY PRODUCTION

SUPPLY OF RED MEAT

NUMBER RAISED

AVERAGE WEIGHT PER BIRD

MARKETING SYSTEM

NUMBER OF TURKEY BREEDER HENS ON FARMS JAN. 1

RELATIVE PRICES, TURKEY AND POULTRY FEED, PREVIOUS JULY THROUGH CURRENT MARCH

"TREND": IMPROVEMENTS IN GENETIC QUALITIES AND PRODUCTION PRACTICES

FARM PRICE OF TURKEY

ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS INDICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE, DOUBTFUL, OR OCCASIONAL IMPORTANCE

U. S. DEPARTMENT OF AGRICULTURE   NEG. 48943-X   BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 9.

RESULTS OF STATISTICAL ANALYSES FOR POULTRY AND EGGS

Tables 4 and 5 give results for analyses dealing with poultry and eggs similar to those given for meats in tables 1 to 3.

Increases of 1 percent in supplies of chickens and turkeys have depressed their retail prices by about the same percentage. The price

TABLE 4.—*Poultry and eggs: Factors affecting year-to-year changes in prices, United States, 1922–41*

Price series and commodity	Coefficient of multiple determination	Effect on price of 1-percent change in—					
		Production or consumption [1]		Disposable income [1]		Supply of competing commodities [1]	
		Net effect [2]	Standard error	Net effect [2]	Standard error	Net effect [2]	Standard error
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Based on retail price:							
Chickens [3]	0. 86	[4]—0.75	0. 18	0. 76	0. 09	[5]—0.42	0. 16
Eggs [6]	. 87	[4]—2.34	. 44	1. 34	. 13		
Based on farm price:							
Chickens	. 86	[4]— .62	. 28	1. 06	. 12	[5]—1.01	. 30
Turkeys	. 90	—1.21	. 25	1. 06	. 20	[7]— .97	. 40
Eggs [6]	. 82	[4]—2.91	. 55	1. 43	. 17		

[1] Per capita basis.
[2] Regression coefficients from analyses based on first differences of logarithms.
[3] Based on *consumption* per capita. Other analyses based on production per capita.
[4] Probably understates true effects of changes in production or consumption upon price.
[5] Consumption of all meat per capita.
[6] Coefficients in this analysis were adjusted to allow for estimated average errors in measuring year-to-year changes in production of eggs.
[7] Production of chickens per capita.

TABLE 5.—*Poultry and eggs: Relationships between year-to-year changes in farm price and retail price, United States, 1922–41*

Commodity	Coefficient of determination	Effect on farm price of 1-percent change in retail price	
		Effect [1]	Standard error
		Percent	*Percent*
Chickens	0. 93	1. 35	0. 09
Eggs	. 97	1. 08	. 05

[1] Regression coefficients from analyses based on first differences of logarithms.

of chicken was significantly affected by supplies of meat, and the price of turkey was significantly affected by supplies of chicken. It is evident from these two relationships that supplies of meat were also a factor in the determination of prices for turkeys. In a special analysis not shown in table 4, supplies of pork from October to December apparently affected significantly the farm price of turkeys.

Retail prices of eggs responded more sharply to changes in production than did prices of any livestock product previously mentioned. The change of –2.3 percent probably understates the true effect of a 1-percent change in per capita production of eggs.

The price-income relationships in table 4 run between 0.8 and 1.4. If a retail-price series for turkeys were available, the regression of retail price upon disposable income would probably be somewhat less than 1.0. Prices of eggs apparently responded more sharply to changes in consumer income than did those of other livestock products.

Prices received by farmers for chickens vary considerably more than do retail prices, but year-to-year variation in prices of eggs is little greater at the farm than at the retail level. These differences reflect the fact that, as a percentage of the retail price, costs of marketing are considerably higher for poultry meat than for eggs.

DAIRY PRODUCTS

Even on the aggregative level shown in figure 10, analysis of demand for dairy products is difficult. The quantity of milk produced in a given year can be largely explained by (1) the number of cows and heifers in dairy herds as of January 1, (2) supplies of roughages and of feed concentrates during the preceding and current years, and (3) the level of milk production per cow, which has gradually increased because of improved genetic qualities of dairy cattle and better pastures and management practices. But specifically accounting for factors which cause the year-to-year changes in production of milk is difficult. Part of this arises from the relative stability of this production, because of such factors as the long productive life span of dairy cows and the heavy fixed investments of dairy producers, particularly in fluid-milk areas. Observed year-to-year changes in production of milk averaged about 2 percent during 1924–41. Thus, although these year-to-year changes may have been estimated within a billion pounds or less at a basic level of 100 to 110 billion pounds total production, as much as 25 percent of the reported year-to-year variation in production of milk may have come from errors of measurement. As production of manufactured dairy products is reported with almost accounting accuracy, errors of estimation are concentrated in estimates of consumption of fluid milk and cream, for which few check data are available for the 1922–41 period.

About 96 percent of the variation in the absolute level of consumption of dairy products (fat solids basis) was associated with variations in total production of milk. In terms of year-to-year changes, however, the degree of association was only 40 percent. The relative stability in milk production means that, for practical purposes, the explainable year-to-year variation in retail prices of dairy products is almost wholly associated with changes in disposable consumer in-
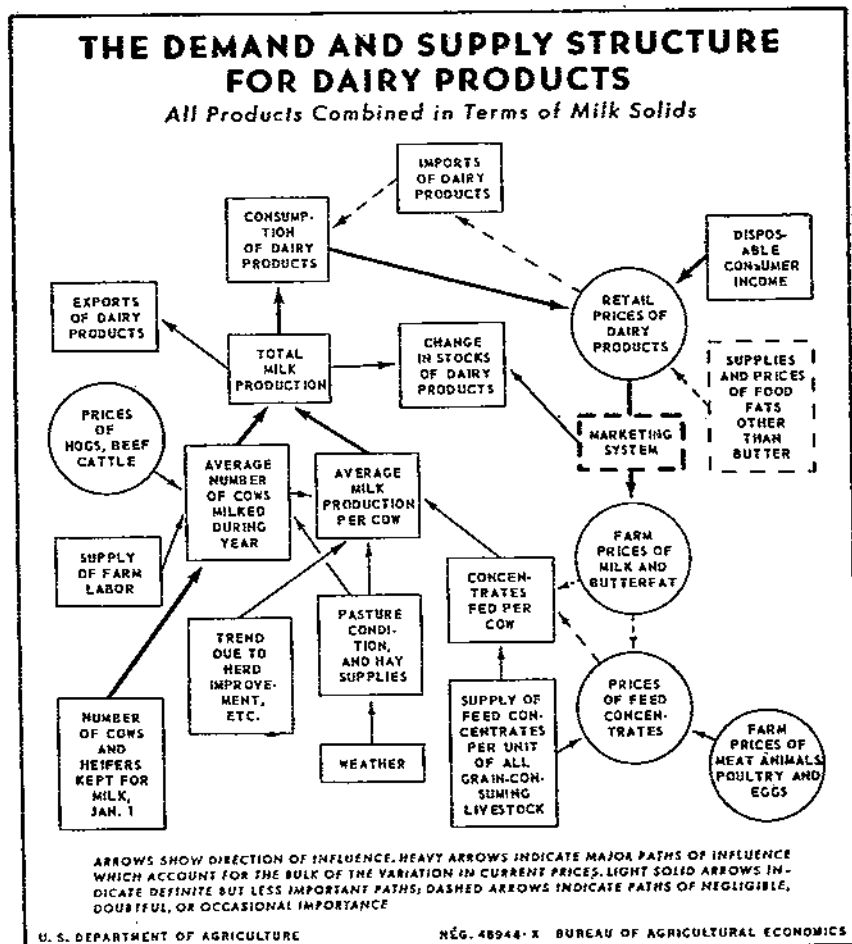
FIGURE 10.

come.   During 1922–41, 84 to 87 percent of the year-to-year variation in retail prices of dairy products was associated with year-to-year changes in disposable income (table 6).   For most dairy items, the addition of the relatively small changes in consumption as explanatory factors did not significantly increase the percentage of explained variance in retail prices.

Figure 10 suggests that there may be significant back-effects from the farm price of milk and butterfat upon the quantity of grains and other concentrates fed to milk cows and hence upon current production of milk.   The dairy economy is related through butter to the whole fats and oils economy although, as prices of butter are usually 2 to 3 times as high as those for its major competitor (oleomargarine), the competitive effects are not always obvious.

TABLE 6.—*Dairy products: Relation of year-to-year changes in retail prices to changes in disposable income, United States, 1922–41*

Commodity	Coefficient of determination	Effect on price of 1-percent change in income [1]	
		Net effect [2]	Standard error
		Percent	*Percent*
Fluid milk_____	0. 87	0. 55	0. 05
Evaporated milk_____	. 84	. 59	. 06
Cheese_____	. 84	. 77	. 08
Butter_____	. 84	1. 01	. 11

[1] Per capita basis.
[2] Regression coefficients from analyses based on first differences of logarithms.

Prices received by farmers for milk for fluid use, for butterfat, and for milk used by plants making butter and nonfat dry milk solids are correlated from 93 to 95 percent with changes in the corresponding retail prices (table 7). However, only 79 percent of the variation in prices received by farmers for milk sold to condenseries and cheese factories is associated with corresponding, that is, simultaneous, variations in retail prices of evaporated milk and cheese. Although some

TABLE 7.—*Dairy products: Relationships between year-to-year changes in farm price and retail price, United States, 1922–41*

Commodity	Coefficient of determination [1]	Effect on farm price of 1-percent change in—			
		Retail price		Other factors	
		Net effect [2]	Standard error	Net effect [2]	Standard error
		Percent	*Percent*	*Percent*	*Percent*
Milk for fluid use_____	0. 93	1. 64	0. 11	_____	_____
Condensery milk_____	. 79	2. 13	. 27	_____	_____
Milk for cheese_____	. 79	1. 76	. 22	_____	_____
Butterfat_____	. 95	[3] 1. 35	. 06	_____	_____
Creamery milk_____	. 95	[3] 1. 19	. 08	[4] 0. 13	0. 04

[1] Represents the percentage of total year-to-year variation in farm price during 1922–41 that was associated with the combined effects of the other variables.
[2] Regression coefficients from analyses based on first differences of logarithms.
[3] Coefficient derived by algebraic linkage of two regressions: (1) Farm price upon wholesale price of butter; and (2) wholesale price upon retail price. Coefficients of determination have been reduced and the standard error increased to allow for residual errors in both equations.
[4] Wholesale price of nonfat dry milk solids (average of prices for both human and animal use).

of the unexplained variations in these cases may come from differences in the weighting and construction of the respective farm and retail price series, the structure of the marketing system for these two groups of products may also be involved. Changes in inventories in both reported and unreported positions may be explanatory factors.

Farm prices of milk and butterfat fluctuate more than do retail prices of the products marketed. Butter has the smallest marketing margin and the smallest percentage relationship between farm and retail price changes. The farm price of fluid milk changed about 1.6 times as sharply as the retail price and the price of milk used for cheese fluctuated about 1.8 times as much as the retail price of cheese. Because of the importance of fixed costs and charges in the marketing system, the price paid for milk by condenseries fluctuated more than twice as sharply as the retail price of evaporated milk.

In terms of the major individual commodities the supply-demand structure for dairy products is a good deal more complex than is indicated by figure 10. In the western Corn Belt and the Great Plains some farmers may decide to sell whole milk for manufacturing rather than farm-separated cream on the basis of relative prices received for the two products. Although year-to-year changes in this choice of marketing forms may be fairly small, in the last 20 years farmers have shifted from marketing mainly farm-separated cream to marketing mainly whole milk. In major manufacturing areas such as Wisconsin, many milk producers have access to at least three different types of outlets—condenseries, cheese factories, and butter and powder plants, that is, plants which make nonfat dry milk solids as well as butter. Some of these producers are also in position to sell milk for fluid use.

Although producers in the major fluid milksheds are protected to some extent by sanitation requirements and other institutional factors, seasonal surpluses of milk in the fluid milksheds are diverted into manufactured products and thus compete in the national markets. Thus, the utilization pattern for total production of milk in a given year involves four or more simultaneously determined derived demand equations.

Neither these complexities nor the even greater ones that would be involved if the minor, but significant, products and byproducts of the dairy industry were introduced into a diagram such as figure 10 need be discussed here. Considering the presence of errors of estimation in the basic milk-production and butterfat-sales series and in the estimates of consumption of fluid milk and cream, it is doubtful whether a satisfactory statistical model of the dairy industry could be derived by any means now known. Any detailed analysis of the demand-supply structure for dairy products must be conceived in terms of many simultaneous equations. Fluctuations in inventories at various market levels are a complicating factor, as are export-import relationships and the relation through butter to the world fats and oils economy.

TOTAL LIVESTOCK PRODUCTS

Often it is convenient to work with large aggregates, such as an index of consumption of all food-livestock products and an index of

the corresponding livestock-product prices. Results from such analyses are shown in table 8. As in the case of all meat, the logical question concerning the extent to which production of livestock is predetermined depends upon the summation of the degrees of predetermination for individual livestock products. It can be shown that the regression coefficient obtained between two aggregates or index numbers such as prices and consumption of all food-livestock products depends upon the elasticities of demand or the flexibilities of price for the individual livestock products and upon the relative variability of their consumption. An additional factor is their relative economic importance as measured by their weights in the index number. To the extent that flexibilities of price for individual members of such an aggregate differ widely, a change in the average level of livestock prices is not independent of the internal distribution of changes in consumption of livestock. Thus, for some purposes, analyses of less aggregative series must be used. From these, an estimate or forecast of the average level of livestock prices can be made by summing the price estimates for individual products, recognizing the competitive relationships which exist among some of the latter.

Considering the relative importance and relative variability of individual consumption or production series for livestock, it may be assumed that 90 percent or so of the year-to-year variation in production of livestock during 1922–41 can be attributed to predetermined factors. Comparable indexes of production and consumption are not available to measure the degree to which consumption of livestock products is predetermined, but a level of 80 percent or more is probable. Thus, the major shortcoming of a demand equation for this commodity group is likely to be its degree of aggregation rather than biases arising from the neglect of supply equations which are determined simultaneously with those for demand.

As food-livestock products as a group, valued at retail prices, are equivalent to a little more than 10 percent of disposable income, the question of whether disposable income is affected significantly by variations in consumption of livestock may be raised. The standard deviation of year-to-year changes in consumption of food livestock (a range that includes about two-thirds of the individual year-to-year changes) in 1922–41 was less than 3 percent, compared with 12 percent for disposable income. This limited variability suggests that variations in supply of livestock accounted for a great deal less than 10 percent of the total variation in disposable income. Moreover, only 4 percent of the year-to-year change in consumption of livestock was associated with changes in disposable income during these years.

If the effects of variation in consumption of livestock are considered as operating upon consumer expenditures (and hence on consumer incomes) via the demand equation illustrated in table 8, the following rough calculations are in order:

1. Effect of a 1-percent increase in consumption of food livestock:
    (a) On retail prices of food-livestock products= —1.64 percent.
    (b) On retail expenditures for food-livestock products= —0.64 percent.
2. Standard deviation of consumption of food livestock=2.7 percent.
3. Approximate retail value of food-livestock products (1922–41 average)=9 billion dollars.
4. Standard deviation of changes in consumer expenditures for food-livestock products attributed to changes in consumption of food livestock (Item 1b times item 2 divided by 100 times item 3)=0.156 billion dollars.

It may be supposed that the variation in disposable income because of changes in the supply of food-livestock products available to consumers is of the same general order of magnitude as the 0.156 billion dollars of item 4. This result is about the same as for pork alone. Although the total value of food-livestock products is about four times that of pork, the percentage variability of consumption of food livestock in 1922–41 was only a fourth as great. No allowance is made for effects of supplies of food-livestock products upon prices of other commodities; probably such effects are neither large nor statistically measurable. The estimated effect of consumption of food livestock upon disposable income in relation to the observed year-to-year variation in disposable personal income during 1922–41 is negligible.

In view of this discussion, the estimates of flexibilities of price for all food-livestock products shown in table 8, which were derived from equations fitted by the method of least squares, appear valid, apart from the question of overaggregation discussed on page 24. Farm prices respond about 1.5 times as much to a 1-percent change in either consumption or disposable income as do retail prices. This reflects the relative stability of marketing charges. On the average, a 1-percent change in the retail price of this commodity group in 1922–41 was associated with a change of 1.5 percent in the farm price.

TABLE 8.—*All food livestock products: Factors affecting year-to-year changes in prices, United States, 1922–41*

Price series	Coefficient of multiple determination	Effect on price of 1-percent change in—			
		Consumption [1]		Disposable income [1]	
		Net effect [2]	Standard error	Net effect [2]	Standard error
		Percent	*Percent*	*Percent*	*Percent*
Retail	0. 98	−1. 64	0. 13	0. 84	0. 93
Farm	. 95	−2. 45	. 31	1. 23	. 07

[1] Per capita basis.
[2] Regression coefficients from analyses based on first differences of logarithms.

DEMAND FOR CROPS, 1922–41

To avoid repetition, diagrams showing the supply-demand structures for a number of typical situations are first discussed. These are referred to in the appropriate commodity discussions, along with results from the statistical analyses based on them. Two such diagrams were discussed in connection with development of the theoretical framework. To provide continuity, brief comments regarding them are included here.

TYPICAL SUPPLY-DEMAND STRUCTURES

The upper part of figure 1 illustrates the simplest case found for perishable crops. In this case production available for marketing is assumed to be not affected by price during the marketing period.

Also the design assumes a single market or end use. Some vegetables produced for fresh market and some fruits in areas where processing is not important fit this pattern reasonably well. Acreage is determined by economic influences and decisions made anywhere from several weeks to several years before the current harvest period. Year-to-year changes in crop yields are mainly owing to weather, insects, and other natural hazards. For some of these crops consumption is practically identical with production and can be treated as a predetermined variable.

A complication recognized in the diagram may arise even when producers of a perishable crop are not organized to control marketings. If the market price does not cover the costs of harvesting, each producer may decide to leave some part of his production unharvested. In effect, this means that the observation applying to price and total production will not lie on the demand curve. It will fall to the right along the producers' supply curve, which is approximately horizontal in this range. If the data or prior knowledge indicate that this actually happens, the production variable may be adjusted for the quantities unharvested. Inclusion of unharvested production in this case would bias the slope of the fitted demand curve toward zero.

The lower part of figure 1 represents a more complicated situation which applies to some fruits or vegetables with both fresh-market and processing outlets. Again production is assumed to depend chiefly upon weather and upon economic influences prior to harvest. This diagram implies that both the processed and fresh forms of the commodity are consumed entirely in the domestic market so that disposable income is the appropriate final demand shifter for both. The statistical relation between farm and retail prices of the processed product is likely to be somewhat looser and more subject to distortion because of changes in inventories, anticipations, and time lags than is the market relationship for the fresh product.

The structure in this diagram indicates the existence of at least two simultaneously determined demand equations, even assuming that a perfect relation exists between the farm and retail prices of both fresh and processed products. In fitting the two basic demand equations, the retail price of each form of the product *minus* the marketing margin or charge appropriate to each could be used in arriving at an equivalent farm price in each case. Under conditions of equilibrium, the equivalent farm prices returned from each outlet should be equal.

If total marketings of a perishable crop are controlled by a producers' group or cooperative marketing organization, advantage can be taken of differences in demand elasticities for the two forms of the product to increase total net revenue. In the 1930's a frequent assumption was that the processed form of a fruit or nut had a more elastic demand than did the fresh product. Consumption of the processed form could be spread out over many months or a full year, whereas it might be necessary to sell the fresh product within the space of a few weeks. If with the same prices in both outlets, demand were more elastic in the processing outlet, total revenue could be increased by shifting part of the crop from fresh-market to processing outlets. The optimum allocation of a given supply would be that in which marginal net revenues from the two outlets were equal. In

general, of course, such a solution or even an approach to it would mean lower average prices to growers from the processing outlet than from the fresh market.

Some programs for diversion or for controlled utilization assumed that the processing demand was independent of that for the fresh product. This may have been approximately true at the outset, but as time wore on it appeared in some cases that the processed product was encroaching upon the original market of the fresh. Oranges and certain tree nuts appear to have followed this pattern. To recognize such interdependence in demand, the retail price or the consumption of each commodity would need to be included in the demand equation of the other.

The diagram in figure 11 illustrates a situation which occurs more frequently with mineral or industrial than with agricultural products. It assumes that production is determined simultaneously with current price. This would be true for certain crops for processing if production were determined mainly by the contract price and if retail prices were based on a fixed mark-up over the contract price. Actually, retail prices are usually adjusted in such a way that available supplies move into consumption and a corresponding adjustment is made in the contract price in subsequent years. Therefore, in effect, production and price are not determined simultaneously. This diagram would apply approximately to those perishable fruits and vegetables a substantial part of which are left unharvested, with the quantity harvested depending mainly on the price at harvest. This situation represents the purest and earliest form of the identification problem as considered, for example, by Working (37) in 1927. With the supply-demand structure as shown in the diagram, the elasticity of demand cannot be determined by single-equation methods. However, if weather (or "other factors") can be introduced as a measured variable, the elasticity of demand can be estimated by using a system of two simultaneous equations.

Figure 12 illustrates the demand-supply structure for feed grains. Some 90 percent of the production of feed grains is consumed by live-stock. The immediate value of these grains to a livestock producer depends upon their value as raw materials in the production of live-stock. The relative stability of livestock-feed price ratios when averaged over periods of 2 to 5 years indicates their importance as regulators of the livestock-feed economy. By and large, a 1-percent increase in prices of grain-consuming livestock is associated with a similar increase in prices of feed grains.

As previously mentioned, 95 percent of the year-to-year variation in farm prices of food-livestock products from 1922 to 1941 was associated with corresponding variations in both consumption of live-stock products and disposable income. Consumption of livestock products in the aggregate can be regarded largely as a predetermined variable. Thus the average farm price of livestock products may be treated as an independently determined variable for the purpose of analyzing the prices of feed grains.

Numbers of grain-consuming livestock on farms at the beginning of a feed-grain marketing year also influence the demand for and the prices of feed grains. Supplies of these grains and of byproduct feeds at the beginning of a marketing year are determined mainly by

DEMAND AND SUPPLY STRUCTURES
FOR PERISHABLE CROPS

Supply and Demand Determined Simultaneously: Single Market
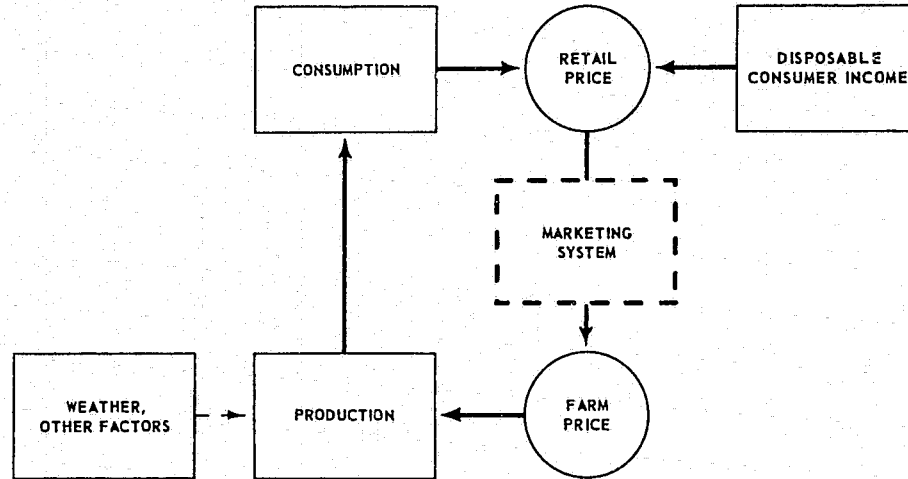
ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE
WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS IN-
DICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE,
DOUBTFUL, OR OCCASIONAL IMPORTANCE

U. S. DEPARTMENT OF AGRICULTURE   NEG. 48932-X   BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 11.

THE DEMAND AND SUPPLY STRUCTURE FOR FEED GRAINS

ARROWS SHOW DIRECTION OF INFLUENCE, HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS IN-DICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS OF NEGLIGIBLE IMPORTANCE IN THE DETERMINATION OF CURRENT PRICE

U. S. DEPARTMENT OF AGRICULTURE   NEG. 48934-X   BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 12.

acreage planted and weather. Demand for feed grains for export and for domestic uses other than feed is not important in most years. These uses normally take less than 10 percent of the total supply of these grains.

Farm prices of feed grains can be estimated from an equation based on farm prices of livestock products, numbers of grain-consuming livestock on farms, and supplies of feed grains and byproduct feeds. Such an equation is discussed in Foote (*11*). This equation also has approximate structural significance. Current supplies and prices of feed grains influence production of livestock during the succeeding few months. This in turn influences numbers of livestock on farms at the beginning of the following year and also the level of farm prices of livestock products which may exist then. As pointed out by Foote (*11*), the feed-grain and livestock economy inherently contains a set of lagged relationships, each of which may be approximated by single-equation methods provided the variables apply to appropriate time units and are properly lagged.

Figure 13 outlines a simple demand-supply structure for export crops such as cotton, wheat, or tobacco. This structure logically im-

THE DEMAND AND SUPPLY STRUCTURE FOR EXPORT CROPS

ARROWS SHOW DIRECTION OF INFLUENCE. HEAVY ARROWS INDICATE MAJOR PATHS OF INFLUENCE WHICH ACCOUNT FOR THE BULK OF THE VARIATION IN CURRENT PRICES. LIGHT SOLID ARROWS INDICATE DEFINITE BUT LESS IMPORTANT PATHS; DASHED ARROWS INDICATE PATHS INVOLVING MORE REMOTE VARIABLES

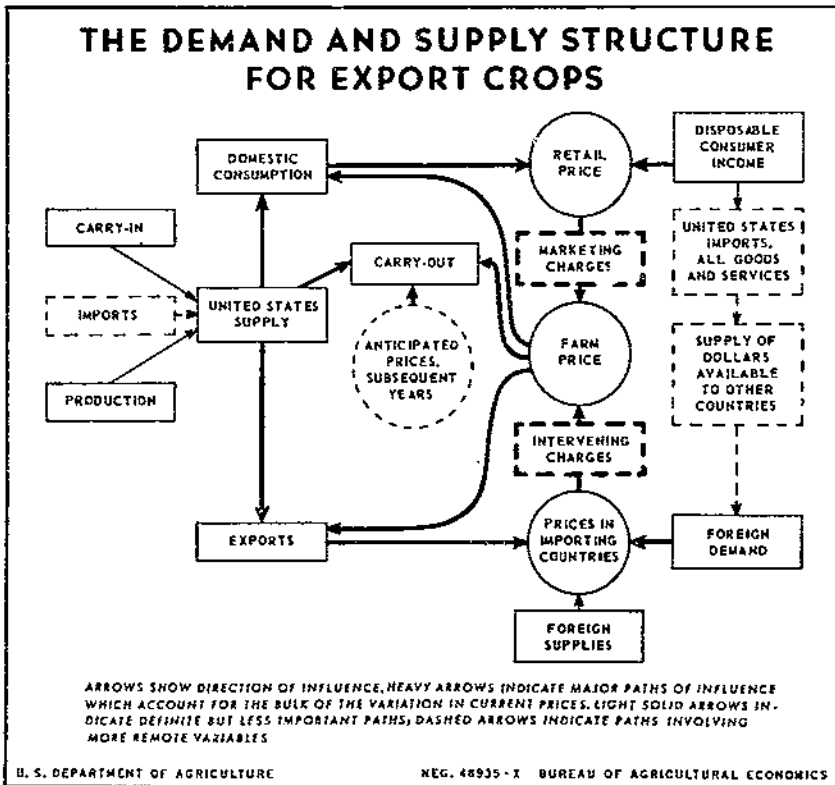U. S. DEPARTMENT OF AGRICULTURE   NEG. 48935-X   BUREAU OF AGRICULTURAL ECONOMICS

Figure 13.

plies demand curves for domestic consumption and for exports from the United States. Also, assuming that prices received by farmers are the same regardless of whether the commodity is exported or consumed domestically, it implies that total disappearance is equal to the sum of domestic disappearance and exports. Obviously this diagram could be extended to include a demand curve for each country that imports the commodity and a supply curve for each country that exports it. As most of the major export crops are storable, storage demands in each exporting and importing country should be considered. The only way to establish a valid single-equation approach for a major export crop would be to choose some representative "world" price and make it a function of world supply and some measure of world demand. Before 1933 such equations for wheat and cotton appeared to have considerable value for forecasting.

Results from some demand equations for crops are summarized in tables 9 and 10. Except where noted, these were derived by the author during 1950–51.

FRUITS AND VEGETABLES

During 1922–41, supply-demand structures for some of the fruits and vegetables listed in table 9 corresponded roughly to the simple diagram shown in the upper part of figure 1. Processing outlets for peaches outside of California and for apples, oranges, lemons and cranberries in all States where grown were relatively minor. This was true also for potatoes, sweetpotatoes, and onions, and for truck crops for fresh market during summer and fall. During these seasons production of truck crops is widely spread throughout the country and most shippers are sufficiently small so that they do not attempt to regulate current price by varying the daily quantities shipped.

Producers of truck crops for fresh market in winter and spring are typically large-scale and are located in specialized producing areas. More careful study of factors that affect prices of winter and spring truck crops might disclose the need of simultaneously determining market-supply and -demand equations, as implied by the diagram in figure 11. Problems of aggregation and errors in both production and price data also are likely to be important.

Processing outlets for some of the fruits listed in table 9 have grown rapidly since the late thirties and still more rapidly since World War II. Production of canned orange and grapefruit juice increased rapidly during the late thirties and early forties. Since World War II production of frozen concentrated orange juice has greatly expanded. Frozen concentrated lemon juice, lemonade, limeade, and other juices are beginning to follow this trend. During most of the time from 1922 to 1941, only a single important domestic outlet existed for oranges. But during the early forties the demand-supply structure included two major outlets, each with its own demand curve. In the last 3 or 4 years a third outlet has been added. The increased demand for the processed products has probably shifted the level, and possibly the elasticity, of the demand equation for fresh oranges as such.

Before 1937 fully 90 percent of the cranberry crop was sold in fresh form but in that year a bumper crop led to a large processing program. This utilization has continued to increase. Data for the years after 1937 suggest that as a result the total demand for cranberries has

TABLE 9.—*Fruits and vegetables: Factors affecting year-to-year changes in farm prices, United States, 1922–41*

Commodity or group	Coefficient of determination	Effect on price of a 1-percent change in—					
		Production		Disposable income		Temperature	
		Net effect [1]	Standard error	Net effect [1]	Standard error	Net effect [1]	Standard error
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fruits:							
Deciduous:							
Apples [2]	0.96	−0.79	0.04	1.04	0.12		
Peaches [2][3]	.80	−.67	.09	.96	.30		
Cranberries [4]	.86	−1.49	.19	.78	.31		
All deciduous [2]	.82	−.68	.09	1.08	.18		
Citrus:							
Oranges	.93	−1.61	.11	1.34	.25		
Grapefruit	.72	−1.77	.28	1.29	.55		
Lemons:							
Shipped fresh:							
Summer [5]	.79	2.48	.40	1.07	.30	[6] −0.98	0.17
Winter [5]	.88	−1.39	.16			[7] −1.69	.37
All lemons	.61	−1.69	.34	[8] .78	.59		
All citrus [2]	.92	−1.32	.10	.98	.20		
All fruits	.82	−.94	.12	1.06	.21		
Potatoes	.93	−3.51	.26	1.20	.33		
Sweetpotatoes	.75	−.77	.16	.89	.24		
Onions:							
All [2]	.89	−2.27	.20	1.00	.29		
Late summer [9]	.85	−2.90	.32	[8] .72	.60		
Truck crops for fresh market [7][10]:							
Calendar year	.85	[11] −1.03	.26	.81	.12		
Winter	.67	[11] −1.13	.35	.92	.31		
Spring	.49	[8] −.95	.48	.63	.22		
Summer	.87	−1.72	.34	1.23	.19		
Fall	.84	−1.67	.35	.85	.20		

[1] Regression coefficients from analyses based on first differences of logarithms. Per capita basis unless otherwise noted.
[2] Based on total production and income.
[3] United States, excluding California.
[4] Based on data for 1932–36. Processing outlets expanded rapidly after 1937. There is evidence that demand is now more elastic.
[5] Adapted from analyses originally developed by Kuznets and Klein (*23*), based on total supplies per capita for the summer months and domestic shipments per capita for the winter months. Prices are measured at the f. o. b. level. The adaptations consist in (1) converting all variables into first differences of logarithms, and (2) substituting disposable personal income for nonagricultural income. The latter adjustment affected the results very little.
[6] Index of summer temperatures in major United States cities.
[7] Index of winter temperatures in major United States cities.
[8] Nonsignificant at 5-percent level.
[9] Analysis developed by Herbert W. Mumford, Jr.
[10] Equations fitted to 1928–41 data only.
[11] Probably understates true effect of production on price.

become somewhat more elastic. That is, the farm price has been somewhat less responsive to changes in production than it was from 1922 to 1936. On the debit side, in some recent years farm prices have been depressed by excessive carryovers of processed cranberries.

The demand equations for "all fruits" and for "all deciduous fruits" probably are too aggregative to be of much practical value. The total for deciduous fruits includes such diverse commodities as grapes (table, wine, and raisin), other fruits for fresh market and processing, and even olives.

No attempt was made in table 9 to include results from single-equation analyses for fruits or vegetables with complicated patterns of utilization. For several of the major deciduous fruits grown in California, two or more simultaneous demand curves (for different forms of the commodity) must be recognized. However, whether enough data exist on consumption, retail prices, and other factors for each utilization to enable accurate fitting of simultaneous-equation systems for these crops is not clear.

No analyses are included for truck crops for processing. Because much of the production of these crops is contracted for in advance, the relation between the current price and current production more nearly approximates a supply than a demand curve. As an indication of this, from 1929 to 1941 the simple regression of production on price, based on year-to-year changes, is slightly positive but statistically nonsignificant. It would not be surprising to find a rather flat supply curve for most truck crops for processing in 1929–41, as in a given area these crops ordinarily used only a small part of the land that was suitable for their production. In the early years of World War II, however, acreage expanded tremendously. In some areas it reached a level at which substantial price increases would have been needed to encourage additional production.

SUGAR AND FATS AND OILS

An exploratory attempt was made to test the hypothesis that consumption of sugar is largely determined by the supply of foods with which sugar is customarily used. Official estimates of consumption of sugar are based on shipments by primary distributors or refiners. Inventories in unreported positions, as in the hands of industrial users, wholesale and retail grocers, and consumers, appear to fluctuate considerably. The official series on consumption of sugar shows some large fluctuations which must reflect chiefly changes in unreported inventories. A rough index of consumption of sugar-using foods showed fairly sizable fluctuations from year to year, but never more than the equivalent of 9 pounds of sugar per capita on an average base of about 100 pounds. However, several times since 1940 the official series on consumption of sugar has changed by more than 15 pounds between adjacent years, and in 1922–41 it twice changed as much as 13 pounds. Thus, the data are not sufficiently accurate to test the hypothesis that consumption of sugar is related to that of sugar-using foods by a relatively constant factor or to establish an elasticity of demand for sugar, *given* the level of consumption of foods with which it is customarily used.

Per capita consumption of food fats and oils in the United States has been relatively stable, except during the rationing period of World War II. An analysis of factors that affect consumption of all fats and oils other than butter by Armore and Burtis (2) indicated that the net elasticity of demand for this aggregate did not differ significantly from zero. An analysis subsequently published by Armore (1) indicates that although the demand for fats and oils used in food other than butter and lard is highly inelastic, it differs significantly from zero.

Some exploratory work was done toward testing the hypothesis that consumption of food fats and oils is related to consumption of the foods with which they are used as ingredients by a relatively constant factor. For example, from 1922 to 1950 the ratio of butter plus oleomargarine consumed per capita to per capita consumption of wheat flour was remarkably stable. Although butter and margarine are used with foods other than bread, this ratio suggests the existence of something like a stable "bread-spread ratio." The ratio between per capita consumption of lettuce and consumption of the "other edible oils" group, which consists largely of salad and cooking oils, was also relatively stable from 1922 to 1950.

FEED GRAINS AND HAY

The first analysis shown for corn embodies the structure shown in figure 12. The supply variable is the total supply (production plus carry-in) of corn, oats, barley, and grain sorghums. These grains may be substituted for corn in most feeding uses. Two demand factors are used in this analysis. The first is an index of prices received by farmers for livestock products, with each product weighted approximately by its grain requirements. The regression coefficient indicates that a 1-percent increase in the average price of grain-consuming livestock is associated with almost a 1-percent increase in the price of corn. The second factor is the number of grain-consuming animal units on farms as of January 1. This coefficient implies that a 1-percent increase in grain-consuming animal units from one year to the next tends to increase the prices of corn by perhaps 2 percent.

The demand-supply structure for barley taken alone should be more complicated than is indicated by the above analysis because of the relatively large quantity of this crop that goes into the brewing industry. However, the quantity of barley used in the brewing industry is small compared with the total supply of all feed grains.

Because minor feed grains can be substituted to a considerable degree for each other and for corn, changes in prices of these grains are closely related from year to year. This is indicated by the lower part of table 10. As production of corn greatly exceeds that of the other feed grains, the price of corn may be used as a barometer and basing point for the entire feed-grain complex. For example, 99 percent of the year-to-year variation in the index of prices received by farmers for all feed grains (including corn) from 1922 to 1941 was associated with fluctuations in the price of corn. However, analyses by Meinken (26) indicate that fluctuations in the prices of minor feed grains relative to that of corn are significantly related to

variations in their relative supplies. This indicates that substitution is not perfect within the relevant range of prices and quantities.

The last three items in table 10 are included to show that changes in prices of high-protein feeds and hay are relatively independent of

TABLE 10.—*Feed grains and hay: Factors affecting year-to-year changes in farm prices, United States, 1922–41*

Commodity	Coefficient of determination	Effect on price of change of 1 percent in—			
		Supply factor		Demand factor	
		Net effect [1]	Standard error	Net effect [1]	Standard error
	Multiple	*Percent*	*Percent*	*Percent*	*Percent*
Hay	0.89	−1.39	0.15	[2] 0.83	0.16
Corn	.85	[3] −1.93	.21	{ [4] .89	.20
				[5] 2.26	.71
Do.	.82	{ [6] −1.26	.28	[8] 1.06	.25
		[7] −.89	.40		
Do.	.85	{ [6] −1.22	.27		
		[9] −.82	.29	[8] .89	.25
		[10] 1.72	1.19		

Commodity	Coefficient of determination	Average percentage change in price associated with 1-percent change in price of corn	
		Net effect [1]	Standard error
	Simple	*Percent*	*Percent*
All feed grains, prices received by farmers	0.99	0.91	0.02
Hominy feed (Chicago)	.97	.86	.03
Price paid by farmers for purchased feed	.91	.55	.04
Sorghum grains	.88	.97	.09
Oats	.82	.73	.08
Barley	.77	.68	.09
Soybean meal (Chicago)	.67	.59	.13
Hay	.51	.40	.09
Tankage (Chicago)	.35	.41	.15

[1] Regression coefficients from analyses based on first differences of logarithms.
[2] Cash receipts from beef cattle and dairy products weighted approximately in proportion to total consumption of hay by each type of cattle.
[3] Total supply of corn, oats, barley, and sorghum grains.
[4] Index of prices received by farmers for grain-consuming livestock (weighted according to grain requirements).
[5] Number of grain-consuming animal units on farms, January 1.
[6] Supply of corn (adjusted for net changes in Commodity Credit Corporation stocks).
[7] Supply of other feed grains and byproduct feeds.
[8] Product of numbers and prices of grain-consuming livestock.
[9] Supply of oats, barley, and sorghum grains, plus wheat and rye fed.
[10] Supply of byproduct feeds. Regression coefficient is statistically nonsignificant.

changes in the price of corn. Much of the correlation indicated in this table is owing to the common effects of changes in livestock prices rather than to true substitution or competition between corn and the dissimilar feeds.

The demand-supply structure for hay corresponds roughly to that shown in the upper part of figure 1, for which a single-equation approach is appropriate. The demand factor used in the analysis for hay (table 10) is an index of cash receipts from sales of dairy products and beef cattle, weighted approximately in proportion to total consumption of hay by dairy and beef cattle respectively. In turn, cash receipts from sales of dairy products and beef cattle are largely determined by consumer income and by the production of those commodities. The supply of hay (production plus carryover) is not substantially affected by the price of hay during the marketing season.

Export Crops

The basic pattern of demand-supply structures for export crops is shown in figure 13. Some wheat is also used as a livestock feed. The demand curve for wheat as a feed is such that the quantity used for this purpose increases sharply as the price of wheat declines toward that of corn. When the price of wheat is well above that of corn, very little wheat is fed to livestock in most parts of the country.

The complete demand structure for wheat logically requires at least three simultaneously fitted demand curves—one each for feed, domestic food use, and export. The demand equation for food use can be approximated reasonably accurately by the following approach. Before 1933, and in some years since, the farm price of wheat grown in this country has been determined by the world demand-supply system for wheat. During certain other years, the price of wheat in this country has been determined chiefly by Government policy in regard to price supports. If interest lies in domestic demand for wheat for food, prices can be regarded largely as an independently determined variable and consumption as dependent upon it. An analysis of year-to-year changes in per capita consumption of flour, which represents the bulk of the wheat used for food in our country, indicated an elasticity of demand with respect to the United States farm price of -0.067. The standard error of this coefficient was 0.027, so that the elasticity obtained differed significantly from zero according to the usual criterion.

An analysis by Lowenstein (24) of factors that affect the quantity of cotton used by mills in this country indicated an elasticity of demand for cotton at the mill level of about -0.3. As in the case of wheat, the price of cotton had been determined by world demand and supply in some of the years from 1920 to 1941 and by Government support prices in a good many years since 1933.

The situation for tobacco has been somewhat similar to those for wheat and cotton. Treating the retail price of cigarettes as a predetermined variable, George R. Rockwell, Jr., in an unpublished study, found that the elasticity of demand for cigarettes in this country is approximately -0.3. The elasticity of derived demand for the leaf tobacco used to manufacture cigarettes is considerably less.

An exploratory simultaneous-equation analysis of domestic and export demands for wheat, cotton, and tobacco as an aggregate was

fitted by the method of reduced forms.   (See page 32.)   The price index and the domestic consumption index of the three commodities were expressed as functions of an index of their total marketings, of domestic disposable income, and of total dollars expended by people in other countries for all United States goods and services.   (This last is roughly analogous to using total consumer expenditures to represent domestic demand.)   The usefulness of this analysis suffers because the commodities thus thrown together are so dissimilar. However, the results were promising.   They implied an elasticity of demand by dealers of about -0.5 in this country and about -1.2 in the foreign market from 1924 to 1939.   However, the regression of price upon disposable income was nonsignificant and of the wrong sign.   Perhaps the major reason for this lies in the fact that the measure of foreign demand used—total dollars expended by people of other countries for goods and services produced here—was correlated to the extent of 73 percent (r^2) with year-to-year changes in our disposable income.   Based on this analysis, it appears desirable to use the simultaneous-equations approach to explore the demand structures for cotton, wheat, and tobacco individually.   Such studies for wheat and cotton are planned under research projects now under way in the Bureau.

DEMAND FOR ALL FOOD AND FOR ALL FARM PRODUCTS

For convenience, analysts both in the Bureau of Agricultural Economics and in other agencies at times use aggregative analyses for (1) all foods and (2) all farm products.   The author also has used an aggregative analysis for all farm products, exclusive of wheat, cotton, and tobacco.   This domestically oriented group includes more than 80 percent of cash receipts from farm marketings.   Its average price is highly associated with changes in aggregate production and in domestic disposable income.

Special complications arise in any analysis that includes as many items as the one for all food.   For example, livestock products account for more than 60 percent of the retail value of food products originating on our farms and sold to domestic consumers.   Consumer purchases of livestock products respond significantly to changes in price. Elasticities of demand at retail for several of these products range from -0.5 to -1.0.

Foods mainly of plant origin include some fruits and vegetables for which demand is even more elastic than the demand for meat. They also include potatoes, dry beans, cereals, sugar, and fats and oils, for which both price and income elasticities of consumption are small.

Aggregative analyses of the demand for all food yield regression coefficients which are complexly weighted averages of the elasticities for individual foods.   If the price for every food at retail dropped 10 percent and income remained constant in real terms, total consumption of food might increase by perhaps 3 to 4 percent.   However, the consumption response is not independent of the distribution of price changes for individual foods, if the assumption of parallel price movements is relaxed.   A drastic decline in prices of potatoes, flour, sugar, and lard would affect total consumption of food negligibly if prices

of meat, poultry, fruits, and vegetables remained constant. But a 10-percent drop in an index of food prices caused by a 30-percent drop in the price of meat might lead to as much as a 6-percent increase in an index of total food consumption.

A least-squares equation expressing prices received by farmers for all farm products as a function of (1) the physical volume of farm marketings, (2) disposable income, and (3) the value of agricultural exports has also been found useful for some purposes. If the relative importance of domestic and export markets does not change, the flexibility of farm prices with respect to total farm marketings should have some significance, as all the variables are largely predetermined. If the relative importance of agricultural exports should increase or decrease sharply, however, the individual equations for domestic and foreign demand would be more useful. In this case, each individual structural equation would include three variables only—price, quantity, and the appropriate demand factor.

An experiment was made to ascertain the kind of structural coefficients that would be consistent with the regression coefficients of the four-variable least-squares equation just discussed (that is, by assuming that it is a reduced-form equation derived from two simultaneously determined equations representing the demand for farm products in domestic and export outlets respectively). By assuming a domestic price flexibility of -1.8 with respect to domestic marketings and $+1.5$ with respect to domestic income, and a price flexibility for exports of -1 with respect to quantity and $+1$ with respect to value, the coefficients of the reduced-form equation were reproduced almost exactly by an appropriate algebraic transformation.[12] The method used does not constitute statistical confirmation nor does any particular level of probability attach to the synthetic results. Nevertheless, it suggests the possibility of interpreting some of our more complicated estimating equations in terms of smaller structural elements.

---

[12] This transformation involves the following: Assume that the demand equation for domestic sales of all farm products is given by

$$p_d = b_1 q_d + b_2 y, \tag{8}$$

and the demand equation for exports of all farm products is given by

$$p_e = b_3 q_e + b_4 f, \quad \text{where} \tag{9}$$

p_d is an index number of prices of all products sold in the domestic market, p_e is an index number of prices of all products exported, q_d and q_e are domestic consumption and exports respectively, y is domestic income, and f is a measure of foreign demand (under free trade conditions, perhaps, simply the total income of foreign consumers), and all variables are expressed in terms of deviations from their means. Assume that total disappearance $(q_d + q_e = q_t)$ is a predetermined variable. Then the equilibrium price for any given combination of q_t, y and f (assuming that p_e and p_d are approximately equal) is

$$p_t = \frac{b_1 b_3}{b_1 + b_3} q_t + \frac{b_2 b_3}{b_1 + b_3} y + \frac{b_1 b_4}{b_1 + b_3} f. \tag{10}$$

Certain assumptions must be made concerning the relative size of the variables if these assumed coefficients of price and income flexibility are to be translated into equivalent regression coefficients. When this is done, based on averages for the period on which the least-squares analysis was based, substitution of the assumed values in equation (10) yields coefficients that are nearly the same as those obtained from the statistical analysis.

POSTWAR CHANGES IN DEMAND RELATIONSHIPS

Demand-supply structures have been described for a number of major farm products, and results from statistical demand equations based on data for 1922–41—roughly the interwar period—have been presented. Here emphasis is placed on the extent to which the interwar relationships apply to the present and on factors or disturbances that caused prices in the war and immediate postwar years to deviate from those indicated by the analyses.

To the extent that they were effective, price ceilings and rationing distorted the normal relationships between price and consumption from 1942 to 1946. This was true of meats, sugar, butter, other fats and oils, and canned fruits during most of the price-control period. Shortages of red meats affected the demand for competing goods, such as poultry and fish. The shortage of butter affected the demand for margarine. The larger labor force, the greater emphasis upon heavy industry, the longer work week, and other factors, both physical and social, also contributed to disturbances such as a temporary halt in the down-trend of consumption of cereals and potatoes. The boom in "eating out" from 1942 to 1946 was a product of many factors, but it may have caused changes in the demand for food which were not part of the relationships reflected in the 1922–41 analyses.

Prices of some commodities fluctuated freely below price ceilings during most of World War II. In some cases, year-to-year changes in production and price apparently followed the prewar pattern, although the basic level of prices indicated a swollen demand relative to the normal effects of disposable income. But for most livestock products (and many other farm products as well) the 1942–46 data cannot be used *directly* to test the 1922–41 analyses. However, 1922–41 demand equations, supplemented by judgments concerning certain disturbing factors, were used to estimate the *pressures* upon price-ceiling and rationing programs during World War II.

Rationing of most foods was suspended late in 1945, and prices of food were decontrolled in the second half of 1946. It would seem, therefore, that beginning in 1947 the prewar demand-supply structures would again be reflected in the year-to-year movements of food prices and perhaps in their absolute levels as well. The remainder of this section attempts to explain, at least partly, some of the food price and consumption phenomena that occurred from 1947 to 1950.

The removal of price controls in 1946 was followed by 2 years of inflation in prices of both farm and nonfarm products. In August 1948, farm prices of meat animals and dairy products began to decline. This led to substantial Government purchases of dairy products for price support during 1949. In the winter of 1949–50 prices of hogs remained for several weeks within a few cents of the mandatory price-support level.

To most economists, the striking feature about farm prices and incomes in 1947 and 1948 was the extent to which they exceeded any forecasts based on prewar regression analyses. The chief disturbance variables involved, including liquid assets and the backlog demands for housing and durable goods, were recognized but they were generally treated in a qualitative fashion. Nevertheless, the sharp drop in prices of meat animals and dairy products toward the end of 1948 took many

commodity experts by surprise. Then it began to appear that this price movement was a return to (or toward) the prewar regression relationships. But most commodity specialists continued to view their prewar estimating equations with suspicion.

In retrospect, it appears that many were overimpressed by the novel elements in the postwar situation and underestimated the continuity of economic behavior. Many of the postwar price phenomena apparently can be explained if allowance is made for (1) The importance of liquid assets, particularly currency and demand deposits, in the hands of consumers, and (2) the need for more than a single year to adjust to the dramatic increase in prices of food following their decontrol in 1946.

CHANGES IN INCOME-EXPENDITURE RELATIONSHIPS

The reliability of a statistical measurement or explanation depends partly upon the number of independent observations on which it is based. Moreover, if probability statements are to be made about the coefficients obtained, these observations must be drawn from some stable, well-defined population. For many economic relationships, the number of annual observations from 1942 to 1950 that may meet this second condition ranges from 0 to 4 or 5. Consequently, the present section deals with hypotheses some of which cannot be statistically tested. At most it can be shown that such hypotheses are consistent with the observed sequences of events that are to be explained and that they are not inconsistent with other events which might logically be implied by them.

The first major hypothesis is that the demand for food from 1942 to 1948 was considerably strengthened by the unprecedented accumulation of liquid assets in the hands of consumers. In its general form, this statement is widely accepted. However, it is possible to give this hypothesis a more specific and, on certain assumptions, even a quantitative form. The assumption underlying this development is that different types of liquid assets can be roughly equated with different classes of expenditure and savings objectives. Within the limitations of published data, the appropriate distinction is taken to be that between currency and demand deposits on the one hand and time deposits and United States Government securities (mainly "war savings bonds") on the other.

The argument for this hypothesis involves three stages:

It is assumed (1) that time deposits and Government securities did not contribute materially to the postwar inflation in food prices but were earmarked for other purposes, (2) that consumer assets held in the form of currency and demand deposits (over and above some "normal" level) indicated a willingness to spend more freely (relative to disposable income) for almost all current consumption items, including food, and (3) that a part of the currency and demand deposits of consumers, defined as "excess cash reserves," affected current expenditures to the same extent, dollar for dollar, as did an equal amount of current disposable income. The first and second propositions would probably be accepted by most economists; the third, in its specific quantitative form, is somewhat arbitrary.

From 1929 to 1940, 81 percent of the year-to-year variation in the total retail value of food products originating in this country and sold to domestic consumers was associated with changes in disposable income. Estimates based on this analysis were below the actual value in each of the years from 1946 through 1951. Results from this analysis were materially improved by adding an estimate of excess cash reserves held by individuals to the figure for disposable income before using it in the regression equation. A detailed analysis of the effect of excess liquid assets upon expenditures for food also would need to consider the distribution of such assets among income groups.

CHANGES IN CONSUMER DEMAND RELATIONSHIPS

In an intensive analysis for an individual commodity, it would be instructive to interpret each annual price-quantity observation in 1941-51 in terms of (1) the normal effects of supply and demand variables, (2) specific changes in structure (such as the addition of military and Lend-Lease demands in 1942–45), (3) disturbance variables affecting consumer demand, such as excess cash reserves, and (4) the effects of price ceilings, rationing, and other wartime controls. This detailed approach is not attempted here, but a few examples and suggestions are given.

For an analysis of demand for food-livestock products as a group, calculated values from 1941 through 1951 were obtained by adding successive year-to-year changes as estimated from the prewar regression of consumption upon retail price and disposable income. Using disposable income plus excess cash reserves as the demand shifter, the consumption figures thus estimated for 1949 and 1950 were almost identical with actual consumption in 1949 and 1950. However, actual consumption considerably exceeded the regression estimates in 1947 and 1948.

Only once from 1922 to 1941 did per capita consumption of livestock products change as much as 6 percent from one year to the next. But the estimating equation would require a decrease of 7.7 percent from 1945 to 1946, followed by a further decline of 9.0 percent in 1947. A plausible hypothesis is that consumers could not complete such a drastic shift in their demand schedules in so short a time.[13]

As an experiment, the author assumed that the quantity of livestock products demanded by consumers would not change more than 5.5 percent (two standard deviations as measured in 1922–41) between adjacent years, and that any additional changes called for by changes in prices and income would be completed in subsequent years. This assumption results in virtually duplicating the actual year-to-year changes in consumption from 1947 through 1950. Moderate departures from this hypothesis would also be consistent with the observed changes.

A similar 1942–50 projection was made of a prewar demand function for meat. This projection yielded an improbably high peak demand of 187 pounds of meat per capita in 1945 and averaged nearly 15 pounds below actual consumption from 1948 to 1950. The

---

[13] In a general, nonquantitative form this hypothesis has been advanced by other analysts. For example, see Burk (7, especially pp. 292 and 298).

simple lag hypothesis that was applied to food livestock products as a group is not sufficient to account for these discrepancies.

A rough check on the peak level of demand for meat at the controlled prices of 1945 and early 1946 is afforded by actual experience. Consumption of meat reached a peak of 172 pounds per capita (seasonally adjusted) in January–March 1946, the first full quarter after meat rationing was abandoned. Prices of meat continued at the 1945 level during this quarter and supplies were freely available. If the increase in effective demand from 1941 to 1945–46 is distributed over the intervening years, the apparent changes in effective demand average only about half as large as those indicated from the 1922–41 regression equation.

The regression estimates called for a reduction of 32 pounds per capita in the demand for meat from 1946 to 1947—the largest impulse to change experienced in 1922–50. If only half of this is allowed as a normal change, in line with the interpretation of the 1941–46 experience, a demand estimate about 10 pounds lower than actual consumption in 1947 is obtained. The decrease in actual consumption from 1947 to 1948 was greater than the regression estimate and this further supports the hypothesis of a lag in adjustment during 1947.

The behavior of meat consumption in 1941–50 is obviously more difficult to reconcile with prewar experience than consumption of food livestock products as a whole. The "allowable" changes in quantities demanded in the range above 150 pounds per capita seem to be little more than half as large as those indicated by 1922–41 experience, which included a maximum consumption of 146 pounds and averaged considerably below 140 pounds. The apparent movements of effective demand from 1942 through 1947 could be reproduced approximately by cutting each of the regression coefficients to half or three-fifths its prewar value. This would be equivalent to assuming that consumption becomes increasingly resistant to change as it is pushed farther from some established norm or previous record. However, similar results might also be obtained by changing only one or two of the three regression coefficients in the prewar equation, or by changing all three in different ways.

In attempting to extrapolate 1922–41 demand equations through and beyond World War II, one major real variable—excess cash reserves of consumers—has been introduced, as have two special hypotheses. These are (1) that it takes more than a year for adjustments in consumption to unpredecedented changes in prices and income to go into effect, at least for important food groups such as total livestock products or all meat, and (2) that elasticities of demand for some major food groups decrease as consumption moves beyond the range of previous experience. The second hypothesis implies that the demand equation in question is not linear (in terms of logarithms of price and consumption) throughout, although it may be approximately so within the 1922–41 range. The disturbance variable—excess cash reserves—did not operate noticeably before 1942 and its effect may largely have disappeared by 1950. The two hypotheses concern possible normal attributes of consumer demand functions which, however, are observable only under unusual conditions.

Perhaps the greatest change in food consumption patterns between 1941 and 1950 was a 35-percent drop in per capita consumption of

butter. This situation is discussed to illustrate that food habits can change significantly under certain conditions. It involves a true structural change which affects the level of the demand equation and possibly its elasticity as well.

Per capita consumption of butter plus margarine during 1947–50 was about 16 percent lower than in 1935–39. Consumption of wheat flour per capita (representing all domestic food use of wheat) was down almost 15 percent, and consumption of potatoes. sweetpotatoes, and cornmeal was down by even larger percentages. Hence the ratio of consumption of butter plus margarine to that of the principal complementary foods was nearly the same in both periods. But the proportions of butter and margarine in total consumption of spreads had shifted radically.

Table 11 indicates that the increase in consumption of margarine was not due to any change in the relative prices of margarine and butter. Civilian consumption of butter was sharply curtailed in 1943 and was held down by the rationing program until 1946. Supplies of vegetable oils permitted consumption of margarine to increase more than 50 percent above the 1930–42 level. Measured in pounds, the increase in margarine was only a fourth as large as the decrease in butter. Under point rationing, consumption of butter by middle-and-high-income groups was probably reduced more than consumption by lower income groups. Consequently, persons who had been little influenced by relative prices of butter and margarine were driven by point values and the physical shortage of butter to try margarine.

TABLE 11.—*Butter and margarine: Price ratio, and ratio of consumption to consumption of wheat flour, averages 1930–50*

Period	Price ratio [1]	Consumption ratio to wheat flour [2]		
		Butter	Margarine	Total
Average:				
1930–42	2. 19	0. 106	0. 016	0. 122
1943–46	2. 23	. 072	. 025	. 097
1947–50	2. 19	. 078	. 042	. 120

[1] When each is measured in cents per pound at retail, using prices for uncolored margarine before 1950.
[2] When each is measured in pounds, actual product weight.

When rationing and price controls were eliminated in 1946 prices of both butter and margarine shot up. Per capita consumption of butter increased only slightly in 1947, and in 1948 it was below the previous (1946) record low. Consumption of margarine increased some sixty percent from 1946 to 1948. In 1948 the ratio of consumption of margarine to that of wheat flour was about 2¾ times as large as the 1939–42 average. Relative to wheat flour, consumption of butter from 1947 to 1950 was less than three-fourths as great as in 1939–42 and only 8 percent above the average level of the rationing period. Changing price ratios were not a major element in the shift, as relative prices of butter and margarine averaged nearly the same in the three periods.

Major elements involved were: (1) A preferred commodity whose supply was forcibly curtailed; (2) a substitute previously regarded as inferior which could move into the vacuum and which many consumers accepted as an adequate replacement; and (3) a basic price advantage in favor of the substitute product, which in the aggregate offset any tendency of consumers to return to the preferred commodity. The relation between butter and margarine in the last two respects was almost unique among food products. The difference in taste was not as much as between, say, competing meats, fruits or vegetables, and the retail price of butter averaged 2.2 times that of margarine.

The three elements mentioned could perhaps be generalized to other pairs of commodities. The extent of the shift in the demand curve for the preferred commodity would depend on: (1) How much its supply was curtailed in an abnormal period; (2) how long the reduced supply was maintained; (3) how closely the other commodity had competed in normal times, and the extent to which the two differed with respect to taste, texture, and appearance; and (4) the extent of the price advantage (if any) in favor of the substitute commodity after the period of forced curtailment ended. The direction of each influence is obvious.

If a commodity differs greatly from competing commodities, demand may tend to "snap back" to its normal relationship to price and income. This likelihood is increased if the substitute product offers no price advantage. On the other hand, tastes for commodities as dissimilar as coffee, tea, and cocoa might be permanently affected if supplies of one were maintained for a full decade at 50 percent or less of the previous norm.

CHANGES IN MARKETING CHARGES

The preceding discussion was concerned with factors that affected consumer demand for food in the postwar period. Between consumer outlay and farm income lies the food-marketing system. Some of the characteristics of this system were discussed earlier. The present section summarizes the overall changes in marketing charges which occurred from 1942 to 1950.

Table 12 shows the basic data relating to marketing margins for food. The same series exists back to 1913. A salient feature of the longer series is that only once before 1943 did the equivalent farm value of food products exceed the marketing bill. That was in 1918. The farm value of food products had increased 3.3 billion dollars from 1915 to 1918 while marketing charges increased only 1.9 billion. With wartime controls removed, marketing margins shot up by 2.9 billion dollars, or more than 40 percent, in 2 years while returns to farmers increased less than 0.5 billion dollars, or about 5 percent. The 1921 deflation reduced farm returns more than marketing margins. The first year of recovery, 1922, yielded returns to farmers 1.7 billion dollars *lower* than in 1918 and marketing charges 1.4 billion dollars *higher*.

For similar reasons, marketing margins for food were bound to rise with the removal of subsidies and price controls in 1946. Between 1940 and 1945, the farm value of food products increased by 6.8 billion dollars and the retail value by 9.0 billion. So far as effects on con-

sumers were concerned, the national food marketing bill increased by only 2.2 billion dollars. Actual margins, including subsidies to processors, increased by a third from 1940 to 1945 while returns to farmers more than doubled. Evidently the wartime measures to restrain marketing costs and margins had been largely successful. Food marketing agencies as a group were not squeezed as seriously as unit marketing margins suggest. Total returns of food processors were increased because of the heavy production for military and Lend-Lease purposes. Railroads improved their income positions despite controlled freight rates because of an unprecedented volume of freight and passenger traffic, including movements of military equipment and personnel.

TABLE 12.—*Domestic civilian purchases of farm food products: Retail costs, farm value, and marketing charges, United States, 1940-52* [1]

Actual value

Year	Retail	Equivalent farm value	Marketing charge		Subsidy payments to processors
			Apparent	Actual	
	Bil. dol.	*Bil. dol.*	*Bil. dol.*	*Bil. dol.*	*Bil. dol.*
1940	13. 8	5. 6	8. 2	8. 2	
1941	15. 7	7. 0	8. 7	8. 7	
1942	18. 9	9. 1	9. 8	9. 8	
1943	21. 4	11. 1	10. 2	10. 5	0. 3
1944	21. 4	11. 2	10. 1	10. 7	. 6
1945	22. 8	12. 4	10. 4	11. 2	. 8
1946	29. 2	15. 6	13. 6	14. 1	. 5
1947	34. 2	18. 2	15. 9	15. 9	
1948	35. 8	18. 7	17. 1	17. 1	
1949	33. 7	16. 6	17. 0	17. 0	
1950	34. 9	17. 1	17. 8	17. 8	
1951	38. 8	19. 6	19. 1	19. 1	
1952	40. 5	20. 0	20. 5	20. 5	

Change from preceding year

Year	Retail	Equivalent farm value	Marketing charge		Subsidy payments to processors
			Apparent	Actual	
1941	1. 9	1. 4	. 5	. 5	
1942	3. 2	2. 1	1. 1	1. 1	
1943	2. 5	2. 0	. 4	. 7	0. 3
1944	. 0	. 1	—. 1	. 2	. 3
1945	1. 4	1. 2	. 3	. 5	. 2
1946	6. 4	3. 2	3. 2	2. 9	—. 3
1947	5. 0	2. 6	2. 3	1. 8	—. 5
1948	1. 6	. 5	1. 1	1. 2	
1949	—2. 1	—2. 1	—. 1	—. 1	
1950	1. 2	. 5	. 8	. 8	
1951	3. 9	2. 5	1. 3	1. 3	
1952	1. 7	. 4	1. 4	1. 4	

[1] Figures rounded from official estimates of the Bureau of Agricultural Economics. See *The Marketing and Transportation Situation* (35), October 1951, table 4.

By July 1946 most of the special wartime sources of revenue were no longer available. Removal of food subsidies meant that an additional billion dollars of revenue had to be obtained (if at all) from consumers. Freight rates were increased sharply to offset reduced volume as well as increased wage rates and costs of material. Postwar reductions in the length of the work week led to demands for an increase in basic wage rates. The upsurge in prices following decontrol was accompanied by bids for cost-of-living increases in wage rates and the rise in corporate profits left employers generally with little basis for resisting them. Prices of coal, steel, automobiles, and many other products were raised to cover the increases in unit labor costs. Freight rates, wage rates, and administered prices rose step by step.

This movement was general throughout the nonfarm sectors of the economy. The retail cost of food to consumers rose from 22.8 billion dollars in 1945 to 35.8 billion dollars in 1948, an increase of 13.0 billion dollars. Roughly half of the increase went to farmers and half to food processing and marketing agencies. The following year marketing charges remained the same, but returns to farmers declined by 2.1 billion dollars. From 1943 through 1948 returns to farmers exceeded marketing and processing costs; in 29 of 30 years before 1943 and in 3 of 4 years during 1949–52, returns to farmers were less than marketing costs.

In summary, examination of food-marketing margins shows the following: (1) As of 1945 the total food-marketing charges paid by consumers were considerably below their peacetime relationship to the farm value of food products; (2) between 1945 and 1949, food-marketing charges paid by consumers approximately made up their lost ground; (3) from 1946 through 1949 this "reflation" of marketing margins drove a wedge between farm and retail prices of food. The normal short-run relationship during 1922–41 was a 60-cent change in farm value of food products for each dollar change at retail. The average increase in farm value in 1946–49 was only 22 percent of the change in retail value.

The relationship between farm value of food products and disposable personal income was fairly close from 1922 to 1941. Deviations from this relationship in the postwar period are hard to explain unless, as is done here, the factors that affect consumer behavior and the forces at work in the food-marketing system are considered separately. It is apparent that the disturbances in farm-retail price spreads for all food apply also in the marketing-system equations for many individual foods.

CHANGES IN DEMAND AT THE LOCAL MARKET LEVEL

As pointed out earlier, demand at the farm or local market level generally can be treated as a derived demand based on ultimate users' demand less intervening charges. The farm level is a convenient point at which to consider the combined effects of changes in demand in all end uses.

CHANGES IN DEMAND FOR DOMESTIC USE

If data on consumption of food in the last decade are examined, it is evident that the levels of some demand equations have shifted substantially since 1922–41. Per capita consumption of potatoes, cereal

products, and butter has trended downward, quite apart from any normal short-run effects of prices or consumer incomes.   As of 1952, consumption of poultry meat was much above the prewar level, but consumption of red meats was only moderately above the 1922–41 average.   However, these last two situations were reflected to some extent in the relative prices of the two commodity groups, and it is not certain that the demand equations themselves had changed greatly.

Demands for newer products, such as frozen fruits and vegetables, increased rapidly in the last decade.   To some extent frozen products have displaced other forms of these foods but in most cases total demand at the farm level has increased.   The introduction of frozen concentrated orange juice has been very successful, and apparently has increased the total demand for oranges.   At the same time, inventories of canned and frozen juices have become potentially important in influencing the farm price of oranges, and the single equations fitted for 1922–41 may be obsolete for forecasting purposes.

The increased numbers of frozen food lockers and of "deep freeze" units in private homes may also have affected at least the short-run (month-to-month) elasticity of demand for perishable products.   In general. an increase in storage capacity relative to normal production seems likely to make total demand (including storage demand) more elastic, and should moderate the price effects of changes in production. Finally, the growth of television may accelerate changes in food habits as compared with those attributable to other forces and media.   The 1922–41 relationships cannot be used without careful consideration of these new factors.

CHANGES IN DEMAND FOR EXPORT

During 1945 and 1946 the United States exported large quantities of meats, fats and oils, and dairy products, as well as grains, for relief of postwar famine.   Since 1945, exports of grain have continued at high levels relative to prewar.   Exports of cotton and tobacco have approximated prewar levels, and substantial quantities of grain sorghums. soybeans, and inedible tallow and greases have been exported.   Prewar exports of the latter commodities were almost negligible.   A new export-demand equation was introduced into the prewar demand-supply structure for them.

The export market since 1939 has differed from that during the 1920's and 1930's.   The extent of exchange controls, import quotas, and, on the United States side. of loans, gifts, and relief shipments to occupied territories has been so great that statistical demand equations are hardly appropriate to describe the realities involved.   Development of synthetic fibers both here and abroad has altered the demand equation for our cotton in both domestic and export markets. Further study is needed to ascertain the extent to which stabilizing tendencies exist in the export market and whether statistical relationships can be established which will be helpful in the years immediately ahead.

EFFECTS OF PRICE-SUPPORT PROGRAMS

Since 1941, prices of such major storable crops as wheat, corn, cotton, and tobacco have been supported at or near 90 percent of parity. To the extent that Government loan and purchase programs are oper-

ative, this implies that a new demand function is added to the former "free market" structure. If supply exceeds market demand at the support level, prices tend to be stabilized at or near the support price. Prices may decline below the support price in certain months owing to seasonal adjustments reflecting storage costs and changes in quality and operational details of the programs. The effects of price supports upon price forecasts for a single year are obvious. To the extent that market prices rest upon the supports, price rather than consumption becomes a predetermined variable, and regression equations based on these years should take this fact into account. Special provisions relating to support programs for individual commodities may cause additional complications.

ACCURACY OF POSTWAR FORECASTS FROM PREWAR EQUATIONS

Table 13 shows, for some 30 price series, the kind of information that is needed in appraising the applicability of prewar regression analyses to the estimation of postwar changes in price. Column 1 shows, for selected price series, an "error tolerance" equal to two standard errors of estimate from the previously discussed analyses based on data for 1922–41. This has the following approximate significance: If the demand-supply structure represented by a 1922–41 regression equation *and* the probability distribution of disturbances or residual errors still apply, we might expect about 1 actual postwar price in 20 to deviate from that based on the regression equation by more than 2 standard errors of *forecast*, provided the values of the independent variables for the new observation fall within the range established by the values for the years included in the analysis. As the standard error of estimate is always smaller than the standard error of forecast, the error tolerance in column 1 is somewhat too small.

For most livestock products, the increase in retail prices from 1946 to 1947 was much greater than is indicated by the corresponding changes in supply and consumer income. The reasons for this are obvious. Retail prices through June 1946 had been held at 1942–43 levels by price ceilings, in the face of a great increase in consumer income and an unprecedented accumulation of ready cash by private individuals. With the removal of price ceilings in the second half of 1946, prices soared to levels in line with these normal and abnormal demand factors. The other deviations in retail meat prices which exceeded the error tolerance occurred during the postulated "lagged readjustment" period of 1948–49. The error for pork in 1951 may be owing partly to the shortage of beef at ceiling prices.

Retail prices of Choice grade beef in 1952 averaged a shade higher than in 1951 despite a 10-percent increase in per capita consumption of beef. However, prices of beef in 1951 had been held below the free-market level, whereas the increased 1952 supplies had eliminated pressures against price ceilings by the end of the year. Moreover, prices of the lower grades of slaughter cattle dropped sharply from 1951 to 1952, both in absolute level and relative to prices of Choice grade steers. Wholesale prices of Choice steer beef at Chicago dropped 2.46 cents a pound between the 2 years, and Commercial steer beef dropped 6.44 cents. These figures suggest that the overall average retail price for beef (all grades) declined significantly relative to

TABLE 13.—*Selected farm and food products: "Error tolerance" and difference between actual year-to-year price change and estimates from regression equations based on data for 1922–41, United States, 1947–52* [1]

Item	Error tolerance for single observation [2]	Percentage of expected price					
		Difference between actual and estimated change in price					
		1947	1948	1949	1950	1951	1952 [3]
Retail price:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Meat: [4]							
Beef, choice grade	5. 8	[5] 53. 5	[6]— 1. 1	[6]— 6. 5	2. 1	— 3. 7	[6] 11. 7
Pork	6. 0	[5] 28. 2	[6]— 7. 1	[6]— 6. 1	— 4. 1	[6] 7. 6	— 4. 3
Lamb	5. 8	[5] 19. 7	0	— 1. 4	— 3. 6	— 3. 3	[6] 10. 4
All meat	3. 4	[5] 41. 9	[6]— 4. 3	[6]— 7. 1	0	—. 2	[6] 6. 2
Fluid milk and cream	5. 4	[5] 8. 6	[6] 5. 7	— 3. 2	[6]— 6. 2	[6] 8. 9	4. 5
Butter	10. 6	[5] 10. 9	. 9	[6]— 11. 9	— 5. 2	6. 4	4. 4
Market margin relationship: [7]							
Meat animals:							
Cattle, choice grade	13. 8	— 11. 5	— 12. 3	[6] 17. 2	— 12. 3	— 6. 2	— 6. 7
Hogs	24. 8	[8]— 29. 5	— 8. 4	— 6. 2	—. 5	— 4. 7	— 1. 6
Lambs	15. 2	— 4. 7	— 7. 1	— 7. 7	3. 5	— 2. 5	— 4. 7
All meat animals	13. 0	— 12. 9	— v. 7	9. 9	— 9. 4	— 3. 4	— 9. 1
Milk for fluid use	5. 8	1. 2	[6]— 8. 2	— 3. 0	—. 9	[6]— 7. 1	— 4. 0
Butterfat	4. 4	[8]— 17. 6	— 3. 8	—. 2	— 1. 4	— 3. 8	— 2. 7
Farm price:							
Meat animals:							
Cattle	12. 6	[5] 29. 1	[6]— 13. 9	— 6. 2	5. 4	. 9	— 7. 7
Hogs	29. 6	15. 6	— 22. 6	— 15. 9	— 7. 3	9. 1	— 12. 9
Lambs	14. 8	— 9. 4	[6]— 16. 8	[6]— 30. 0	—. 9	— 11. 0	6. 2
All meat animals	15. 8	[5] 25. 0	[6]— 18. 0	— 9. 8	— 1. 4	5. 2	— 10. 7

Milk for fluid use [4]	6.8	6.4	−1.1	[6]−7.3	[6]−8.0	[6]11.7	3.4
Butterfat [4]	14.8	14.3	−13.3	−11.5	−4.3	−5.2	−5.0
Apples	13.4	[6]−33.6	.5	−11.3	−.5	0	[6]17.5
Peaches (excl. California)	33.2	−23.4	−3.4	−16.4	−.2	3.5	16.1
Oranges	28.0	[6]−32.7	8.1	23.9	−10.9	[6]−30.5	--------
Potatoes:							
Based on total production	32.6	[6]−42.2	[6]−39.6	[6]−37.3	−23.3	[6]−38.9	[6]55.6
Based on production less Government purchase	32.6	−2.5	[6]−39.5	−6.0	−32.6	2.6	[6]55.6
Onions	30.4	−7.5	−22.2	−13.9	−21.5	24.5	25.0
Hay	17.2	1.6	10.2	−8.6	−4.5	1.9	6.3
Corn	37.8	7.4	−18.2	17.8	26.2	−10.7	−9.2
Price of other feeds relative to price of corn:							
Sorghum grains	24.6	−9.8	−.5	18.3	−18.0	−1.8	[6]24.7
Oats	22.0	.5	−1.8	−1.8	4.5	−1.8	−3.4
Barley	24.6	5.0	−5.8	−4.7	.2	−1.4	7.2
Price paid by farmers for all feed	10.6	1.2	5.2	6.4	−5.4	7.2	1.2

[1] Supply variables used in the underlying analyses are production unless otherwise noted.

[2] Twice the standard error of estimate. If the real economic relationships and the factors making for residual errors or disturbances are the same as in 1922–41, about 1 actual price in 20 would be expected to deviate from the estimated price by more than 2 standard errors of *forecast*, provided the values of the independent variables for the new observation fall within the range established by the values for the years included in the analysis. The error tolerance as computed is slightly to considerably smaller than this, and deviations of larger size would be expected somewhat more frequently.

[3] Preliminary.

[4] Underlying analyses include per capita consumption as supply variable.

[5] Prices in 1946 averaged materially below free-market levels, because of price controls. Better estimates for 1947 could be obtained by using 1941 (the last prewar observation unaffected by price ceilings) as a point of departure.

[6] Difference greater than the error tolerance shown in column 2.

[7] Basic analyses express farm price (or equivalent farm value) as a function of retail price.

[8] Apparent market margins during the first half of 1946 were held down with the aid of subsidies; hence, farm prices in 1946 were abnormally high relative to retail prices.

the published retail price series which refers to Choice grade only. A more comprehensive retail price series, if available, would be more nearly comparable to the consumption variable for beef and would probably be less affected by shifts in the relative supplies and prices of different grades of beef.

The movement of milk prices in 1950 and 1951 can be attributed partly to the release of price-support stocks of dairy products, which delayed for several months the normal response of prices of dairy products to the increase in demand following the outbreak of hostilities in Korea.

The "market margin relationships" are equations which express the farm prices or equivalent farm values of each product as functions of their retail prices. The 1947 deviations for hogs and butterfat may have been caused partly by the removal of processor subsidies in mid-1946, which resulted in an unusual widening in apparent marketing margins. Even in other years, actual farm prices are predominantly lower than the regression estimates. This probably reflects the continued widening of market margins which persisted even after farm and retail prices of food had started to decline from their postwar peak. Also the coefficients from analyses for which the data were expressed as logarithms (which essentially involve *percentage* relationships) for 1922–41, when the farmers' share of the retail food dollar was relatively low, may involve some distortion in postwar years when the farmers' percentage, particularly for livestock products, was considerably higher.

The behavior of farm prices reflects changes in relationships and new factors that affect both consumer demand and marketing margins. In some cases these reinforce each other; in others they are partially offsetting.

Prices of fruit were high in 1946. The sharp drops into 1947 suggest that demand for inventories of processed fruit may have been important in 1946. This demand was absent, or abnormally low, in 1947. Prices of potatoes based on total production are "out of bounds" in 5 of 6 years. When Government price-support purchases are subtracted, the pattern of deviations is radically changed, and only 2 of the 6 residuals exceed 2 standard errors of estimate. However, the persistence of these two large residuals suggests either that this is not the proper way to adjust for price-support influences or that there may have been real changes in the structure of market demand. Price ceilings on the 1951 potato crop were partly responsible for the unexpectedly large increase in prices for the 1952 crop. The 1951 crop was used up much earlier than usual, and the extreme shortage of storage potatoes in April and May of 1952 created a vacuum (and a speculative atmosphere) which resulted in very high prices during the early months of the 1952 marketing season. By February 1953, prices of 1952 crop potatoes were much below those of a year earlier, as would be expected from the larger production in 1952. Prices of corn, hay, and onions stayed well within bounds in each of the postwar years.

When expressed as functions of the price of corn, prices of oats and barley show perhaps abnormally small variation in price. The stabilizing effects of price supports for these grains, which are set at fairly uniform relationships to the loan rates for corn, may account for this. Prices of sorghum grains in 1952 were unusually high relative to corn.

The sorghum crop was the smallest since 1939 and the corn crop was a near record.

The errors in price estimates shown in table 13 justify more intensive analysis than is found here. Some additional deviations probably could be explained in terms of specific disturbing factors. Year-to-year changes in the signs of successive large residuals might in some cases be traced to fluctuations in inventory demand. More exacting tests could be applied in searching for changes in demand structures. For example, a sequence of 4 or 5 negative deviations of moderate size, as in several of the "market margin relationships," can be shown to indicate that a downward shift in the equation that relates farm to retail prices probably occurred. To show that the prewar model equations still apply, it is necessary not only that the individual residuals be of moderate size but that there be random variations in sign.

On the whole, the prewar regressions for crops appear to have held up very well. Those for livestock products show deviations which are attributable to known disturbing factors, but some of the deviations and patterns may be owing to real changes in structure. Certainly the years shown, which included postwar decontrol, inflation, readjustment, and the partial mobilization and control of 1950–52, constitute an unusually severe trial for any normal forecasting relationships.

LONG-TIME TRENDS IN DEMAND

A study such as this, which concentrates on short-run variations within a recent period, does not in general supply a basis for long-run projections. Pronounced trends in consumption of food have occurred since 1909, when comprehensive estimates began. Trend is still the dominant element in consumption of frozen fruits and vegetables and some canned fruit juices.

Table 14 illustrates the changes that have occurred in consumption of individual foods between 1909 and 1950. Although statistical series beginning before 1909 are limited, food habits continuously evolved and changed during the 19th century. Railroads, refrigeration, and commercial canning made possible major changes in the diets of city people in the latter half of the century. In the first half some agriculturists were deploring the newfangled tendency of northern farmers to sell wheat and buy flour rather than grind the wheat themselves. In the 1850's cookbooks devoted separate sections to summer and winter menus.[14]

Food habits are characteristic of individuals, families, or, at most, of homogeneous social groups. The habits of different groups change at varying rates, depending on many factors. Lower income groups in most communities tend to emulate the food patterns of the more prosperous groups so far as finances permit. In the past, when immigrant groups were sufficiently concentrated to maintain their own community life and standards, their food habits were resistant to change. Migration from farms to cities forced some changes and encouraged others. Changes in food habits have been of interest to nutritionists, social psychologists, and the marketing agencies directly affected.

---

[14] For an account of dietary changes in the United States during the 19th century see Cummings (*9*, chs. 2–6).

Trends in national average consumption of individual foods reflect other factors in addition to *bona fide* changes in food habits. For example, per capita consumption of sweetpotatoes in this country declined more than 30 percent from 1935–39 to 1950. However, nearly half of the sweetpotatoes used in this country for food are consumed on a million or so southern farms. A disproportionate share of the sweetpotatoes sold goes to southern towns and cities, where consumption appears to be highest among families having low incomes. According to the 1948 Bureau of Human Nutrition and Home Economics data for Birmingham (*36*), consumption of sweetpotatoes declines rapidly as family income increases.

According to official estimates of crop disposition, sweetpotatoes used in farm households declined from 25.4 million bushels in 1935–39 to 17.0 million in 1949–50. The quantity sold declined from 25.8 million to 23.7 million bushels. The drop in farm household use has been associated with a substantial reduction in farm population in the South. The effect of this factor should, if possible, be allowed for before an attempt is made to determine the relationship of average consumption in this country to prices of sweetpotatoes and disposable income.

TABLE 14.—*Selected foods: Per capita consumption in the United States, 1909 and 1950*

Commodity	Per capita consumption		
	1909 [1]	1950	1950 as percentage of 1909
	Pounds	*Pounds*	*Percent*
Cheese	3.9	7.7	197
Condensed and evaporated milk	5.4	20.0	370
Ice cream	1.5	16.1	1,073
Nonfat dry milk solids	[2] .2	3.6	1,800
Margarine	1.2	6.1	508
Grapefruit, fresh	.9	8.1	900
Fruits:			
Canned	3.0	20.9	697
Frozen	[3] .2	4.3	2,150
Fruit juices, canned	[4] .5	13.7	2,915
Lettuce	[5] 7.0	16.8	240
Vegetables:			
Canned	15.2	41.8	275
Frozen	[6] .4	3.3	825
Potatoes	193	104	54
Sweetpotatoes	26	12.8	49
Wheat flour	207	133	64
Cornmeal and flour	52.5	13.5	26
Coffee	9.1	16.1	177
Cocoa beans	1.3	4.3	331

[1] Or earliest year for which official estimate is available.
[2] 1920.
[3] 1925.
[4] 1910.
[5] 1918.
[6] 1937.

Similar considerations are involved in explaining trends in the consumption of cornmeal. On the average, per capita consumption of cornmeal in this country declined about 40 percent between 1935–39 and 1950. Use of corn by farm households (mostly custom ground into meal at small local mills) declined from 29.2 million bushels in 1935–39 to 16.7 million in 1949–50. The latter figure amounted to 30 percent or more of all cornmeal consumed in this country.

Of the farm household use of cornmeal in 1949–50, 16.1 million bushels, or 96 percent, was concentrated in the South. In this region 2.1 million farms grew corn in 1944. At present, the number is probably less than 2 millions. Presumably, some of these farms neither grind their own corn nor have it custom ground. Probably a third of all the cornmeal used in our country is consumed on less than 2 million southern farms.

Use of cornmeal by nonfarm people also is concentrated in the South. The 1948 BHNHE survey (36) showed a per capita use of 0.90 pound a week in Birmingham, compared with 0.01 pound in Buffalo and Minneapolis-St. Paul and 0.05 pound in San Francisco. In Birmingham, consumption of cornmeal declined with increasing family income, ranging from 1.40 pounds per person per week in the lowest income group to 0.53 pound for families with incomes above $4,000. This negative relationship to family income indicates the direction in which food habits of the lower income groups are likely to change as their incomes increase.

Many examples of this type could be cited. Back of every major trend in food consumption lies a story of social change, technological development, or popularly held nutritional theories. However, the remainder of this section is limited to some of the more technical considerations regarding the use of trends in statistical analysis of price and consumption.

In either a first-difference or an original-value analysis, trends must be explained on different bases than the regression coefficients between economic variables. Each linear trend as such is perfectly correlated with every other linear trend. If some concrete variable which logically belongs in the analysis can be identified, it should be included. The real variable will not have a time pattern that is *perfectly* smooth, and its first differences will fluctuate. Sometimes a choice between two possible trend variables can be made on the basis of the significance of their respective contributions to the regression analysis as a whole.

The time variable is irreversible. Any projection of this variable is an extrapolation beyond the range of experience reflected in the estimating equation. This is not necessarily true of economic variables such as per capita consumption and price, particularly if the latter is deflated.

If trend is an important part of the explanation in a demand analysis, the size of the multiple correlation coefficient obtained may inspire greater confidence than is justified. The trend itself must be explained before credit can be claimed for the increase in explained variance which is attributed to it.

Trends in real variables, such as population living on southern farms or percentage of consumers owning refrigerators, are relevant to a

discussion of trends in consumption of food, but their separate importance cannot be determined by correlation analysis. Cross-section data, such as family budget studies, sometimes enable us to identify the particular regions or income groups in which consumption of a given product is concentrated. Repeated sample surveys could be designed to trace changes in food habits within relatively homogeneous subgroups. Even so there would remain the problem of explaining the trend for each subgroup in order to justify some simple extrapolation procedure. If the repeated surveys obtained quantitative information on some of the relevant factors, the explanation could be carried further by statistical means.

Carefully designed surveys repeated at appropriate intervals could do much in the future to explain trends, but statistical tests can rarely be applied to discriminate between two real explanations of trends during a past period. The methods used and the deductions based upon them must be chiefly those of the economic historian rather than those of the professional statistician.

LITERATURE CITED

(1) ARMORE, SIDNEY J.
    1953. THE DEMAND AND PRICE STRUCTURE FOR FOOD FATS AND OILS. U. S.
        Dept. Agr. Tech. Bul. 1068, 69 pp., illus.
(2) ———, and BURTIS, EDGAR L.
    1950. FACTORS AFFECTING CONSUMPTION OF FATS AND OILS, OTHER THAN
        BUTTER, IN THE UNITED STATES. U. S. Bur. Agr. Econ., Agr.
        Econ. Research. 2:1–9, illus.
(3) BEAN, LOUIS H.
    1929. A SIMPLIFIED METHOD OF GRAPHIC CURVILINEAR CORRELATION. Amer.
        Statis. Assoc. Jour. 24:386–397, illus.
(4) BENINI, RODOLPHO
    1907. SULL'USO DELLE FORMOLE EMPIRICHE NELL'ECONOMIA APPLICATA.
        Giornale Degli Economisti. 35:1053–1063.
(5) BILKEY, WARREN J.
    1951. THE BASIC RELATIONSHIPS IN CONSUMER EXPENDITURE BEHAVIOR.
        Harvard Univ. Studies in Marketing Farm Products. No. 4–H,
        66 pp., illus.
(6) BREIMYER, HAROLD F.
    1952. FORECASTING ANNUAL CATTLE SLAUGHTER. Jour. Farm Econ. 34:
        392–398.
(7) BURK, MARGUERITE C.
    1951. CHANGES IN THE DEMAND FOR FOOD FROM 1941 TO 1950. Jour.
        Farm Econ. 33:281–298.
(8) COURNOT, AUGUSTIN
    1929. RESEARCHES INTO THE MATHEMATICAL PRINCIPLES OF THE THEORY
        OF WEALTH. First published 1838. Translated 1897 by Na-
        thanel T. Bacon. 213 pp., illus. New York and London.
(9) CUMMINGS, RICHARD OSBORN
    1940. THE AMERICAN AND HIS FOOD. 267 pp., illus. Chicago.
(10) EZEKIEL, MORDECAI
    1930. METHODS OF CORRELATION ANALYSIS. 427 pp., illus. New York.
(11) FOOTE, RICHARD J.
    1953. STATISTICAL ANALYSES RELATING TO THE FEED-LIVESTOCK ECONOMY.
        U. S. Dept. Agr. Tech. Bul. 1070, 41 pp., illus.
(12) FOX, KARL A.
    1951. FACTORS AFFECTING FARM INCOME, FARM PRICES, AND FOOD CONSUMP-
        TION. U. S. Bur. Agr. Econ., Agr. Econ. Research. 3:65–82.

(13) Fox, Karl A.
    1954. STRUCTURAL ANALYSIS AND THE MEASUREMENT OF DEMAND FOR FARM PRODUCTS. Review Econ. and Statis. Vol. 36. [In press.]

(14) Foytik, Jerry
    1951. CHARACTERISTICS OF DEMAND FOR CALIFORNIA PLUMS. Hilgardia. 20 : 407–527, illus.

(15) Frisch, Ragnar
    1928. CORRELATION AND SCATTER IN STATISTICAL VARIABLES. Nordic Statis. Jour. 1 : 36–102.

(16) ———
    1934. STATISTICAL CONFLUENCE ANALYSIS BY MEANS OF COMPLETE REGRESSION SYSTEMS. 192 pp. Oslo.

(17) Girshick, Meyer A., and Haavelmo, Trygve
    1947. STATISTICAL ANALYSIS OF THE DEMAND FOR FOOD: EXAMPLES OF SIMULTANEOUS ESTIMATION OF STRUCTURAL EQUATIONS. Econometrica. 15 : 79–111.

(18) Haavelmo, Trygve
    1943. THE STATISTICAL IMPLICATIONS OF A SYSTEM OF SIMULTANEOUS EQUATIONS. Econometrica. 11 : 1–12.

(19) Johnson, Glenn L.
    1952. BURLEY TOBACCO CONTROL PROGRAMS. THEIR OVER-ALL EFFECT ON PRODUCTION AND PRICES, 1933–50. Ky. Agr. Expt. Sta. Bul. 580, 112 pp., illus.

(20) Klein, Lawrence R.
    1950. ECONOMIC FLUCTUATIONS IN THE UNITED STATES, 1921–1941. Cowles Commission for Research in Economics Monograph 11, 174 pp.

(21) Koopmans, Tjalling
    1945. STATISTICAL ESTIMATION OF SIMULTANEOUS ECONOMIC RELATIONS. Amer. Statis. Assoc. Jour. 40 : 448–466.

(22) ———, editor
    1950. STATISTICAL INFERENCE IN DYNAMIC MODELS. Cowles Commission for Research in Economics Monograph 10, 438 pp.

(23) Kuznets, George M., and Klein, Lawrence R.
    1943. A STATISTICAL ANALYSIS OF THE DOMESTIC DEMAND FOR LEMONS, 1921–1941. Giannini Found. Agr. Econ. Rept. 84, 112 pp., illus. [Processed.]

(24) Lowenstein, Frank
    1952. FACTORS AFFECTING THE DOMESTIC MILL CONSUMPTION OF COTTON. U. S. Bur. Agr. Econ., Agr. Econ. Research. 4 : 44–51, illus.

(25) McCallister, Kenneth J., Poats, Frederick J., and Jones, Mary Winston
    1952. RETAIL MARKET NEWS AS AN AID IN MARKETING. U. S. Dept. Agr. Marketing Research Rept. 19, 92 pp., illus. (Processed.)

(26) Meinken, Kenneth W.
    1953. THE DEMAND AND PRICE STRUCTURE FOR OATS, BARLEY, AND SORGHUM GRAINS. U. S. Dept. Agr. Tech. Bul. 1080. 103 pp., illus.

(27) Moore, Henry L.
    1914. ECONOMIC CYCLES: THEIR LAW AND CAUSE. 149 pp., illus. New York.

(28) ———
    1917. FORECASTING THE YIELD AND PRICE OF COTTON. 173 pp., illus. New York.

(29) Prest, A. R.
    1949. SOME EXPERIMENTS IN DEMAND ANALYSIS. Review Econ. and Statis. 31 : 34–49.

(30) Schultz, Henry
    1928. STATISTICAL LAWS OF DEMAND AND SUPPLY, WITH SPECIAL APPLICATION TO SUGAR. 228 pp., illus. Chicago.

(31) ———
    1930. THE STANDARD ERROR OF A FORECAST FROM A CURVE. Amer. Statis. Assoc. Jour. 25 : 139–185.

(32) ———
    1938. THE THEORY AND MEASUREMENT OF DEMAND. 817 pp., illus. Chicago.

(33) STONE, RICHARD
      1945. THE ANALYSIS OF MARKET DEMAND.   Royal Statis. Soc. Jour.   108:
            286–382, illus.
(34) TINBERGEN, J.
      1939. STATISTICAL TESTING OF BUSINESS-CYCLE THEORIES.   VOL. I. A METHOD
             AND ITS APPLICATION TO INVESTMENT ACTIVITY.   164 pp., illus.
             Geneva, League of Nation's Economic Intelligence Service.
(35) UNITED STATES BUREAU OF AGRICULTURAL ECONOMICS
      1953. MARKETING AND TRANSPORTATION SITUATION.   Washington, D. C.
            [Processed.] and earlier issues.
(36) UNITED STATES BUREAU OF HUMAN NUTRITION AND HOME ECONOMICS
      1949. FAMILY FOOD CONSUMPTION IN FOUR CITIES, WINTER 1948, A SUMMARY
             REPORT, BIRMINGHAM, ALABAMA, BUFFALO, NEW YORK, MINNE-
             APOLIS-ST. PAUL, MINNESOTA, SAN FRANCISCO, CALIFORNIA.   1948
             Food Consumption Surveys Prel. Rept. 7, 25 pp.   [Processed.]
(37) WORKING, ELMER
      1927. WHAT DO STATISTICAL "DEMAND CURVES" SHOW?   Quart. Jour. Econ.
             41 : 212–235, illus.
(38) WORKING, HOLBROOK
      1925. THE STATISTICAL DETERMINATION OF DEMAND CURVES.   Quart. Jour.
             Econ.   39 : 503–543.
(39) ———, and HOTELLING, HAROLD
      1929. THE APPLICATION OF THE THEORY OF ERROR TO THE INTERPRETATION
             OF TRENDS.   Amer. Statis. Assoc. Jour.   24 : 73–85.

END