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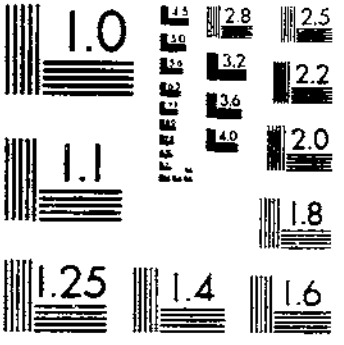
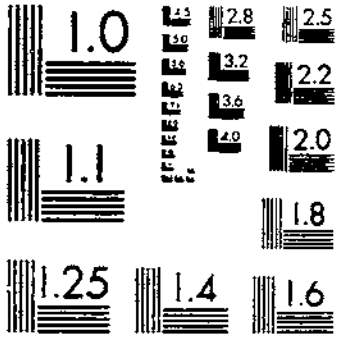


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



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

Preface

Various legislative and economic groups concerned with agricultural policy have long been interested in the relation between charges for marketing farm foods and payments to the farmer-producer for his products. A marked decline in these payments relative to consumer expenditures for farm-originated foods since World War II has focused attention on the need for additional information to analyze past and future trends in factors underlying changes in marketing costs.

The demand relations estimated in this report were developed as part of a larger investigation of factors affecting demand, supply, and productivity for food marketing services. Insight into factors affecting the demand for food manufacturers' services compared with those affecting the demand for farm products will help explain the continuing decline of the farm share of consumer expenditures for foods. A major objective of this investigation is to develop long-range projections on the agricultural food marketing bill which will supplement Department of Agriculture long-range projections on the demand for and output of food products.

Processing costs for the food products included in this study accounted for about $11 billion in 1961 roughly one-fourth of the total farm food marketing bill. This percentage has remained fairly constant during the last four decades. This is the third report related to the investigation of output and utilization of resources in factory processing of farm food products. The first report was "Output of Factories Processing Farm Food Products in the United States, 1909-58," Technical Bulletin No. 1223, the second, "Output per Man-Hour in Factories Processing Farm Food Products," Technical Bulletin No. 1243. Additional studies will be reported as they are completed.

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December 1964

Summary

From the end of World War I to the late 1950's, the period covered in this report, U.S. civilian consumption of manufactured farm foods grew at a substantially faster rate than consumption of all farm food products. This resulted from the increased consumption of processed foods by households and, perhaps more important, a shift from home to factory processing.

This study uses a simple econometric model to explain the behavior of households contributing to this trend. Three demand relations associated with household consumption of processed food products are estimated. They are: (1) A demand relation facing farm food manufacturers for processed foods; (2) a demand relation facing farm food manufacturers for their services; and (3) a demand relation facing farmers for farm products for processing.

A major finding of the analysis is that the demand of households for factory processing services increased between two and three times as fast as the demand for farm food products during the period studied. Of all the variables that might have shifted the demand curves, real per capita income was the only empirically significant one. Therefore, estimated income elasticities can be used to compare the relative increases in the demand curves over the four decades.

The estimated income elasticity for food manufacturers' services was 0.80; for farm food products used in manufacturing, 0.35; and for manufactured food products, 0.57. The income elasticity for manufactured foods is approximately the weighted sum of the income elasticity for farm products and for manufacturers' services.

The estimated income elasticities overstate the "true" theoretical income elasticities because they reflect a secular increase in the opportunity costs of the housewife's time spent in home processing. That is, they reflect a substitution (price) effect as well as the true income effect. The most we can say with available data about the theoretical income elasticity for processing services is that it is probably less than unity, and, with more certainty, no larger than unity.

Another major finding is that household purchases of factory processing services responded about as much to changes in the price of these services as they did to changes in income. The estimated limits for the price elasticity for factory processing services are —0.79 (using quantity as the dependent variable) and —1.68 (using price as the dependent variable). These estimated limits, based on the least-squares method, bracket the theoretical price elasticity with respect to the two sources of least-squares bias (the "simultaneous equations" effect and errors of observation in the independent variables). Taking into account biases in the estimates due to errors in the data, households may have even responded more to changes in price than in income. By comparison, the estimated limits for the price elasticity for farm food products are —0.09 and —0.44. The estimated limits for manufactured foods are —0.12 and —0.72.

The strength of the price effect is not surprising. The household demand for factory processing services is a residual demand. It is the difference between the household's consumption demand for processing services (broadly defined to include home produced as well as purchased services), and its own supply of services. Thus, a decrease in the factory price of services will induce households to consume more processing services and to substitute factory for home processing. Technically, the "observed" residual demand elasticity is a magnified sum of the household's demand and supply elasticities.

There is no indication that the income and price elasticities changed significantly between the pre- and post-World War II years. Also, there was no indication of a lag in the response of households to changes in income and prices that was longer than a year. Households apparently adjust their "actual" consumption levels for food and processing services to "intended" levels within a year.

Finally, the study includes experiments with an "expected" income series based on the concept of an average economic horizon for all categories of consumption. On the whole, the results show that the use of such an average expected income series is inappropriate for the foods and services included in this study. The results indicate that even if an expected income series were constructed specifically for food it would probably not significantly affect the magnitude of the income elasticities based on the usual "measured" income series. It would therefore not affect agriculture policy considerations implied by the estimated size of the income elasticity.

DEMAND FOR MANUFACTURED FOODS, MANUFACTURERS' SERVICES, AND FARM PRODUCTS IN FOOD MANUFACTURING—A STATISTICAL ANALYSIS

By William H. Waldorf, Economist, Marketing Economics Division, Economic Research Service

Introduction

Since at least the turn of this century, the earliest period for which data are available, household consumption of foods originating on U.S. farms has included an increasing proportion of food manufacturers' services. Consequently, the farm share of manufactured foods, after allowing for price changes, has shown a secular decline. This trend reflects both an increase in consumption of processed foods and, as has been commonly observed, a shift from household to factory processing.

This study employs a simple econometric model to explain household behavior contributing to this trend. More specifically, it estimates three demand relations associated with domestic civilian consumption of processed farm food products: (1) A demand relation facing manufacturers for total manufactured farm foods; (2) a demand relation facing manufacturers for total food manufacturers' services; and (3) a demand relation facing farmers for total farm products consumed in food manufacturing.

Primary interest in this study is in (2); relations (1) and (3) contribute additional evidence about (2) and also help to "round out" the study. Originally, attempts were also made to estimate similar demand relations for individual foods; but, because of data problems the present study was limited to the total; work on individual foods was postponed for future studies. Table 1 indicates that there was some change in the product mix between 1919 and 1958. For purposes of this study, the change was apparently not large enough to significantly affect this estimated income elasticity for the total.[1]

The empirical part of the study generates an interesting if unfortunate byproduct. The measure of food manufacturers' services is based mainly on Bureau of Census data on value added by food manufactures adjusted for price changes, so-called double-deflated value added.[2] This series is particularly sensitive to measurement errors

[1] Using income elasticities by commodity group estimated by Clark from household survey data (*11*), the estimated income elasticity for the aggregate based on the 1958 weights shown in table 1 was less than 2 percentage points (or 10 percent) larger than the aggregate estimate using the 1919 weights. (Italic numbers in parentheses refer to items in Literature Cited, p. 33.)

[2] Ideally, the quantity and price series for food manufacturers' services should include factory processing services only; actually the time series based on census data also reflect some distribution services performed by food manufacturers. For detailed description and analysis of the data, see Appendix C.

TABLE 1.— *Distribution of manufactured foods processed from U.S. farm products, in 1947–49 prices, 1919 and 1958*

Commodity group	1919	1958
	Percent	*Percent*
Meats [1]	42. 1	38. 9
Manufactured dairy products [2]	11. 8	12. 8
Processed fruits and vegetables [3]	4. 3	14. 4
Grain mill and cereal products [4]	12. 3	6. 5
Bakery products [5]	12. 4	12. 8
Sugar and confectionery [6]	9. 5	6. 2
Miscellaneous foods [7]	7. 6	8. 4
Total	100. 0	100. 0

[1] Includes beef, pork, veal, mutton and lamb, and prepared meat products; excludes poultry.
[2] Includes creamery butter, natural cheese, concentrated milk, ice cream and ices, and special dairy products; excludes fluid milk and cream.
[3] Includes canned fruits and vegetables, dehydrated fruits and vegetables, pickles and sauces, frozen fruits and vegetables, and canned specialties.
[4] Includes flour, meal, cereal products, rice, and blended and prepared flour.
[5] Includes breads, rolls, pastries, pies, biscuits, and crackers.
[6] Includes sugar manufactured from domestically grown sugarcane and beet sugar, and candy and other confections.
[7] Includes leavening compounds, shortening and cooking oils, margarine, corn products, flavorings, macaroni and spaghetti, and peanut butter.

Source: See Appendix C, p. 44.

in the data, and it was necessary to carry out a number of experiments in order to estimate limits for the parameters with respect to these errors. It appears that measuring double-deflated value added yields some of the best evidence available on the alleged existence of measurement errors in Bureau of Labor Statistics wholesale prices (*37*).

Previous Studies

As far as I know, there have been no previous attempts to estimate a demand relation for food manufacturers' services, which probably can be explained by the intractability of the data. In fact, the most novel part of this study is the attempt to estimate the responsiveness of household purchases of food manufacturers' services to changes in prices of these services. Also, the statistical analysis of the other two demand relations is the most comprehensive attempt I know to estimate these relations.

Louis Fourt (*16*) as part of his broad study of empirical income elasticities for food and its component values estimated a demand relation for total manufactured foods (including foods not originating on U.S. farms) and income elasticities for food manufacturers' services. Using quantity as the dependent variable and total consumption as a proxy for Friedman's concept of permanent income, Fourt's estimates of the price and income elasticities for manufactured foods for the years 1929–41 and 1946–54 are 0.38 and 0.94, respectively. His estimates of the income elasticities for 'processors' own inputs" [income originating] and "processors' nonfarm purchases" [including transportation and assembly] are 1.17 and 1.20, respectively. Fourt concluded that "Services purchased by manufacturers are *not* more

elastic than other portions of the food marketing sector. On the other hand, neither are processors' own inputs" (*16*, p. 95). His estimate of the income elasticity for total farm-food marketing services (including distribution as well as processing services) was 1.42.[3]

Besides Fourt's study, there have been other econometric attempts to explain the historic decline in the farm share of consumer expenditures for farm originated foods. If we assume effective consumer choice in purchasing farm-food marketing services, then there is a simple hypothesis to explain this trend: The income elasticity for marketing services is larger than the income elasticity for the basic farm product ingredients, given only minor restrictions on relative prices. Fourt (*16*), Bunkers and Cochrane (*8*), Burk (*9*), Daly (*12*), and Schultz (*44*) have all estimated income elasticities from time series for total farm-food marketing services and for farm food products in order to test this hypothesis. Despite differences in their estimated income elasticities (which range from 0.72 to 1.42), they have all come to the same conclusion - the income elasticity for food marketing services is larger than that for farm food products.[4]

Essentially, the same hypothesis can be employed to explain the trend originally pointed out in this study. The problem is that neither the income elasticities estimated in this study nor those estimated by the other researchers can be used to test this hypothesis. Conceptually, this study and the others (at least, implicitly) view the household as both a consumption and a production unit. Time series, however, are not available to capture the effects of changes in efficiency of a household on its purchases of marketing services. Theoretical and empirical considerations indicate that the estimated income elasticities are probably biased upwards because of this specification error. The best we can do with available data is estimate an upper limit for the true income elasticity with respect to this specification bias. Since factors affecting household efficiency in food processing are demand shifters, we tested a weaker hypothesis to explain the historic decline in the farm share of manufactured foods: The demand for food manufacturers' services increased more than the demand for farm products.

Mincer (*34*) and Becker (*2*) have pointed out and generalized this class of specification bias. Applied to our problem, they show the need to consider opportunity costs (foregone wages) of nonworking time in studies of household demand. Omitting opportunity costs in household demand studies tends to bias the estimated parameters. An implication of Becker's theoretical analysis is that an increase in wage rates relative to market prices will increase the incentive to economize time relative to market goods. In terms of this study, the incentive will be to substitute commercial processing for household processing. Accordingly, the income elasticities estimated by Fourt

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[3] The marketing bill measures the difference between consumer expenditures for farm products and payments received by farmers for equivalent quantities of produce. Thus, as used in this study, total marketing includes processing and distributing agricultural products from farms on which they are produced to households.

[4] There is no need to extensively review these studies here; this has already been done by Fourt. Our principal interest in these studies is to help place this study in the perspective of the other research in this area. Conceptually, the empirical results in this study for food manufacturers' services are most comparable with those by Bunkers and Cochrane.

and the other researchers, as well as those in this study, may be biased: They may reflect a price (substitution) effect as well as an income effect. The theoretical analysis in this study is in terms of a household supply function for food processing services which includes considerations of opportunity costs of housework, household productivity, and other factors affecting supply conditions.[6]

The Model

Theoretical Considerations

The household's market demand for food processing services is a residual demand. Viewed as a consumption unit with a utility function and an income constraint, the household has a consumer demand function for food processing services broadly defined to include home as well as market services. If we assume that processing services are normal goods, then a decrease in the price of a service will result in a consumer substitution toward the service, income and other prices constant; an increase in income, prices constant, will increase the demand for the service. Viewed as a production unit, the household is a supplier of food processing services. At a given market price for a service, part of the quantity demanded is supplied by the household itself. The difference between the consumer demand and the household supply of a service is the household's market demand. Thus, given the household demand function for food processing services, broadly defined, and the household supply conditions for food processing services, a decrease in the market price of food processing services will induce the household as a consumer unit to substitute food processing services for other goods and services; and, as a production unit, to substitute between commercial and home processing.

The household's market demand for food processing services, therefore, includes not only the income and price variables in the consumer demand function but also the variables in the household's supply function. The household supply of food processing services depends on the household production function, opportunity costs of the housewife's time used in food processing, prices and depreciation rates of home appliances, interest rates on consumer credit, wages of domestics, and other factors. Improvements in productivity resulting from economies of scale and better technology, decreases in prices of appliances, or a decrease in the interest rate on consumer credit will tend to increase the household supply of food processing services; and, consequently, decrease the household's market demand for these services. More job opportunities and higher real wages for women in the market mean an increase in opportunity costs of the housewives' time spent in home processing. An increase in opportunity costs tends to decrease the supply of household processing; and, hence, increase the market demand for these services.

[6] Unfortunately, the papers by Mincer and Becker came to my attention too late to receive the consideration they deserve. Becker's theoretical analysis looks particularly promising for future research in marketing beyond the scope of the present study.

Besides the literature cited in the text, there is also extensive related literature by home economists on how much the housewife earns per hour by baking her own bread, and so on; for a review of some of this literature, see Reid (*42*); for an early consideration of the role of opportunity costs in household production, see Reid (*41*).

Mincer (*85*) has also pointed out the relation between the family demand for leisure and its market demand for services. One way in which the family as a unit can increase its consumption of leisure is by purchasing food processing services instead of doing its own processing. If we assume that leisure is a normal good, and thus a positive leisure-income relation, then an increase in income will tend to increase the market demand for food processing services.

The Econometric Model

If it is assumed that the household has an effective choice among foods in processed and unprocessed form, then the household demand for manufactured farm foods is essentially the sum of its demand for the basic food ingredients and its demand for factory processing services. Because of data problems, none of the three relations are measured at the household (retail) level. The first two are demand relations facing food manufacturers, and the third is a demand relation facing farmers. Each was derived from a household market demand function, a supply function for the intermediate food marketing sector(s), and a derived demand function for the particular goods or services. This means that the income and price elasticities in the three "reduced form" relations reflect not only household behavior but also behavior and technology of firms in the intermediate stages of marketing the goods and services. The derivation of the reduced form relations and formulas showing the relationship between the coefficients in the household market demand functions and in the reduced form relations are discussed in Appendix A.

The three (reduced form) demand relations estimated in the empirical part of the study, assuming complete adjustment within the observation period, are

(1) $X_{mt} = F_1 (P_{mt}, P_{st}, P_{ft}, \ldots; Z_t \ldots; Y_t; T; u_{1t})$ Demand for manufactured foods

(2) $X_{st} = F_2 (P_{st}, P_{mt}, P_{ft}, P_{ft} \ldots; Z_t \ldots; Y_t; T; u_{2t})$ Demand for food manufacturers' services

(3) $X_{ft} = F_3 (P_{ft}, P_{mt}, P_{ft}, P_{st} \ldots; Z_t \ldots; Y_t; T; u_{3t})$ Demand for farm products consumed in food manufacturing

where,

X_{mt} = per capita domestic civilian consumption of manufactured farm foods (measured at the factory level).

X_{st} = per capita domestic civilian consumption of manufacturers' services related to farm food products (measured at the factory level).

X_{ft} = per capita domestic civilian consumption of farm food products consumed in food manufacturing (measured at the farm level).

P_{mt} = price of manufactured farm foods (at the factory level) deflated by retail prices of other consumer goods and services.

P_{st} = price of food manufacturers' services (at the factory level) deflated by prices of other consumer goods and services.

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P_{fi} = price of farm food products (at the farm level) consumed in food manufacturing deflated by prices of other consumer goods and services.

P_{di} = wholesale-retail price spread for manufactured farm foods, deflated by prices of other consumer goods and services.

P_{ei} = farm-retail price spread for manufactured farm foods deflated by prices of other consumer goods and services.

P_{ri} = retail price of fresh fruits and vegetables deflated by prices of other consumer goods and services.

Y_i = real per capita income.

Z_i = per capita consumption of farm foods processed on farms.

T = trend (1919 = 1).

u_{ri} = disturbance term attached to i^{th} equation.

Based on graphic analysis and the usual desire for simplicity, it is assumed that elasticities with respect to all of the variables except T are constant, and that the trend is exponential. That is, the three reduced forms are assumed linear in the logarithms of all the variables except T.[6] We can limit the discussion to equation (2); essentially the same reasoning applies to the other two equations.

The econometric model includes only empirically manageable variables; and, unfortunately, there are no variables to capture changes in the economic efficiency of household processing. The estimated price and income elasticities reflect substitution between home and factory processing services as well as substitution and income effects derived from the pure theory of consumption. The price elasticity using equation (2) is obtained from a household demand function which, as was pointed out in the theoretical discussion, is a residual demand. It reflects underlying consumer demand and household supply elasticities for food processing services. If we assume a negative consumer demand elasticity and a positive household supply elasticity, then the treatment of the household demand for food processing services as a residual demand implies that the price elasticity in demand relation (2) is a magnified sum of the two basic elasticities.[7] That is, the estimated price elasticity using relation (2) can be expected to be greater in absolute value than the basic consumer demand elasticity.

The theoretical considerations imply that the income elasticity using equation (2) reflects both the services-income relation in the consumer demand relation for food processing services, broadly defined, and the leisure-income relation. These both imply a positive income elasticity, assuming leisure and processing services are normal goods in consumption. Long's data (*31*) on wage rates of married

[6] The use of reduced forms which are linear in the logarithms of the variables assumes that the household demand, industry supply, and derived demand relations which underlie the reduced forms are also linear in the logarithms of the variables. This form for the supply and derived demand relations is consistent with a Cobb-Douglas production function in food manufacturing. In measuring Engel curves from family budget data, there appears to be an empirical basis for preferring an equation which is linear in the logarithms; see, Prais and Houthakker (*30*). Lewis and Douglas (*30*) show that in linear Engel curves, income elasticities tend to unity as income increases.

[7] The estimated price elasticity in the residual household demand relation for food processing services is $\epsilon_h = \lambda\epsilon_c + (\lambda - 1)\epsilon_s$ where ϵ_h is the residual demand elasticity, ϵ_c is the elasticity of consumer demand, and ϵ_s is the elasticity of household supply, all in absolute values. λ is the reciprocal of the fraction of purchased services to total services consumed.

women in the labor force indicate that the housewife's opportunity cost has been positively correlated with real per capita income, Y_t, during most of the period studied. For all the reasons outlined by Mitchell (*30*), there is a strong presumption that productivity gains in the household have been smaller than those in the commercial sector. These two historical movements imply that the income elasticity estimated using relation (2) will probably reflect a substitution between home and factory food processing services. The upward bias imparted to the estimated income elasticity because of this specification error depends on the degree of correlation between the housewife's opportunity cost and income and on the importance of opportunity costs as a supply shifter in household processing. Stated another way, the income variable, Y_t, is probably also a proxy for opportunity cost of the housewife's labor used in home processing.

Turning to the other variables in equation (2), the household's market demand for food processing services may increase because the retail price of the processed product is less than the retail price of its fresh (or less processed) counterpart. This might occur because higher costs of processing are more than offset by lower costs of distributing the processed product (1). The retail price of fresh fruits and vegetables, P_{rt}, is used in an attempt to test the empirical significance of this factor. During the period studied, fruits and vegetables were the most important food products available to households in both fresh and processed form, and there was a substantial upward trend in the percentage of fruits and vegetables purchased in processed form. The elasticity with respect to P_{rt} should be positive.

For given income and prices, farm families do more home processing than nonfarm families. Therefore, a movement of families off farms will increase the demand for factory processing services. Besides processing foods for home consumption, farmers also process food for direct off-farm sale. A decrease in the price of factory processing relative to farm processing will induce farm and nonfarm households to shift to factory processed foods. The variable Z_t, per capita consumption of farm foods processed on farms, is an attempt to capture the combined effects of the demographic factor and the changes in relative prices between factory and farm processing. The partial elasticity with respect to Z_t should be negative; if the partial elasticity is not significantly different, statistically, from zero, we can conclude that the estimated price and income elasticities were not significantly affected by the movement of families off farms or changes in supply conditions for on-farm processing services.[5]

The price spread variable, P_{dt}, appears in equation (2) [and equation (1)] because the reduced form measures the demand at the factory level—not at the household level. Conceptually, the parameters in equation (2) reflect the behavior and techniques of production of firms distributing manufactured foods. The price spread variable, P_{dt}, is included to test whether changes in the behavior and techniques of production in food distribution significantly affected the demand for food manufacturers' services during the period studied. Theoretically, we require a price variable for food distribution services; the

[5] An analysis of the effect of the historic movement of families off farms based on household survey data is contained in Appendix B. There are no satisfactory data to gage the effect of changes in the distribution sector as a competing supplier of food processing services; however, the evidence available suggests that it was not empirically significant during the period studied (p. 45).

price spread actually reflects both changes in prices of distribution services and changes in the amount of distribution services per unit of goods distributed. However, we can treat the spread, P_{dt}, as a proxy for the "true" price series since they are probably highly correlated. Thus, if the estimated elasticity with respect to P_{dt} is not significantly different from zero, we can conclude that we have probably not omitted a variable which affected X_{ft} through the retail price but not through the wholesale price or other variables included in (2). As shown in Appendix A, the estimated price and income elasticities in the reduced form equations are (in absolute value) less than or equal to those that would be estimated at the retail level. If P_{dt} is not empirically significant, then we can conclude that the estimated income elasticity in the reduced form is not significantly different than that which would be estimated at the retail level.[9]

Changes in family size and composition, can also affect the demand for factory processing services. These demographic factors are not formally included in the econometric model because of lack of adequate time series. They are, however, discussed in Appendix B, where household survey data were employed in order to judge whether changes in household size and composition could have significantly affected consumption of manufactured farm foods during the period studied.

Model With Incomplete Adjustment

Demand relations (1), (2), and (3) are derived from a static model and assume that households and marketing firms adjust their actual purchases to desired or intended purchases within the period of observation. Since the estimated demand relations in this study are mainly based on annual data, this assumes that the adjustments to intended levels are completed within a year. A host of technological, institutional, and psychological rigidities (habits) can readily be enumerated for hypothesizing that adjustment is not "instantaneous" (*33*). Nerlove (*38*, *39*) in his work on consumer demand for food in the United States and in the United Kingdom found that complete adjustment requires more than a year.

This study employs the same simple lag model in order to test whether the lag between intended and actual consumption of manufactured farm foods, food manufacturers' services, and farm products consumed in food manufacturing is longer than a year. The adjustment equation in logarithms for the demand for manufactured farm foods is:

$$(4)\quad \log X_{mt} - \log X_{mt-1} = \delta\,[\log X^*_{mt} - \log X_{mt-1}]$$

where X^*_{mt} is the intended or long-run rate of consumption and X_{mt} and X_{mt-1} are the actual rates of consumption in the current and preceding year. The elasticity of adjustment is δ where $0 \leqq \delta \leqq 1$.

If we interpret the dependent variable in equation (1) as the intended rate of consumption of manufactured farm foods, (remem-

[9] The analysis in Appendix A was demonstrated only for equation (1), but it also applies to equation (2) and to equation (3) where the farm retail price spread, P_{rt}, is used.

bering that (1) is assumed linear in the logarithms, and omitting the trend variable), the equation is:

$$(5)\quad \log X^*_{mt} = \alpha_0 + \alpha_1 \log P_{mt} + \alpha_2 \log P_{rt} + \alpha_3 \log P_{at} + \alpha_4 \log Z_t + \alpha_5 \log Y_t + u_{1t}$$

Solving (4) and (5) simultaneously to eliminate X^*_{mt}:

$$(6)\quad \log X_{mt} = \alpha_0 + \alpha_1\delta \log P_{mt} + \alpha_2\delta \log P_{rt} + \alpha_3\delta \log P_{at} + \alpha_4\delta \log Z_t + \alpha_5\delta \log Y_t + (1-\delta) \log X_{mt-1} + \delta u_{1t}$$

The estimated elasticity or adjustment, $\hat{\delta}$, is obtained by subtracting the estimated coefficient of X_{mt-1} from unity. The estimated long run elasticities with respect to each variable are derived by dividing the estimated coefficients in (6) by the estimated elasticity of adjustment.

The adjustment equation (4) is undoubtedly too simple. But it is better to test the hypothesis that adjustment is completed within a year than to simply assume it. Brandow (*6*) and Griliches (*21*, *22*) have both pointed out severe pitfalls in estimating the elasticity of adjustment.

Expected Income

The statistical analyses are based on the usual concept of per capita real disposable income; that is, on a concept of measured income. The study also includes experiments with an expected income series which is an empirical approximation of Friedman's permanent income concept. This series attempts to estimate a "normal" or intended income level to which households adjust their consumption. The expected income series is a weighted moving average of the per capita real personal disposable income series. The weights are those published by Friedman (*18*, p. 147), and are for an empirical approximation of permanent income related to *total* consumption.

Using Friedman's weights assumes that the time horizon for total consumption is, in some sense, an average of the time horizons for different categories of consumption. Obviously, this need not be the case. As Friedman himself points out (*18*, pp. 207–208):

> One possible source of difficulty with this approach is the necessity of taking permanent income to mean the same thing for the different categories of consumption. We have interpreted the exact meaning of permanent income in terms of the horizon of the consumer unit. Now there seems to be no reason why the horizon should be the same for all individual categories of consumption and some reasons why it should differ systematically. For example, it seems highly plausible that housing expenditures are planned in terms of a longer horizon, and so a different concept of permanent income, than expenditures on, say, food. If this turns out to be a meaningful way of looking at the problem, the concept of permanent income applicable to total consumption will have to be regarded as an average of the concepts applicable to each category and our roughly estimated horizon of three years, as an average of shorter and longer horizons.

Friedman further conjectured "whether this difficulty will in practice turn out to be serious or whether, on the contrary, the use of the same concept of permanent income for all categories will yield acceptable results" (*18*, p. 208).

The purpose of the experiments with the expected income series is to determine whether the concept of permanent income appropriate for the total consumption function would yield better results than those obtained using measured income.

Statistical Considerations

The study includes two least-squares estimates of the price elasticities in order to bracket the true value with respect to least-squares bias (*24, 25*). If quantity (or price) is used as the dependent variable, the least-squares method would result in biased estimates of the structural parameters in the demand relations. There are two reasons for this. First, it ignores other relations among the (endogenous) variables (the simultaneous equations problem).[10] Second, there are errors of observation in the variables chosen as independent variables in the regression analysis.[11]

When quantity is used as the dependent variable the estimated price elasticity is a lower limit (in absolute value) with respect to these two sources of least-squares bias; when price is used as the dependent variable, the estimated price elasticity (the reciprocal of the price flexibility) yields an upper limit (in absolute value).

Unfortunately, the same procedure cannot be used for bracketing the income elasticity. Food manufacturing is a relatively important sector in the economy and changes in consumption of manufactured farm foods will probably have more than a negligible effect on employment and income. Changes in the quantity of manufactured farm foods and income will probably be positively correlated, and the least-squares estimate using either quantity or income as dependent variables will be biased upward. The least-squares estimates of the income elasticities given in this study use quantity as the dependent variable. This means that the two sources of least-squares bias are offsetting to some unknown extent (*25*).

Statistical Findings

This section is divided into four main parts: The first three show the statistical results for the three demand relations based on the U.S. Department of Commerce series on personal disposable income, and the fourth summarizes the results based on the expected income series.

Demand for Manufactured Farm Foods

Assuming Complete Adjustment

The statistical results for equation (1) of the model based on annual data for 1919-41 and 1946–58 are:

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[10] Within the context of a larger model of the total farm-food marketing system the three demand equations estimated in this study are overidentified.

[11] Strictly speaking, the errors of observation have to be statistically independent of each other and of the true values of the variables. Actually, the quantity series for manufactured farm foods and for farm products consumed in food manufacturing were derived by deflating value series. Similarly, the price series for manufacturers' services was obtained by dividing the value series by a quantity series. There is some presumption that the errors of observation may not be totally uncorrelated; hopefully, they are not statistically significantly correlated.

$$(7)\quad \log X_{mt} = -0.130 \underset{(0.067)}{-0.211} \log P_{mt} \underset{(0.077)}{+0.146} \log P_{vt} \underset{(0.140)}{+0.111} \log P_{dt} \underset{(0.062)}{+0.105} \log Z_t \underset{(0.074)}{+0.577} \log Y_t \underset{(0.001)}{-0.001} T$$

$$R^2 = 0.949$$

The estimated elasticities with respect to P_{vt}, and P_{dt} and Z_t are all less than twice their standard errors and, hence, not statistically significantly different from zero. The signs for P_{dt} and Z_t are also in the wrong direction. The estimated elasticity with respect to P_{vt} is nearly twice its standard error, but further experimenting only decreased its statistical significance. It is perhaps surprising that the trend is not statistically significant. The regression for the same period, omitting P_{vt}, P_{dt}, and Z_t is:

$$(8)\quad \log X_{mt} = 0.404 \underset{(0.049)}{-0.129} \log P_{mt} \underset{(0.081)}{+0.602} \log Y_t \underset{(0.0005)}{-0.0003} T$$

$$R^2 = 0.940$$

The trend is still statistically insignificant; and, even if we ignore the statistical test, its magnitude is less than one-tenth of 1 percent per year, small enough to be ignored. A regression similar to (7) was also run in first differences of the logarithms of the variables because of high intercorrelation between Y_t and Z_t and the results were essentially the same.

These findings indicate, at least in the aggregate, that developments in food distribution, changes in the price of fresh fruits and vegetables, and the declining role of the farm sector as a supplier of processed foods were not empirically significant in shifting the demand curve for *total* manufactured farm foods during the period studied.[12] The findings with respect to Z_t mean that the movement of families off farm has not significantly increased the total demand for manufactured farm foods. In sum, we can reduce the empirical considerations to the price and income variables.

Table 2 summarizes the statistical results using quantity, price, and income. Regression (9) for 1919–41 and 1946–58 using quantity as the dependent variable yields the best fit (highest R^2); and, judging from the Durbin-Watson statistic (d), there is no significant serial correlation in the residuals. The estimated price and income elasticities based on (9) are −0.12 and 0.57, respectively. The actual and estimated values are plotted in figure 1. The results in first differences of the logarithms (10) are poorer judging by the same statistical tests, but the estimated elasticities are still not significantly different than those in (9).

In order to estimate the upper limit of the price elasticity with respect to the least-squares bias, regressions were also run using price as the dependent variable [(15) and (16)]. Based on (15), the equation in the logarithms of the variables, the estimated upper limit (in absolute value) of the price elasticity is −0.72 (the reciprocal of −1.39). Hence, allowing for least-squares bias, the price elasticity of demand for manufactured farm foods lies between −0.12 and −0.72.

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[12] Perhaps, more accurately, the effects of P_{vt}, P_{dt}, and Z_t are lost in aggregation.

TABLE 2.—*Estimates of U.S. civilian demand for manufactured farm food products, measured at the factory level* [1]

Equation	Time period	Number of observations	Dependent variable	Constant term	Coefficients and standard errors (in parentheses) of—						R^2	d
					$\log X_{mt}$	$\log P_{mt}$	$\log Y_t$	$\Delta\log X_{mt}$	$\Delta\log P_{mt}$	$\Delta\log Y_t$		
(9)	1919-41 1946-58	36	$\log X_{mt}$	0.472		−0.122 (.047)	0.573 (.033)				0.940	1.92
(10)	1920-41 1947-58	34	$\Delta\log X_{mt}$	−.001					−0.152 (.092)	0.606 (.141)	.373	*2.85
(11)	1919-41	23	$\log X_{mt}$	.254		−.089 (.065)	.627 (.077)				.775	
(12)	1920-41	22	$\Delta\log X_{mt}$	−.002					−.169 (.142)	.660 (.203)	.376	
(13)	1946-58	13	$\log X_{mt}$	1.581		−.340 (.151)	.354 (.204)				.850	
(14)	1947-58	12	$\Delta\log X_{mt}$	.002					−.339 (.156)	.079 (.330)	.510	
(15)	1919-41 1946-58	36	$\log P_{mt}$	.968	−1.391 (.534)		1.213 (.284)				.601	*.75
(16)	1920-41 1947-58	34	$\Delta\log P_{mt}$					−0.537 (.323)		.854 (.297)	.210	1.57

[1] Excludes fluid milk, cream, and poultry.

X_{mt}=per capita consumption of manufactured farm food products (measured at the factory level).
P_{mt}=index of prices of manufactured farm food products based on BLS wholesale prices deflated by the BLS consumer price index for all commodities, excluding manufactured foods.
Y_t=per capita real disposable income based on U.S. Department of Commerce personal disposable income (*71*).
R^2=coefficient of determination.
d=Durbin-Watson statistic (*significant at the 5-percent level using a 2-tailed test).

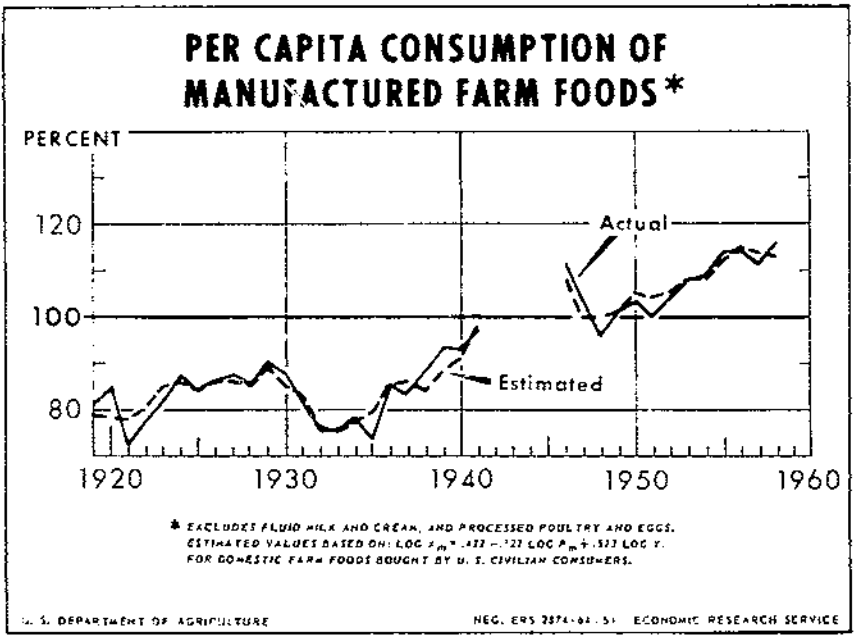

Figure 1

In order to test whether there had been a change in the price and income elasticities between the prewar and postwar years, regressions were run for 1919–41 and for 1946–58, separately [equations (11) through (14)]. There are too few observations for the postwar period; graphic analysis shows that the results are substantially affected by a few extreme values. Hence, the best that can be done is to compare the results for the prewar years with those for the prewar and postwar years combined. The estimated price and income elasticities for 1919–41 shown in (11) and (12) are not statistically significantly different than those estimated for 1919–41 and 1946–58. This is at least consistent with the hypothesis that there has been no change.[13]

The time series on civilian consumption of manufactured farm foods, X_{mt}, was derived by deflating value series by indexes of prices of manufactured farm foods constructed from BLS wholesale prices. There is a strong presumption that these price series are biased on two counts: (1) The price deflators reflect secular increases in the amount of manufacturers' services per unit of product and in improvements in the quality of basic food ingredients; and (2) reported price changes do not reflect true transaction prices and the errors are correlated with cyclical changes in income (*37*).[14] For brevity, we shall refer to (1) as a "trend" error and (2) as a "cyclical" error.

[13] Additional experiments with an equation using dummy variables to test for changes in the income and price elasticities as well as for a shift in the demand relation between the prewar and postwar periods did not reveal any significant changes either.

[14] The construction of the series and a discussion of these specification errors are given in Appendix C.

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In absolute values, the trend error tends to bias both the estimated price and income elasticities for X_{mt} downward; the cyclical error tends to bias them both upward. The estimated income elasticity is particularly sensitive to the trend error. For example, if we increase the trend in X_{mt} (and decrease the trend in P_{mt}) by 0.5 percent per year, the estimated income elasticity increases from 0.57 to 0.78 whereas the estimated price elasticity increases only from −0.12 to −0.20.[15]

Assuming Incomplete Adjustment

The above estimated equations assume that the adjustment of demand to changes in price and income is completed within 1 year. In order to test this, a regression was run on the distributed lag model (*6*). The statistical results are:

$$(17)\quad \log X_{mt}=\underset{(0.048)}{0.431}-\underset{(0.069)}{0.116}\log P_{mt}+\underset{(0.114)}{0.532}\log Y_t+0.078\log X_{mt-1}$$

$$R^2=0.941$$

The elasticity with respect to the lagged endogeneous variable, 0.08, used to estimate the elasticity of adjustment and the long-run price and income elasticities is less than its standard error; and, hence, not significantly different from zero. The estimated elasticity with respect to X_{mt-1} is small so that even if we disregard the statistical test of significance it indicates that nearly all (92 percent) of the adjustment of actual consumption to intended levels occurred within a year. The estimated long-run price elasticity (0.13) and income elasticity (0.58) are both within rounding errors of the estimates based on the static model (9). These results are perhaps not surprising since there was no serial correlation in the residuals of (9).

Demand for Farm Products Used in Food Manufacturing

Assuming Complete Adjustment

The statistical results of fitting equation (3) for 1919–41 plus 1946–58 are:

$$(18)\quad \log X_{ft}=\underset{(0.077)}{0.185}-\underset{(0.211)}{0.180}\log P_{ft}+\underset{(0.079)}{0.047}\log P_{et}+\underset{(0.113)}{0.097}\log P_{ot}$$

$$+\underset{(0.149)}{0.136}\log Z_t+\underset{(0.0009)}{0.514}\log Y_t+0.0004\ T$$

$$R^2=0.844$$

[15] The following tabulation shows the effect of imposing trends on X_{mt} (and P_{mt}) (using an equation linear in the logarithms of the variables):

Assumed percent per year	Estimated elasticities with respect to— Price	Income
0.0	−0.122	0.573
.5	−.196	.776
1.0	−.304	.951
1.5	−.412	1.080

We should also point out that both P_{mt} and Y_t are deflated by the BLS consumer price index; and there is the strong presumption that this price deflator also reflects secular quality improvements (*37*). Hence, to some unknown extent, the secular error in the consumer price index offsets the specification bias in the estimated price and income elasticities due to the trend error.

The estimated elasticities with respect to P_{st} and Z_t are less than twice their standard errors and thus not statistically significant. The estimated elasticity with respect to P_{ct}, the farm-retail price spread, is not statistically significant either; nor is the trend. Also, the signs for P_{st} and Z_t are in the wrong direction. The statistical findings based on first differences of the logarithms were essentially the same. Additional experiments using the price of food manufacturers' services, P_{st}, indicated that it, too, was not statistically significant.

These statistical findings for farm products agree with those for manufactured food products [equation (7)]. The rejected coefficients in (7) and (18) were also small in absolute magnitude as well as statistically insignificant. These consistent findings based on closely related series constructed from wholly independent sources strengthen the evidence that changes in the price of fresh fruits and vegetables, movements of families off farms, and changes in price spreads were not empirically significant in affecting factory processing of farm food products during the period studied. Eliminating P_{st}, P_{ct} and Z_t does not affect the significance of the estimated trend:

$$\log X_{ft}=0.872-\underset{(0.036)}{0.120}\log P_{ft}+\underset{(0.074)}{0.445}\log Y_t-\underset{(0.0006)}{0.0008}\,T \qquad (19)$$
$$R^2=0.827$$

Table 3 summarizes the statistical results using quantity, price, and income. Using quantity as the dependent variable, the regression in the logarithms of the variables for 1919–41 and 1946–58 results in (20) estimated price and income elasticities of —0.09 and 0.35, respectively. There is some positive serial correlation in the residuals; however, the Durbin-Watson test statistic (d) is inconclusive at the 5-percent level. The use of first differences to "get around" problems of the serial correlation in the residuals and a high intercorrelation between income and price was hardly successful (21). Regressions were also run with (a) an index of rail freight rates for farm food products (*58*), (b) an index of prices of intermediate goods purchased by food manufacturers (*63*), and (c) an index of prices of packaging materials bought by food manufacturers [that is, a component of (b)]; but none of these were statistically significant.

Comparison of (19) and (20) shows that the estimated income elasticity is smaller when we exclude the trend variable. This is due to a high intercorrelation between income and trend ($r_{YT}=0.89$). The predicted values are about the same (fig. 2). Since the estimated trend in (19) is small and not statistically significant, we can tentatively accept the results in equation (20). Using price as the dependent variable, the estimated price flexibility of demand shown in (26) is —2.26, and the reciprocal of this, —0.44, is the estimated upper limit (in absolute value) of the price elasticity with respect to least-squares bias. Thus, for the years 1919–41 and 1946–58, the limits on the true price elasticity with respect to least-squares bias are —0.09 and —0.44.

As in manufactured food, there is no indication that the price and income elasticities of demand for farm products consumed in food manufacturing have changed significantly between the prewar and postwar periods. But again, the test of this leaves something to be

TABLE 3.—*Estimates of U.S. civilian demand for domestic farm products consumed in food manufacturing, measured at the farm level* [1]

Equation	Time period	Number of observations	Dependent variable	Constant term	Coefficients and standard errors (in parentheses) of—						R^2	d
					log X_{ft}	log P_{ft}	log Y_t	Δlog X_{ft}	Δlog P_{ft}	Δlog Y_t		
(20)	1919–41 1946–58	36	log X_{ft}	1.103		−0.093 (.031)	0.346 (.034)				0.814	1.40
(21)	1920–41 1946–58	34	Δlog X_{ft}	−.002					−0.124 (.060)	0.427 (.136)	.245	*2.88
(22)	1919–41	23	log X_{ft}	.925		−.102 (.042)	.413 (.081)				.567	
(23)	1920–41	22	Δlog X_{ft}	−.001					−.130 (.089)	.474 (.195)	.242	
(24)	1946–58	13	log X_{ft}	2.711		−.242 (.125)	−.085 (.315)				.551	
(25)	1947–58	12	Δlog X_{ft}	.002					−.229 (.106)	.042 (.282)	.395	
(26)	1919–41 1946–58	36	log P_{ft}	2.129	−2.260 (.764)		1.383 (.241)				.608	*.58
(27)	1920–41 1947–58	34	Δlog P_{ft}	−.014				−.965 (.471)		1.502 (.342)	.386	1.77

[1] Excludes fluid milk, cream, and poultry.

X_{ft} = per capita consumption of farm products consumed in food manufacturing (measured at the farm level).

P_{ft} = index of prices of farm products used in food manufacturing deflated by BLS consumer price index for all commodities.

Y_t = per capita real disposable income based on U.S. Department of Commerce personal disposable income (*71*).

R^2 = coefficient of determination.

d = Durbin-Watson statistic (*significant at the 5-percent level using a 2-tailed test).

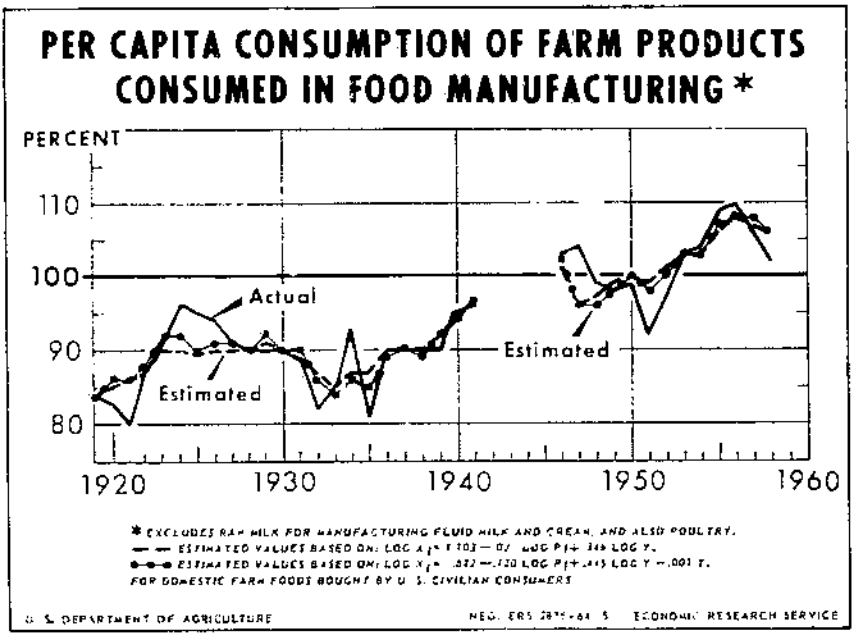

Figure 2

desired. There are not enough observations for the postwar years to be able to compare elasticities estimated separately for the two periods. For the prewar years, 1919–41, the estimated income and price elasticities [(22) and (23)] are not statistically significantly different from those computed for 1919–41 and 1946–58. Again, this is at least consistent with the hypothesis of no change.[16]

There are two sources of specification errors in the data that could bias the estimated parameters.[17] First, the quantity series used to measure X_{ft} was obtained by deflating a value series by the farm price index used to measure P_{ft}. This price index was constructed from Statistical Reporting Service prices received by farmers, which is essentially a unit value series. Thus, there is the presumption that the deflator reflects secular improvements in quality of farm products. This means that the price index probably has a secular upward bias and the quantity series has a secular downward bias.

The second source of error arises in constructing the basic value series; it too suggests a downward secular bias in measuring X_{ft}. Except for livestock, the value of farm products comprising the series includes products destined for commercial nonfactory processing as well as factory processing. During the four decades studied, the overall trend was from nonfactory to factory processing. To the extent that the secular errors in measuring X_{ft} and P_{ft} are important, they tend to bias the estimated price and income elasticities down-

[16] The results were the same for experiments using dummy variables to test whether equation (22) had shifted or the elasticities had changed.

[17] For a more complete discussion of the data, see Appendix C.

ward. Unfortunately, the estimated income elasticity is sensitive to a secular bias in X_{mt}; the estimated price elasticity is not.[18]

Assuming Incomplete Adjustment

The distributed lag model was employed again to test whether actual consumption of farm products used in food manufacturing adjusted to desired levels within a year. The statistical results for 1919–41 plus 1946–58 are:

$$(28)\quad \log X_{ft} = \underset{}{0.887} \underset{(0.032)}{-0.080 \log P_{ft}} \underset{(0.055)}{+0.286 \log Y_t} \underset{(0.139)}{+0.188 \log X_{ft-1}}$$
$$(1)\ R^2 = .824.$$

The coefficient of the lagged dependent variable used to compute the elasticity of adjustment is less than twice its standard error, hence, not statistically significantly different from zero. Also, the price and income elasticities estimated in (28) are not significantly different from those estimated in (20). Again, even ignoring these statistical tests, the estimated long-run price and income elasticities derived by dividing the coefficients in (28) by the estimated elasticity of adjustment (0.812) are within rounding errors of the estimates in (20). Hence, it appears that adjustment of actual consumption of farm products to desired levels is virtually completed within a year, the same as for manufactured farm foods.

Demand for Food Manufacturers' Services

The series constructed to measure food manufacturers' services is based mainly on Bureau of Census data for "value added by manufactures," adjusted for price changes.[19] Value of gross output was deflated by an index of prices of output constructed from BLS wholesale food prices; cost of materials and supplies was deflated by an index of prices of materials and supplies based on SRS prices received by farmers and on BLS wholesale prices for purchased nonfarm materials and supplies. The difference between these two deflated series measures value added in constant prices. This double-deflated

[18] The following tabulation based on imposing secular trends indicates the sensitivity of the estimated price and income elasticities to secular bias in X_{ft} (using an equation linear in the logarithms of the variables):

Assumed percent per year	*Estimated elasticity with respect to—*	
	Price	*Income*
0.0	−0.093	0.346
.5	−.160	.570
1.0	−.233	.768

It might also be pointed out that the estimated negative trends in the equation for manufactured farm foods (8) and in the equation for farm products (19) are both consistent with a presumed downward secular bias in the quantity series. There are too many factors which may affect the estimated trend to make this a very useful way to gage the extent of the bias.

[19] According to the Bureau of the Census, value added is "calculated by subtracting the cost of materials, supplies, containers, fuel, purchased electric energy, and contract work from the total value of shipments" (*66*). In 1958, the Census revised this definition to include the effect of value added by merchandising operations and the net change in finished goods and work-in-process inventories (that is, "adjusted" value added). The Census has not always been consistent in its definition of value added. The method, sources, and problems in constructing the series on food manufacturers' services are discussed in detail in Appendix C.

net output series was adjusted for exports, sales to military, and changes in inventories in order to reflect domestic civilian consumption only. The price index for food manufacturers' services is an implicit unit value series obtained by dividing value added in current prices by value added in constant prices. Thus, the price series for food manufacturers services reflects not only true price changes but also changes in the service mix.

Value added data are only available biennially between 1919 and 1939, for 1947, and annually since 1949. Therefore, the statistical analysis is only for the model assuming complete adjustment within a year. We also assume that the demand structure for food manufacturers' services did not change significantly between the prewar and postwar periods. The previous statistical findings on these questions for manufactured foods and for farm products indicate the suitability of these assumptions since manufacturers' services account for about 80 percent of the difference between these two series.

Appendix C on the data underscores the distressing fact that none of the laborious attempts to construct a single time series for measuring food manufacturers' services was entirely successful. This section on the statistical analysis includes experiments with several time series; but, interest is focused mainly on the *benchmarked* double-deflated value added measure of food manufacturers' services. Some experiments are made with the unbenchmarked series and with a series derived as the difference between manufactured farm foods and food products used in food manufacturing; and, finally, the income elasticities estimated for the three demand relations are checked for consistency.

Food Manufacturers' Services [20]

The regression of the demand relation for food manufacturers' services based on the double-deflated value added measure for the period 1919–58 is:

$$\begin{aligned}(29)\quad \log X_{st} = {} & 0.581 - 1.177 \log P_{st} + 0.149 \log P_{et} + 0.038 \log P_{dt} \\ & \qquad (0.129) \qquad\quad (0.162) \qquad\quad (0.278) \\ & + 0.470 \log Z_t + 0.714 \log Y_t + 0.009\ T \\ & \qquad (0.128) \qquad\quad (0.168) \qquad\quad (0.002) \\ & \qquad\qquad R^2 = 0.966.\end{aligned}$$

The estimated elasticities with respect to P_{et} and P_{dt} are both less than their standard errors and not statistically significant. These results are consistent with the findings in equations (7) and (18) for X_{mt} and X_{ft}. The estimated elasticity with respect to Z_t is large and between 3 and 4 times its standard error, but the sign is in the wrong direction. The estimated elasticity for Z_t also drops to 0.06 and is statistically insignificant when we eliminate the trend term which reflects a high negative intercorrelation between the two variables ($r_{ZT} = -0.96$). In contrast to the findings for X_{mt} and X_{ft} the trend is statistically significant. Additional experiments using the price of farm products, P_{ft}, indicated that it was not statistically significant.

Table 4 summarizes the statistical results and shows that they are sensitive to inclusion of the trend variable, particularly the estimated

[20] Unless otherwise noted, the analysis based on the double-deflated value added series refers to the benchmarked data discussed in Appendix C.

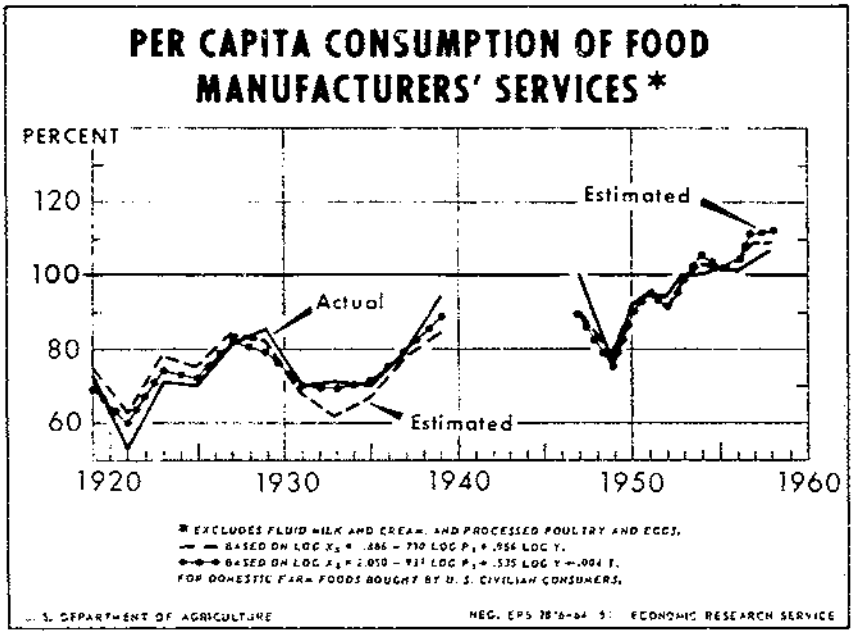

Figure 3

income elasticity. The estimated price and income elasticities in equation (30) excluding the trend variable are −0.79 and 0.86. When we include the trend variable (31), the estimated elasticities change to −0.93 and 0.54 (fig. 3). The estimated trend is nearly 1 percent per year, which is about the rate of growth built into the quantity series by benchmarking it. There is some serial correlation in the residuals of the equation when trend is excluded (the Durbin-Watson test is inconclusive at the 5-percent level) which is apparently due to the benchmarking, and including a trend variable only picks it up.

The increase in the standard error of the estimated income elasticity in (31) reflects the high intercorrelation between income and trend.[21] The result in first differences of the logarithms (32) also eliminates the trend benchmarked into the series and does not help the intercorrelation problem. The estimated price and income elasticities are both increased (in absolute terms) but because of the large standard errors they are not statistically significantly different. The use of first differences magnifies the errors in the price and quantity series.

These results suggest an income elasticity for food manufacturers' services that is no larger, and may even be significantly smaller, than unity. The estimated limits for the price elasticity with respect to least-squares bias are wider based on the equations excluding the trend and include those based on the equations with the trend term. Using

[21] The matrix of simple correlation coefficients of the independent variables is:

	P_{x_1}	Y_t	T
P_{x_1}	1.00	0.77	0.77
Y_t		1.00	0.92
T			1.00

TABLE 4.—*Estimates of U.S. civilian demand for food manufacturers' services related to domestic farm products, measured at the factory level*[1]

Equation	Time period[2]	Number of observations	Dependent variable	Constant term	Coefficient and standard errors (in parentheses) of—							R^2	d[3]
					log X_{st}	log P_{st}	log Y_t	T	Δ log X_{st}	Δ log P_{st}	Δ log Y_t		
(30)	1919–58	22	log X_{st}	0.886		−0.790 (.192)	0.856 (.087)					0.869	1.04
(31)	1919–58	22	log X_{st}	2.050		−.931 (.158)	.535 (.116)	0.004 (.001)				.921	2.10
(32)	1920–58	20	Δ log X_{st}[3]	−.002						−1.166 (.151)	0.794 (.155)	.853	2.06
(33)	1919–58	22	log P_{st}	1.004	−0.596 (.145)		.696 (.097)					.786	*.79
(34)	1919–58	22	log P_{st}	1.924	−.706 (.120)		.438 (.108)	.003 (.001)				.871	1.39
(35)	1920–58	20	Δ log P_{st}[3]	−.372					6.858 (2.646)		−1.577 (4.260)	.342	2.37

[1] Excludes fluid milk, cream, and poultry.

[2] Regressions based on biennial benchmarked double-deflated value added data from 1919 to 1939 and for 1947 to 1949; and on annual data from 1949 to 1958.

[3] Based on grouping data biennially for both prewar and postwar years; that is, the analysis is based on first differences of biennial data.

X_{st}=per capita consumption of food manufacturers' services related to farm products (measured at the factory level).
P_{st}=index of implicit prices of food manufacturers' services deflated by BLS consumer price index for all commodities.
Y_t=per capita real disposable income based on U.S. Department of Commerce personal disposable income (*71*).
T=trend (1919=1).
R^2=coefficient of determination.
d=Durbin-Watson statistic (*significant at the 5-percent level using a 2-tailed test).

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the wider limits, the estimated lower limit (in absolute value) of the price elasticity based on quantity as the dependent variable (30) is −0.79; and the estimated upper limit (in absolute value) based on price as the dependent variable (33) is −1.67, the reciprocal of −0.59.[22]

The above description of the index of food manufacturers' services indicates that there are two value series and two price series used to compute the index. Analysis of the basic data (Appendix C) shows that the only specification errors in these four series that significantly affect the quantity index are the errors in the BLS wholesale price deflators discussed in the section on manufactured foods (p. 3). The effects here are that the measure of food manufacturers' services (1) understates a secular increase in the amount of manufacturers' services per unit of product and (2) tends to overstate cyclical fluctuations. Again, for brevity, we shall label (1) as a "trend" error and (2) as a "cyclical" error, although the trend error for food manufacturers' services has a more limited meaning than for manufactured foods. As in manufactured foods, the trend error tends to bias both the price and income elasticities downward (in absolute value), whereas the cyclical error tends to bias them both upward (in absolute value).[23]

The series on food manufacturers' services was benchmarked in order to correct for the trend error; however, there is little doubt that the

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[22] There is a possibility of spurious statistical results. As previously noted, the price index for food manufacturers' service is an implicit price series obtained by dividing an index of value added in current prices by the index of value added in constant prices. This means that the errors of measurement in the price and quantity series tend to be negatively correlated. This, in turn, tends to bias the estimated price elasticity toward minus one and to increase the coefficient of determination (R^2). In order to test whether the statistical results are spurious, the following regressions were run:

(36) $\log V_{at} = -1.111 + \underset{(0.192)}{0.209} \log P_{at} + \underset{(0.087)}{0.856} \log Y_t \quad R^2 = 0.937$

(37) $\log V_{at} = -0.994 + \underset{(0.145)}{0.404} \log X_{at} + \underset{(0.097)}{0.695} \log Y_t \quad R^2 = 0.952$

where,

(38) $\log V_{at} = \log P_{at} + \log X_{at}$.

Substituting $\log V_{at}$ from (38) in the other equations:

(39) $\log X_{at} = -1.111 - 0.791 \log P_{at} + 0.856 \log Y_t$

(40) $\log P_{at} = -0.994 - 0.556 \log X_{at} + 0.695 \log Y_t$.

Comparison of these results with those in table 4 indicates that neither the high coefficients of determination nor the estimates of the price elasticities are spurious on this account. The same is true when a trend term is used.

For essentially the same reasons, there is also the possibility of spurious results in estimating the demand relations for manufactured foods and farm products. However, judging from the statistical findings, this bias is negligible.

[23] Presumably, the deflated cost of materials and supplies (the subtrahend) used to construct the double-deflated value added series also has a downward secular bias because the SRS prices received by farmers used to deflate the costs data reflect quality improvements in the basic food ingredients (p. 47). To the extent that the downward secular bias in the deflated value of gross output (the minuend) and the downward secular bias in deflated cost of materials and supplies (the subtrahend) are compensating, the measure of food manufacturers' services does not reflect quality improvements in the basic food ingredients—as it should not.

benchmarking only partly corrects the series.[24] The best we can do is attempt to estimate upper limits (in absolute value) for the price and income elasticities with respect to the two kinds of specification errors. The statistical results of imposing trends on the *unbenchmarked* index of food manufacturers' services are summarized in table 5. The estimated price and income elasticities, −0.69 and 0.72, based on the unbenchmarked data are not much different than those based on the benchmarked series. The largest assumed rate of growth in per capita consumption of food manufacturers' services is 2.5 percent a year. This is about the same as the annual rate of growth in per capita value added measured in *current* prices. Since prices of food manufacturers' services probably rose to some extent between 1919 and 1958, the 2.5 percent rate can probably be treated as an upper limit.[25]

The estimated income elasticity reaches a peak of 0.93 in equation (44) when the assumed trend is 1.5 percent per year. Thus, the estimated upper limit with respect to the specification errors for the income elasticity is in the neighborhood of unity. The estimated price elasticity is extremely sensitive to trends; it increases from −0.69 when there is no assumed trend (41) to −1.39 when the assumed trend is 2.5 percent per year (46). This estimate of −1.39 is within the limits estimated with respect to the least-squares bias.[26]

In a further, more speculative, attempt to narrow the estimated limits for the price elasticity, the analysis based on the double-deflated value added series was limited to the six benchmark observations. This is the best available series with respect to the trend error, and it also avoids bias resulting from the cyclical error. Also, if 1.0 is accepted as the upper limit for the income elasticity, then we can estimate an upper limit for the price elasticity with respect to the least-squares bias. Any assumed value of the income elasticity which is less than 1.0 will yield an estimated price elasticity between the estimated upper limit and zero. Using $P_{s,t}$ as the dependent variable and the part of $X_{s,t}$ not explained by changes in income as the independent variable, the estimated upper limit (in absolute value) is −1.38. This limit may still understate the absolute value of the price elasticity because of possible remaining trend bias, but it does point to a limit which is larger than unity in absolute value.[27]

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[24] The benchmark series for double-deflated value added was laboriously constructed for selected "normal" census years (1919, 1929, 1937, 1947, 1954, and 1958). The main difference between the benchmarked and unbenchmarked series is that the former is largely based on unit values derived from census value and output data in order to deflate value of gross output. As far as I know, these unit value series are the only comprehensive data other than BLS wholesale prices for deflating value of gross output. For a detailed discussion, see Appendix C.

[25] There is, of course, no way of knowing that absolute prices for food processing services rose to *some* extent during the four decades, and, therefore, that 2.5 percent per year is an upward limit. This speculation is based on more than cursory observation, however. The general price level (measured by implicit price deflator for gross national product) rose 80 percent during the four decades; and during this period total productivity gains in food manufacturing were about the same as in the nonfarm sector as a whole (*50*). Increases in average hourly earnings and returns to capital in food manufacturing also paralleled increases in the nonfarm sector.

[26] The estimated price elasticities in table 5 should be taken cautiously for, as the table demonstrates, imposing trends on the quantity and price series tends to bias the estimated price elasticities to minus one.

[27] Besides having to assume limits for the income elasticity, the method also assumes a positive correlation between shifts in the demand curve (that is, the part of $X_{s,t}$ not explained by income) and price [see Harberger (*24*)].

TABLE 5.—*Estimates of the U.S. civilian demand for food manufacturers' services, measured at the factory level, quantity and price series adjusted for assumed trends* [1]

(Based on unbenchmarked double-deflated value added)

Equation	Assumed percent per year	Time period [2]	Number of observations	Dependent variable	Constant term	Coefficients and standard errors (in parentheses) of—		
						log P_{st}	log Y_t	R^2
(41)	0	1919–58	22	log X_{st}	1.090	−0.686 (.151)	0.721 (.111)	0.720
(42)	.5	1919–58	22	log X_{st}	−.536	−.723 (.192)	.809 (.100)	.836
(43)	1.0	1919–58	22	log X_{st}	−.832	−.885 (.234)	.904 (.076)	.900
(44)	1.5	1919–58	22	log X_{st}	−.951	−1.150 (.240)	.929 (.057)	.939
(45)	2.0	1919–58	22	log X_{st}	−.780	−1.339 (.203)	.856 (.069)	.964
(46)	2.5	1919–58	22	log X_{st}	−.528	−1.386 (.158)	.762 (.085)	.977

[1] Excludes fluid milk, cream, and poultry.

[2] Regressions based on biennial data from 1919 to 1939 and for 1947 to 1949; and on annual data from 1949 to 1958.

X_{st}=per capita consumption of food manufacturers' services related to farm products (measured at the factory level).
P_{st}=index of implicit prices for food manufacturers' services deflated by BLS consumer price index for all commodities.
Y_t=per capita real disposable income based on U.S. Department of Commerce personal disposable income (*71*).
R^2=coefficient of determination.

Goods and Services Added Between Farm and Factory Sales

Although the findings presented in this section are of interest in themselves, their main purpose is to present some additional evidence on the demand relation for food manufacturers' services. As defined in this study, the quantity of goods and services added between farm and factory sales of farm-originated foods is,

$$(47) \qquad X_{at}=X_{mt}-X_{ft}.$$

The quantity of food manufacturers' services, X_{st}, accounted for about 80 percent of X_{at} in 1947.[28] The difference between X_{at} and X_{st} includes assembling of farm products; transportation of farm products between farms and food manufacturers; and food manufacturers' purchases of packaging materials, fuel, power and light, and other intermediate materials and supplies purchased from the nonfarm sector. From 1919 to 1958, X_{at} increased about 160 percent compared with a rise of about 145 percent in X_{st}. Thus, the estimated parameters using X_{at} reflect a somewhat greater secular increase than those using X_{st}.[29]

The regression equation analogous to (30) based on annual data for 1919–41 and 1946–58 is,

$$(48) \quad \log X_{at}=0.060-\underset{(0.134)}{0.466}\log P_{at}+\underset{(0.059)}{0.934}\log Y_t$$

$$R^2=0.893 \qquad d=1.268$$

where P_{at} is the implicit price of goods and services included in X_{at}. It was obtained, like P_{st}, by dividing X_{at} into a series measuring the current dollar value of X_{at}.

The estimated price elasticity, −0.47, is smaller, in absolute value, than the estimated price elasticity, −0.79, for food manufacturers' services. However, given the standard errors and the differences between the two basic series, these estimated price elasticities are essentially within the limits estimated for food manufacturers' services. The estimated income elasticity for X_{at}, 0.93, is also about the same as that estimated for X_{st}, 0.86. The Durbin-Watson test for serial correlation in the residuals is inconclusive at the 5-percent level of significance. Other variables in the model (P_{ot}, P_{dt}, P_{ft}, and Z_t) were also tried, but none were statistically significant. This, again, is consistent with the previous findings with respect to these variables.

The regression including the trend variable is:

$$(49) \quad \log X_{at}=0.965-\underset{(0.152)}{0.600}\log P_{at}+\underset{(0.144)}{0.705}\log Y_t+\underset{(0.0014)}{0.0023}T$$

$$R^2=0.903 \qquad d=1.273$$

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[28] This ratio is computed in part, from the BLS Interindustry Study for 1947 (*14*), the only source from which a direct estimate can be computed.

[29] Unfortunately, the additional evidence yielded by experiments with X_{at} is not as independent as we would like. As supporting evidence, the important differences between the measures of X_{st} and X_{at} are that (1) X_{at} is about 25 percent larger than X_{st} which means that the specification errors in using BLS wholesale prices for deflators will not be as significant in X_{at} as in X_{st} (see Appendix C); (2) the data for value of farm products used in calculating X_{at} (that is, in calculating X_f) is based on Agriculture rather than Census data used in computing X_{st}; and, (3) data for X_{at} are available annually.

The absolute magnitudes for the estimated parameters changed somewhat from those in (48), but the differences are not large enough to be statistically significant. Also, the magnitudes are essentially within the broad limits estimated for the parameters in the demand relation for food manufacturers' services. What is perhaps more interesting is that the estimated trend is not statistically significant, and the Durbin-Watson test remains inconclusive at the 5-percent level of significance. This lends additional support to the belief that the significant trend and the inconclusive test for serial correlation in the residuals in estimating the demand relation for food manufacturers' services (31) probably reflects the benchmarking of the series.

The regression equation when price is used as the dependent variable, omitting the trend term, is:

$$(50)\quad \log P_{at} = \underset{}{1.601} - \underset{(0.165)}{0.573} \log X_{at} + \underset{(0.171)}{0.498} \log Y_t$$

$$R^2 = 0.277 \qquad d = 0.689$$

The estimated upper limit (in absolute value) for the price elasticity is therefore -1.74 (the reciprocal of -0.573) with respect to the least-squares bias; and, from (48) the lower limit (in absolute value) is -0.47.

In sum, the estimated limits for the price elasticity with respect to the least-squares bias, and the estimated income elasticity based on X_{at} are essentially the same as those estimated using X_{st}.[30] Unfortunately, the estimates based on X_{at} are subject to the same specification errors as are present in X_{st}. Because X_{at} is about a fourth larger than X_{st}, however, the bias in the estimated parameters resulting from these errors is to some extent smaller when X_{at} rather than X_{st} is used.[31]

Consistency of Estimated Income Elasticities

The estimated income elasticities can be checked to see if they are consistent. Because X_{st} accounted for about 80 percent of X_{at}, and because some of the factors accounting for the differences (packaging supplies, fuel, electricity, and power) are probably highly correlated with X_{st} we can assume that the findings for X_{at} essentially apply to X_{st} also. From equation (47) we can derive the formula that the income elasticity for manufactured foods, η_m, is the weighted sum of the income elasticity for the farm products consumed in food manufacturing, η_f, and the income elasticity of the goods and services

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[30] Because of the way in which P_{at} was derived, regressions similar to those for food manufacturers' services (footnote 22) were run in order to test for spurious correlation. The estimated limits for the price elasticity, the estimated income elasticity, and the coefficient of determination were the same as those in (48), (49), and (50).

[31] All of the regressions for X_{at} are based on annual data for 1919–41 and 1946–58 whereas those for X_{st} are based on 22 selected years during these periods. A regression for X_{at} was also run using data only for those 22 years for which data were available for X_{st}. The following results show that there is only a numerically small and statistically insignificant difference for X_{at},

$$(51)\quad \log X_{at} = -0.054 - \underset{(0.174)}{0.510} \log P_{at} + \underset{(0.060)}{1.001} \log Y_t \qquad R^2 = 0.938$$

Presumably the same would probably also be true for X_{st}.

added between farm and factory sales, η_a (η_s) where the weights are the farm share, w_f, and $1-w_f$.[32] That is,

$$(52) \quad \eta_m = w_f \eta_f + (1-w_f)\eta_a.$$

The estimated value of η_f in (20) was 0.35, and the estimated value of η_a in (48) was 0.93; w_f ranged from 0.65 (1919–21) to 0.60 (1954–56). Inserting these estimates in (52), the indirect estimates of η_m are 0.55 and 0.58 compared with the direct estimate of 0.57 in (9). Thus, the estimated income elasticities are consistent. Although aesthetically satisfying, this, of course, may only indicate that the trend and cyclical biases in estimating η_m and η_a (and η_s) are consistent.

The previous results can also be used to find an implied upper limit for η_m with respect to the specification errors in the data. The experiments imposing trends on X_{st} (table 5) yielded an estimated upper limit for η_s of unity. On the assumption that this is also true for η_a, the estimated value for η_f of 0.35 implies an upper limit for η_m of 0.64. The estimated value for η_f of 0.45 when a trend variable was included (19) implies an upper limit for η_m of 0.67.

Experiments With an Expected Income Variable

All of the statistical results so far have been based on the Department of Commerce series on personal disposable income (measured income). This section reports the statistical results for the three demand relations based on the expected income series. The weights used to construct the expected income series are those derived by Friedman to estimate the consumption function. The question we are asking in this section is whether it would have been better to use the expected income series based on a concept of permanent income appropriate for the total consumption function. That is, whether this average concept is empirically satisfactory when applied to the different goods and services included in this study. Since the use of total consumption as a proxy for permanent income assumes the average concept (18), our findings also have implications for the use of this proxy in demand studies for food and food marketing services.

The statistical results are summarized in table 6; all of the regressions use quantity as the dependent variable. For the regressions based on the logarithms of the variables, the estimated income and price elasticities in the demand relations for manufactured foods (53) and for farm products (59) are about the same using the expected or the measured income series. For food manufacturers' services (56), the estimated price and income elasticities based on expected income are larger, but not statistically significantly larger and still not large

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[32] Taking partial derivatives of (47)

$$\frac{\partial X_{mt}}{\partial Y_t} = \frac{\partial X_{ft}}{\partial Y_t} + \frac{\partial X_{at}}{\partial Y_t}$$

and, multiplying both sides of the equality by $\frac{Y_t}{X_{mt}}$ and converting to elasticities,

$$\left(\frac{\partial Y_t}{\partial X_{mt}} \frac{X_{mt}}{Y_t}\right) = \frac{X_{ft}}{X_{mt}}\left(\frac{\partial X_{ft}}{\partial Y_t} \cdot \frac{Y_t}{X_{ft}}\right) + \frac{X_{at}}{X_{mt}}\left(\frac{\partial X_{at}}{\partial Y_t} \cdot \frac{Y_t}{X_{at}}\right)$$

or, using w_f for the farm share and η's for the income elasticities the result is (52).

TABLE 6.—*Estimates of U.S. civilian demand for manufactured farm foods, food manufacturers' services, and farm products based on expected income* [1]

Equation	Time period	Number of observations	Dependent variable	Variables (except T)	Constant term	Coefficients and standard errors (in parentheses) of independent variables					R^2	d
						P_{mt}	P_{st}	P_{ft}	Y_{et}	T		
Manufactured farm food products												
(53)	1919–41 1946–58	36	$\log X_{mt}$	log	0.373	−0.070 (.063)			0.572 (.047)		0.887	1.28
(54)	1920–41 1947–58	34	$\Delta\log X_{mt}$	$\Delta\log$	−.001	−.081 (.093)			1.110 (.316)		.285	2.78
(55)	1919–41	22	$\log X_{mt}$	log	−1.241	.062 (.063)			1.042 (.132)		.763	
Food manufacturers' services [2]												
(56)	1919–58	22	$\log X_{st}$	log	.899		−1.013 (.214)		.994 (.103)		.865	1.11
(57)	1919–58	22	$\log X_{st}$	log	2.030		−1.049 (.180)		.617 (.154)	0.004 (.001)	.909	2.13
(58)	1920–58	20	$\Delta\log X_{st}$	$\Delta\log$	−.003		−1.148 (.191)		1.270 (.389)		.766	2.45

Farm products consumed in food manufacturing

(59)	1919–41 1946–58	36	$\log X_{ft}$	log	1.084			−.057 (.036)	.330 (.041)		.736	1.40
(60)	1920–41 1947–58	34	$\Delta\log X_{ft}$	$\Delta\log$	.001			−.064 (.060)	.539 (.299)		.098	2.88
(61)	1919–41	22	$\log X_{ft}$	log	.565			−.027 (.046)	.489 (.156)		.332	

[1] Excludes fluid milk, cream, and poultry.
[2] Regressions based on biennial data from 1919 to 1939 and for 1947 to 1949; and on annual data from 1949 to 1958.

X_{mt}=per capita consumption of manufactured farm food products (measured at the factory level).
X_{st}=per capita consumption of food manufacturers' services related to farm products (measured at the factory level).
X_{ft}=per capita consumption of farm products consumed in food manufacturing (measured at the farm level).
P_{mt}=index of prices of manufactured farm food products based on wholesale prices deflated by the BLS consumer price index for all commodities (except manufactured foods).
P_{st}=index of implicit prices of food manufacturers' services deflated by BLS consumer price index for all commodities.
P_{ft}=index of prices of farm products consumed in food manufacturing deflated by BLS consumer price index for all commodities.
Y_{et}=per capita expected income.
T=trend (1919=1).
R^2=coefficient of determination.
d=Durbin-Watson statistic (* significant at the 5-percent level using a 2-tailed test).

enough to alter the conclusions based on measured income series. Greater reliance however, should be placed on the tests based on the regressions for manufactured foods and for farm products because these regressions use annual data during both the prewar and postwar years and because these data are better.

Differences between the estimated income elasticities using first-differences of the logarithms [(54), (58), (60)] and the logarithms themselves are greater when the expected income series is employed than when the measured income series is used. This is the opposite of what is implied by the permanent income hypothesis. The transitory components of income, which Friedman defines to include errors of observation, tend to be more important in first-differences than in the original data. Since expected income is not supposed to reflect the transitory component, the estimated income elasticities based on first-differences and on the original data should be more stable when the expected income series is used.

Equations (55) and (61) show the estimated income elasticities for manufactured farm foods and for farm products used in food manufacturing based on data for the prewar years, 1919–41, only. The estimated income elasticities based on data for 1919–41 and on data for the entire period 1919–41 and 1946–58 are considerably less stable when the expected income series is used. This, too, is not what we expect under the permanent income hypothesis. The greater importance of transitory factors in the actual series means that the estimated income elasticities based on measured income should be more affected by altering the length of the period. This is especially true for the periods considered here since the Great Depression of the thirties weighs heavily in the estimates based on data for 1919–41. This was a period presumably marked by large variation in the transitory component of income (*18*).

Still another test is to compare the coefficients of correlation. According to the procedure employed by Friedman, the pattern of weights chosen to construct the expected income series is the pattern that yields the consumption function with the maximum correlation coefficient. Comparison of all the regressions in table 6 and their counterparts in the other tables based on measured income show that in every case the correlation coefficients are smaller when the expected income series is used. At the extreme, the actual income series can be looked at as an empirical approximation to the permanent income concept for manufactured food with a weight of 1.0 in the current year and weights of 0 in all preceeding years. Thus, the larger correlation coefficients using the actual income data indicate that the estimated average horizon (roughly 3 years) underlying Friedman's calculations for the consumption function is too long for food.

These statistical results indicate that the permanent income concept appropriate for the total consumption function is inappropriate for foods and services related to foods. It also implies that total consumption is not an appropriate proxy for demand studies for foods and for food marketing services.

Previous and Future Research

Comparison of Findings With Previous Studies

Despite minor difference in scope, the elasticities estimated in this study bear comparison with those obtained by Fourt (*16*). Using quantity as the dependent variable, Fourt's estimated price elasticity (—0.38) and income elasticity (0.94) for manufactured foods for the period 1929–41 and 1946–54 are both substantially larger (in absolute value) than those estimated in this study. There was no attempt to completely reconcile Fourt's results with those in this study; but the main difference is apparently due to the "quality" of the quantity series used.

Fourt used the Department of Commerce series on corporate sales by food and kindred products manufacturers deflated by the BLS consumer price index and put on a per capita basis. Between 1929 and 1954, this deflated per capita series increased by 60 percent compared with an increase of 20 percent in the series on manufactured farm foods used in this study. The Commerce series on food expenditures (excluding alcoholic beverages) per person deflated by an index of retail food prices also rose less than 30 percent during the same period. There is little doubt that the series used by Fourt overstates the trend. The Commerce series on corporate sales is classified on a company basis and may be considerably removed from consumption of the finished processed food products. Among other things, it includes double-counting resulting from interfirm sales of unfinished commodities.

Again using quantity as the dependent variable, Fourt's estimate of the income elasticity for farm food products moving through the marketing system is 0.45, and his estimated price elasticity is 0.06. These estimates based on data for 1929–41 and 1946–54 are about the same as those made in this study.

Finally, Fourt's estimated income elasticities for processors' nonfarm purchases and for processors' own inputs imply an estimated income elasticity for food manufacturers' services (and for all goods and services added between farm and factory sales) of 1.20. Because of data problems, Fourt qualified these estimates and concluded that these income elasticities were not more elastic than the income elasticity for total farm-food marketing services (distribution and manufacturing services); his estimated income elasticity for the total was 1.42. Thus, the results in this study yield a more precise estimate.

The other studies mentioned in the Introduction are for total marketing services (manufacturing plus distribution services) related to all domestically produced farm food products (fresh as well as processed). The lower estimate of the income elasticity (0.96) made by Bunkers and Cochrane is conceptually closest to the estimates made in this study. Their estimate for total marketing services and the estimate for food manufacturers' services in this study implies that the income elasticity for distribution services is in the neighborhood of unity or larger than unity. This estimated income elasticity for food distribution services also reflects changes in the opportunity costs of the housewife's time.

Suggested Future Research

The most obvious suggestions for future research are that demand studies for food processing services be made at a much less aggregative level and that attempts be made to capture the effects of changes in household efficiency. The need to limit this study to total food manufacturers' services is especially unfortunate because it means, among other things, that the estimated demand relations reflect changes in the product and service mix. Changes in total manufacturers' services related to farm food products can result from (1) shifts among food commodities using different farm ingredients (meat and bread), or (2) shifts among food commodities made from the same farm product but having different amounts of manufacturers' services per unit of product (fresh and cooked ham). The time series used to measure quantity and price of manufacturers' services reflect both (1) and (2). Ideally, a demand relation should be estimated that would reflect (2) only.

Household survey data offer the potentially most fruitful approach for estimating pure income elasticities for food processing services.[33] Originally, an attempt was also made to estimate Engel curves for food processing services from household survey data; but, there are very few commodities which are specified finely enough for this purpose. Commodities published in consumer surveys are generally specified too broadly to be able to judge to what extent an estimated quality-income elasticity reflects an up-grading in the quality of the basic food ingredients, additional processing (marketing) services, or changes in the product mix.[34]

Given available statistics, household survey data also offer the best potential for gaging the effect of changes in household efficiency on the demand for food processing services. Surveys which include data on wages of employed housewives as well as data on income and demographic factors can be used to measure the importance of differences in housewife's opportunity costs on household processing. This would make it possible to separate the substitution effect from the true income effect.[35]

The above discussion indicates that the measurement problem in this study is essentially a refinement of the "quality" problem that

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[33] The problem of estimating the income elasticity of processing (or total marketing) services from household survey data is analogous to estimating the income elasticity of quality (that is, the elasticity of price with respect to income). In fact, the empirical quality-income elasticity is a weighted sum of the income elasticity of marketing services and the income elasticity of quality differences in the basic food ingredients. For an example of estimating quality-income elasticities from survey data, see Prais and Houthakker (*40*) and references cited in their bibliography. Fox (*17*), comparing the difference between the expenditure-income elasticity (0.28) and the quantity-income elasticity (0.14) for all foods (excluding condiments, alcoholic beverages, and coffee) estimated from the 1948 urban food consumption survey, states that "one-fourth, or one-third of the difference probably goes to marketing services." He does not tell how he arrived at this breakdown, however. For an explicit attempt to use consumer budget data in a study of total food marketing services and a review of the pitfalls, see Black (*4*).

[34] For an interesting illustration of the use of household survey data for food marketing services when ideally specified commodities can be found, see Reid's study of the demand for milk distribution services (*43*).

[35] See Mincer's use of the BLS 1950 Survey of Consumer Expenditures to study the labor supply function for married women (*34*).

arises in constructing index numbers for prices and quantities. A method suggested by Stone (*48*) and used by Griliches (*23*) for attacking the quality problem in price indexes may also be useful for measuring implicit prices and consumption of processing services as well as other kinds of marketing services.[36] The method would employ regression techniques in order to measure the relationship between the price of the manufactured food products and different kinds of processing services and food ingredients used in a group of processed foods. If this were done over a period of years, it would yield an index of the implicit prices for these services. This index could then be used to deflate a value added series for these services in order to obtain the quantity series.

Finally, the experiments with the permanent income hypothesis presented in this study indicate that future work in relating this hypothesis to food should begin by constructing an expected income series specifically for food. As the study indicates, the size of the estimated income elasticity will probably not be significantly different compared with using the Commerce series on disposable income (measured income); however, the permanent income hypothesis may yield more stable estimates of the income elasticities for food over time, as well as between budget data and time series, than econometricians have hitherto experienced with the absolute income hypothesis. An expected income series appropriate to total food would probably also be appropriate, in practice, for individual food products. It would also be interesting and useful to simultaneously experiment with expected price series for total foods and for specific foods.

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Appendix A: Relation Between Demand at Retail Level and Demand at Factory Level

None of the demand relations estimated in this study were measured at the retail level. The demand for manufactured farm foods (1) and the demand for food manufacturers' services (2) are demand relations facing food manufacturers; and the demand for farm products consumed in food manufacturing (3) is a demand relation facing farmers. Thus, the demand relation for manufactured farm foods reflects not only the behavior of households, but also the behavior and techniques of production of firms engaged in distributing processed foods. This appendix shows the relationship between the coefficients in the estimated demand relations

and the structural parameters in consumer demand relations which reflect household behavior only. It also shows how the reduced form relations used in the study were derived.[37] The analysis is limited to manufactured farm foods; however, the same reasoning applies to the other two demand relations.

The three structural relations used to derive the reduced form equation for manufactured farm foods are (omitting t subscripts):

(62) $X_r=\theta(P_r, Y, Z, T)$ — Household demand relation.

(63) $X_r=\rho(P_r, P_m, P_d, T)$ — Distribution sector's supply relation.

(64) $X_m=\gamma(P_m, P_r, P_d, T)$ — Distribution sector's derived demand for manufactured foods.

Where,

X_r = quantity of manufactured farm foods measured at the retail level.
X_m = quantity of manufactured farm foods measured at the factory level.
P_r = retail price of manufactured farm foods.
P_m = factory price of manufactured farm foods.
P_d = price of distribution services.
Y = per capita income.
Z = other demand shifters.
T = trend variable.

Conceptually, the price (index) of distribution services, P_d, is analogous to the implicit price (index) of food manufacturers' services, P_s. P_d is the supply price of all distribution services employed in getting manufactured farm products from factories to households. It reflects supply prices of labor, capital, and other inputs, and the techniques of production in the food distribution sector.

It is assumed that manufactured foods are sufficiently perishable so that there is no problem of stocks (that is, sales equal output); that there are no exports or imports; and that X_r and X_m are measured in the same units. It follows that [38]

$$X_m=X_r. \tag{65}$$

Assuming the same form for the three relations (linear in the logarithms of the variables) we can obtain the following behavior relation for the food distribution sector from (63), (64), and (65),

$$X_m=\eta(P_m, P_r, P_d, T). \tag{66}$$

Eliminating P_r from (62) and (66), the partially reduced form is

$$X_m=\phi(P_m, Y, Z, P_d, T). \tag{67}$$

From (62) and (65), we obtain the total differential,

$$dX_r=dX_m=\left(\frac{\partial X_m}{\partial P_r}\right)_\theta dP_r+\left(\frac{\partial X_m}{\partial Y}\right)_\theta dY+\left(\frac{\partial X_m}{\partial Z}\right)_\theta dZ+\left(\frac{\partial X_m}{\partial T}\right)_\theta dT \tag{68}$$

and from (66)

$$dX_m=\left(\frac{\partial X_m}{\partial P_m}\right)_\eta dP_m+\left(\frac{\partial X_m}{\partial P_r}\right)_\eta dP_r+\left(\frac{\partial X_m}{\partial P_d}\right)_\eta dP_d+\left(\frac{\partial X_m}{\partial T}\right)_\eta dT. \tag{69}$$

Solving for dP_r in (69) and substituting in (68), the result after eliminating and collecting terms is

$$dX_m=\left[1-\left(\frac{\partial X_m}{\partial P_r}\right)_\theta\left(\frac{\partial P_r}{\partial X_m}\right)_\eta\right]^{-1}\left[-\left(\frac{\partial X_m}{\partial P_r}\right)_\theta\left(\frac{\partial P_r}{\partial P_m}\right)_\eta dP_m\right.$$
$$-\left(\frac{\partial X_m}{\partial P_r}\right)_\theta\left(\frac{\partial P_r}{\partial P_d}\right)_\eta dP_d+\left(\frac{\partial X_m}{\partial Y}\right)_\theta dY+\left(\frac{\partial X_m}{\partial Z}\right)_\theta dZ+$$
$$\left.\left(\left(\frac{\partial X_m}{\partial T}\right)_\theta-\left(\frac{\partial X_m}{\partial P_r}\right)_\theta\left(\frac{\partial P_r}{\partial T}\right)_\eta\right)dT\right]. \tag{70}$$

[37] The formulation in this appendix is based on the work of Hildreth and Jarrett (*27*).

[38] The results would be essentially the same, if we assumed that $\frac{X_m}{X_r}$ = constant—that is, that the quantity of distribution services per unit of manufactured food remains constant.

We next obtain the total differential for (67),

$$(71)\quad dX_m=\left(\frac{\partial X_m}{\partial P_m}\right)_\phi dP_m+\left(\frac{\partial X_m}{\partial Y}\right)_\phi dY+\left(\frac{\partial X_m}{\partial Z}\right)_\phi dZ+\left(\frac{\partial X_m}{\partial P_d}\right)_\phi dP_d+\left(\frac{\partial X_m}{\partial T}\right)_\phi dT.$$

Equating coefficients from (70) and (71) and transforming to elasticities (where all elasticities are taken as positive numbers) the final results are:

$$(72)\quad E_{\phi P_m}=E_{\theta P_r}\left[\left(\frac{\partial P_r}{\partial P_m}\right)_\eta\frac{P_m}{P_r}\right]\left[1-\left(\frac{\partial X_m}{\partial P_r}\right)_\theta\left(\frac{\partial P_r}{\partial X_m}\right)_\eta\right]^{-1}$$

$$(73)\quad E_{\phi Y}=E_{\theta Y}\left[1-\left(\frac{\partial X_m}{\partial P_r}\right)_\theta\left(\frac{\partial P_r}{\partial X_m}\right)_\eta\right]^{-1}$$

$$(74)\quad E_{\phi Z}=E_{\theta Z}\left[1-\left(\frac{\partial X_m}{\partial P_r}\right)_\theta\left(\frac{\partial P_r}{\partial X_m}\right)_\eta\right]^{-1}.$$

The terms for the trend variable were not transformed to elasticities, but a brief glance at (70) and (71) indicates that the trend coefficient estimated in the reduced form relation (1) reflects not only household behavior, but also the behavior and production techniques employed in the distribution sector.

Turning to the elasticities, each of the terms to the right of the equality signs has the same denominator. The first partial derivative in the denominator, $\left(\frac{\partial X_m}{\partial P_r}\right)_\phi$, shows the change in quantity demanded by consumers with respect to changes in price, holding income and other things constant. This term multiplied by $\frac{X_m}{P_r}$ is the price elasticity of demand. Therefore, the first term can be assumed to be negative. The second term $\left(\frac{\partial P_r}{\partial X_m}\right)_\eta$, is from the distribution sector's behavior relation and shows the change in retail price with respect to changes in the quantity of manufactured foods moving through the system, holding the price of distribution services and the state of technology constant. Generally, this term can be expected to be greater than or equal to zero. If there are constant returns to scale and effective competition in input and product markets in the food distribution sector, this second derivative will be zero; if there are diseconomies of scale, it will be positive. For constant dollar margin or constant percentage margin, the partial derivative is zero. In sum, the denominator of each of the terms to the right of the equality signs is likely to be greater than or equal to one, that is:

$$\left[1-\left(\frac{\partial X_m}{\partial P_r}\right)\left(\frac{\partial P_r}{\partial X_m}\right)\right]\geq 1.$$

This means that the income elasticity, $E_{\theta Y}$, and the elasticity of any other demand "shifter", $E_{\phi z}$, are *at least* as large as those measured at the factory level. That is,

$$(75)\quad E_{\phi Y}\leqq E_{\theta Y}$$

$$(76)\quad E_{\phi z}\leqq E_{\theta z}.$$

Turning next to the price elasticity, there is another term, $\left[\left(\frac{\partial P_r}{\partial P_m}\right)\eta\,\frac{P_m}{P_r}\right]$, for which we have to guess the sign and limits. Hildreth and Jarrett have labeled this term the "elasticity of transmission." It shows the percentage change in retail price with respect to a given percentage change in the factory price, holding output, the price of other distribution services, and the state of technology constant. This term can be expected to be positive and probably less than or equal to one. In the case of constant percentage margins it is equal to one, for constant dollar margins it is less than one. The price elasticity of consumer demand at the retail level is, therefore, *probably at least* as large as the price elasticity measured at the factory level. That is,

$$(77)\quad E_{\phi P_m}\leqq E_{\theta P_m}$$

where both price elasticities are measured as positive numbers.

Appendix B: Some Demographic Factors

Movement of population off farms and historic changes in family composition and size have, to varying degrees, affected total food consumption. This appendix reports some attempts using household survey data to determine whether changes in these demographic factors were empirically important enough to have shifted the aggregate demand relations estimated in this study.[39] Besides the economic question of finding demand shifters, there is also the problem of statistical specification errors. Demographic changes are often correlated with changes in monetary variables, and their omission in the regression analysis can bias the estimated parameters.[40]

Movement of Population Off Farms

Farm families have historically produced, and still produce, a substantial fraction of food for home consumption. Farm production used in home consumption requires farm families to perform many services in preparing and preserving foods that urban consumers generally buy. Thus, movement of families off farms could significantly increase the demand for manufactured farm foods. In order to test whether there is a difference between farm and nonfarm purchases of manufactured farm foods—and whether the pattern has changed over time—published household survey data were first adjusted for differences in family size and then standardized for differences in money income (table 7).[41] That is, farm and nonfarm differences were estimated holding (measured) income and family size constant. For intertemporal comparisons, it was assumed that all urbanizations experienced similar price changes.[42]

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[39] Problems of gaging the importance of changes in demographic ("taste determining") factors in empirical research are legion: Variations in consumer behavior which cannot be explained by available income and price series may reflect not only differences in tastes, but also (probably) the researcher's inability to measure relevant (including implicit) prices or to correctly "allow" for incomplete adjustment to changes in monetary variables. These problems are well illustrated in comparing food consumption behavior between farm and nonfarm families and behavior between households with and without employed homemakers. This study will necessarily beg off the problem of identifying these different kinds of specification errors. For a discussion of tastes in the theory of demand, see Stigler (*47*).

[40] The trend term used in estimating the demand relations acts as a proxy for demographic factors; however, it is obviously not possible to know how good a proxy it is. Too, a statistically significant trend may also reflect understatement of quality improvements in the quantity series, choice of the wrong form of the estimating equation, or a host of other possible specification errors correlated with time.

[41] Adjustment for family size was based on a food expenditures-family size elasticity of ⅓ estimated by Brady and Barber (*5*). The Brady-Barber estimate relates to expenditures for all foods, not just manufactured farm foods. The elasticity obviously varies among foods; however, judging from Burk's data (*10*), commercially processed farm foods included in this study accounted for about three-fourths of the value (in farm prices) of all farm-produced foods handled commercially in both 1925 and 1954. Hence, the error from using the Brady-Barber estimate is not likely to be significant on this account.

The Brady-Barber estimate was obtained by holding measured income constant. Friedman argues that because average permanent income tends to increase with family size, a partial correlation analysis holding measured income fixed tends to bias the estimated family size elasticity upward. Perhaps a more obvious possible error is that the Brady-Barber estimate is based on a simple count of heads and takes no account of age or sex composition. These biases are probably also not important for the analysis based on table 7.

[42] The basic data for spring 1942 are from the survey of Family Spending and Saving in Wartime (*57*) (hereafter FSSW) and for spring 1955 from the Household Food Consumption Survey for 1955 (*59*) (hereafter HFCS). The HFCS reports only disposable *money* income; thus to make intertemporal comparisons, the FSSW data were also classified by disposable money income. The data were standardized for differences in money income between spring 1942 and spring 1955 by "imposing" the 1955 *money* income distribution for *all* urbanizations reported in the HFCS on urban, rural nonfarm, and rural farm households in both spring 1942 and spring 1955.

TABLE 7.—*Value of purchased manufactured farm foods per household adjusted for differences in household size by urbanization, week in spring 1942 and spring 1955* [1]

Spring 1942 [2]		Spring 1955 [3]	
Money income (after income taxes)—dollars	Value purchased manufactured farm foods—dollars	Money income (after income taxes)—dollars	Value purchased manufactured farm foods—dollars
URBAN		URBAN	
0–499	3.26	Under 1,000	9.23
500–999	4.43	1,000–1,999	10.03
1,000–1,499	5.71	2,000–2,999	12.33
1,500–1,999	6.28	3,000–3,999	14.43
2,000–2,499	7.34	4,000–4,999	15.31
2,500–2,999	7.62	5,000–5,999	16.57
3,000–4,999	8.48	6,000–7,999	16.81
5,000–9,999	9.23	8,000–9,999	17.18
		10,000 & over	20.89
RURAL NONFARM		RURAL NONFARM	
0–499	3.09	Under 1,000	7.08
500–999	4.42	1,000–1,999	9.44
1,000–1,499	5.26	2,000–2,999	12.55
1,500–1,999	5.84	3,000–3,999	13.33
2,000–2,999	6.51	4,000–4,999	14.79
3,000–over	7.21	5,000–5,999	15.91
		6,000–7,999	16.68
		8,000–9,999	18.57
		10,000 & over	16.27
RURAL FARM		RURAL FARM	
0–499	2.56	Under 1,000	7.28
500–999	3.20	1,000–1,999	9.25
1,000–1,499	3.72	2,000–2,999	10.47
1,500–1,999	4.98	3,000–3,999	10.92
2,000–2,999	4.43	4,000–4,999	11.34
3,000–over	4.62	5,000–5,999	12.93
		6,000–7,999	12.81
		8,000–9,999	12.80
		10,000 & over	16.58

[1] Excludes fluid milk, cream, and poultry. Differences in household size adjusted by using total food consumption elasticity with respect to family size of ⅓ estimated by Brady and Barber (*5*, p. 198).

[2] Data compiled from Family Food Consumption in the United States (*57*).

[3] Data compiled from Food Consumption of Households in the United States (*59*).

The computations indicate that, if there had been no difference in money income or family size among different urbanizations during the survey week of spring 1942, urban families would have spent $6.26 for manufactured farm foods compared with $5.66 spent by rural nonfarm families and $4.21 by rural farm families. During the survey week of spring 1955, comparable estimates (in 1955 prices) show that urban households would have spent $14.48 compared with $13.76 spent by rural nonfarm households and $11.33 by rural farm households. These

figures indicate that although average purchases of manufactured farm foods by urban households declined relative to average purchases by farm families—from 1.5:1 to 1.3:1—the difference remained substantial.[43]

These ratios were used to approximate the partial effect (that is, holding income and family size constant) of the movement of the population off farms on the historic rise in purchased manufactured farm foods. In 1919, about 30 percent of the total population lived on farms compared to 12 percent in 1958. If we assume that the ratio was 2 : 1 in both years (certainly an upper limit), then food purchases per 3.5-person family in 1958 would have been about 10 percent larger than in 1919 because of the movement of the population off farms. Since the difference between farm and nonfarm household purchases has been shrinking over the last four decades, the effect of the movement of population off farms is probably smaller than 10 percent.[44] In sum, the movement of families off farms could have significantly increased the demand for factory processed farm foods.[45]

Family Composition

Apparently, changes in age and sex composition of families during the period 1919 to 1958 have not had a significant effect on expenditures for food. Although this conclusion is based on less than satisfactory estimates of equivalent expenditure scales and on some experimenting, more precise estimates would probably not alter the conclusion significantly.[46]

Because of the way in which the data are presented in publication, the analyses of family composition and size (in the next section) are in terms of total food, not just manufactured domestic farm foods. This qualification, too, is probably not important for this study.[47]

Estimates of adult equivalent expenditures scales from survey data indicate that the largest difference occurs between children less than 10 years old and other persons (table 8).[48] In 1920, the number of children less than 10 years of

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[43] Again, these results are based on holding measured, not permanent, income constant. As noted in footnote 41, Friedman has pointed out that partial correlation analysis employing measured income "disguises" rather than eliminates the influence of income (*18*). For any given level of measured income, permanent income is likely to be higher for nonfarm households than for farm households. Hence, if the permanent income hypothesis is accepted, the difference between nonfarm and farm household purchases of manufactured foods is apt to be overstated because the estimates reflect differences in permanent income.

Also, some of the difference in purchases between farm and nonfarm households undoubtedly reflects differences in (nonmeasurable) costs which could not be captured in the analysis. These two biases, although in the same direction, probably do not account for the total difference between farm and nonfarm food consumption behavior; however, they do indicate that the estimated importance of movement of families off farms may be overstated.

[44] It may also be overstated for the reasons given in footnote 41.

[45] Although the discussion in the text has been limited to a comparison of farm and nonfarm families, we are interested in all population and occupational characteristics and changes in these characteristics that significantly affect consumer demand for manufactured farm foods. However, the comparison between farm and nonfarm families is not completely arbitrary; as far as I know, the difference between income-expenditures patterns for foods between these two groups is larger than between any other population groups for which estimates have been made. For a comparison of food consumption in different size cities and different regions, see Tobin (*49*).

[46] The original intention was to use, in the time series analysis, a population series weighted by expenditures scales (that is, adult equivalent units) instead of "unweighted" population; however, this presents more problems than it solves. Strictly speaking, it would require equivalent income scales ("ammains") for the income variable as well as equivalent expenditure scales ("fammains") for the manufactured food expenditures variable (*40*). For time series studies of the demand for food using equivalent adult expenditure units, see Bunkers and Cochrane '8.

[47] See footnote 41.

[48] For a review of expenditures scales between 1917 and 1937, see Woodbury '52. Woodbury concludes that " . . . the difference in scales representing the relative costs for persons of different ages and sex to that of the adult male, are relatively minor, though doubtless ample to justify the adoption of the best scale in place of one poorly adapted to the needs of the particular problem."

age accounted for about 22 percent of the total population; the ratio declined to 16 percent in 1940, and rose again to 22 percent in 1958 (table 9). A food expenditure scale of 0.35 for children less than 10 years old and a scale of 1.00 for all persons 10 years of age or older was assumed as a first approximation. This should overstate the effect of the change in age distribution on food expenditures (table 8). Using these scales, per capita food expenditures would have increased 4 percent

TABLE 8.—*Expenditure scales for foods by age and sex, United States and Great Britain*

Age and sex	United States		Great Britain	
	Stiebeling and Phipard 1936 [1]	Institute of Home Economics 1960 [2]	Prais and Houthakker 1937–39 [3]	Brown 1951 [4]
	Percent	*Percent*	*Percent*	*Percent*
Moderately active man (20 to 74 years old)	100	100	100	100
Boys:				
Less than 1 year old	51	42	32	59
1 year old	54	51	51	59
2 years old	55	51	51	59
3 years old	59	51	51	59
4 years old	61	63	51	59
5 years old	65	63	55	68
6 years old	73	63	55	68
7 years old	80	75	55	68
8 years old	87	75	55	68
9 years old	91	75	55	68
10 years old	95	90	69	68
11 years old	98	90	69	68
12 years old	103	90	69	68
13 years old	107	106	69	68
14 years old	112	106	82	101
15 years old	112	106	82	101
16 to 19 years old	114	124	82	101
Women: Moderately active women (20 to 74 years old)	92	80	86	[5]
Girls:				
Less than 12 years old	[5]	[5]	[5]	[5]
12 years old	93	[5]	[5]	[5]
13 years old	97	96	65	[5]
14 years old	101	96	65	[5]
15 years old	101	96	65	[5]
16 to 19 years old	100	96	65	[5]

[1] Based on diets of employed wage earners and clerical workers in cities who spend moderate amounts for food, using July–August 1936 retail food prices; see Stiebeling and Phipard (*46*).

[2] Based on moderate-cost plan diet developed by Institute of Home Economics using the Household Food Consumption Survey 1955 and retail prices in 1960. Recommended scales about the same as actual expenditures for families with incomes between $4,000 and $5,000; see Family Economics Review (*56*).

[3] Based on *actual* expenditures reported by working and middle-class families in 1937–39; see Prais and Houthakker (*40*).

[4] Based on actual expenditures reported in survey for first 7 months of 1951, a year of price controls and rationing in Great Britain. Brown (*7*) used his basic scale "First Man and Woman in Households (over 20)" for which he assumed a value of 2.00. For other adult men and women, he reports weights of 0.90 and 0.87, respectively.

[5] The same as reported for boys, when reported. (Stiebeling and Phipard report slightly different scales for boys and girls under 12 years.)

TABLE 9.—*Percentage of population less than 10 years old, and population weighted by expenditures scales per person, selected years 1920 to 1958*

Year	Percentage of population less than 10 years	Per capita, weighted population using expenditures scales based on—	
		Assumed values under 10, 0.35; 10 and over, 1.00	Institute of Home Economics Moderate-Cost Plan
	Percent	*Percent*	*Percent*
1920	21.8	100.0	100.0
1940	16.1	104.4	101.6
1950	19.5	101.8	99.3
1958	21.7	100.0	98.4

Sources: Historical Statistics of the United States (*69*) and Family Economics Review (*56*).

from 1920 to 1940 and declined about 4 percent from 1940 to 1958, as a result of the change in the proportion of population less than 10 years of age.

There have been two attempts to estimate equivalent expenditures scales for food in Great Britain (table 8). However, the only scales I know for food expenditures in the United States are based on nutritional requirements—that is, they estimate what families *need* rather than what they actually *spend*. In an attempt to further test the importance of changes in family composition, weights were derived from the Moderate-Cost Plan developed by the Institute of Home Economics from the HFCS (table 8). Although the scale using the Moderate-Cost Plan is based on nutritional units, it is virtually the same as the food expenditures scale for households with incomes between $4,000 and $5,000, reported in the HFCS.[49] The more refined analysis based on the Moderate-Cost Plan scale also indicates that changes in the age-sex composition of the population did not significantly affect food expenditures during either the interwar or post-World War II periods (table 9).

Family Size

The decline in average size of households since the end of World War I has probably had a significant effect on per capita consumption of manufactured farm foods. Again, the direction of change is clear, but only a rough guess can be made of the magnitude.

Survey studies have consistently—if not unambiguously—shown that there are substantial economies of scale in family expenditures for food—that is, holding (measured) income constant, an increase in family size is accompanied by a less than proportionate increase in food expenditures. Brady and Barber (*5*), using all surveys between 1901 and 1944 in which food expenditures are tabulated by income and family size, estimated the partial elasticity of food expenditures with respect to size of *urban* families to be about one-third.[50] Their estimates

[49] A potential source of error in using this scale is the change in relative prices over time; children's diets include relatively more milk and less meat than adults' diets, and the price of meat has risen relative to the price of milk since World War I. It would, however, be a major task to adjust for price changes. Comparison with the Stiebeling-Phipard scale for 1936 (table 8) suggests that it would probably not be important for this study. For a brief review of pitfalls in adult equivalent scales, see Reid (*42*).

[50] For qualifications in the use of the Brady-Barber estimate in this study, see footnote 41. These qualifications also apply to the other estimates of the family size elasticity discussed in the text and are probably more serious in the present context than in the previous analysis of movement of families off farms.

ranged from one-fourth to one-half and appeared to center around one-third which they finally accepted. Tobin, using only the FSSW for *urban* families in 1941, obtained an estimate of one-fourth (*40*). Both the Brady-Barber and Tobin estimates measure family size by a simple count of heads; it would be preferable to have a measure holding family composition constant.

From 1920 to 1957, the (arithmetic) average size of households declined from 4.34 to 3.42—that is, a decline of 21 percent.[51] Applying the Brady-Barber estimate of one-third, expenditures for food would have decreased about 7 percent per household because of the decline in family size from 1919 to 1957. Thus, household consumption *per person* could have increased as much as 17 percent. The Brady-Barber estimate of one-half implies that household consumption per person could have risen 13 percent. These rough estimates suggest that the decline in the average size of households could have significantly increased per capita consumption of total foods—and manufactured farm foods—during the four decades included in this study. Unfortunately, historical data on family size are far too aggregative to show any interesting variations that might have helped explain changes in civilian consumption of manufactured farm foods. Omission of a variable for household size in the regression analysis, however, could mean that the estimated income elasticity is biased upward.

We can now summarize the findings in the appendix: The evidence based largely on household survey data suggests that both the movement of population off farms and the decline in average household size could have significantly increased the demand for manufactured farm foods during the period 1919–58. Apparently, changes in family composition did not significantly affect the demand for total manufactured farm foods. None of those findings, however, is based on too firm data.

Appendix C: The Data

This appendix describes in greater detail specification errors in the time series employed in the statistical part of the study. Several of the series were developed especially for this study; these series are described in greater detail than the others. The discussion deals mainly with three kinds of specification errors in the series: (1) The so-called index-number problem, (2) the quality problem (including changes in processing services per unit of product), and (3) a rigidity (or systematic lag) between reported and transactions prices. Before turning to the specific series, some general comments can be made about (1).

As is well known, an index-number formula computed with base-period weights (Laspeyres formula) and one with given-period weights (Paasche formula) can yield significantly different results. However, as is equally well known, the base-period and given-period weighted indexes can be used to bracket the true index. Ideally, we might construct both base and given-period weighted indexes of all the series, and, if they differed significantly, run analyses on the two sets of data and use the estimated coefficients to set limits on the index-number problem. As a practical matter, data for deriving weights for most of the series are not available for both base and given years: Where sufficient data are available, it would be a major undertaking to construct the two indexes. A cross-weight formula (a variation of the Marshall-Edgeworth formula) and frequent weight periods were used. Index numbers computed by the cross-weight formula will lie somewhere between the Laspeyres and Paasche indexes. Use of the cross-weight formula and of frequent weight periods should "reduce" the index-number problem.

Manufactured Farm Foods

The series on consumption of manufactured farm food products (table 10) was constructed mainly from published and unpublished data on the value of output of finished commodities. As originally defined by Kuznets (*28*) and used in this study, finished commodities are commodities in their ultimate form for purchase by households; unfinished commodities are those destined for further processing. Data for value of finished manufactured foods are almost totally estimated from value of product data published in the Census of Manufactures. Hence, the series on consumption of manufactured farm foods relates to factory production only (that is, factory production within the scope of the Census of

[51] Figures measure population per household, not desired statistics on family size.

Manufactures).[32] These production data unfortunately reflect distribution as well as processing services performed by food manufacturers. A very rough estimate based on fragmentary data suggests that these distribution services could account for a significant percentage of the value of output of manufactured foods; this problem is reviewed in more detail in the section on food manufacturers' services.

Data on finished manufactured foods are only available in years for which there have been Censuses of Manufactures. The data used in this study are from the following sources: Biennial estimates between 1919 and 1929 are from Kuznets (*88*); biennial estimates between 1929 and 1939 are from the Office of Business Economics (*70*); and for the first two postwar censuses, 1947 and 1954, unpublished

TABLE 10.—*Index numbers: Per capita civilian consumption and deflated wholesale price of manufactured domestic farm foods, United States, 1919–41 and 1946–58*[1]

(1947–49=100)

Year	Consumption manufactured foods[2] (X_m)	Deflated wholesale price manufactured foods[3] (P_m)	Year	Consumption manufactured foods[2] (X_m)	Deflated wholesale price manufactured foods[3] (P_m)
1919	81.4	99.7	1938	88.0	66.4
			1939	93.1	63.6
1920	85.4	84.5			
1921	72.4	63.8	1940	93.3	64.3
1922	77.2	64.3	1941	97.4	72.4
1923	81.4	64.2			
1924	86.7	63.3	1946	110.6	84.3
1925	84.0	69.3	1947	102.7	103.6
1926	86.1	68.3	1948	96.2	104.6
1927	86.8	67.3	1949	101.1	92.2
1928	84.6	72.3			
1929	90.4	70.8	1950	103.4	94.3
			1951	100.1	101.1
1930	88.5	64.8	1952	104.2	93.7
1931	81.4	58.0	1953	107.6	86.6
1932	74.6	52.3	1954	109.2	86.0
1933	75.4	56.2	1955	113.8	82.8
1934	78.1	65.5	1956	114.1	80.1
1935	72.9	80.4	1957	110.8	81.6
1936	85.5	75.4	1958	116.0	85.9
1937	82.7	77.4			

[1] Excludes fluid milk, cream, and poultry.

[2] Consumption is measured at the factory level; does not reflect distribution services added by the distribution sector.

[3] Based on BLS wholesale prices for manufactured foods weighted according to their relative importance in consumption. Wholesale price series was deflated by the BLS consumer price index for all commodities, except manufactured farm foods.

Sources: Data on output of finished commodities from Kuznets (*88*); Shaw (*46*); Department of Commerce (*70*), and official statistics of Office of Business Economics, Department of Commerce. Interpolating series on corporate sales by food and kindred products manufacturers from Department of Commerce, Survey of Current Business (*71*).

[32] Apparently, factory processing of farm foods accounted for about the same fraction of total farm products processed by the marketing system in 1954 as in 1919. The ratio of the value of factory inputs of farm products to all marketed farm products destined for commercial processing was 93 percent in 1954 compared with 91 percent in 1919.

estimates were obtained from the OBE.[31] Between 1919 and 1929, Shaw's annual series (57) on value of finished output of food and kindred products was used to interpolate the biennial estimates for value of finished output of manufactured farm foods. OBE annual series on corporate sales by food and kindred products manufacturers (71) was used to interpolate the biennial estimates between 1929 and 1939 and between 1947 and 1954, and to extrapolate the series to 1958.[32] The annual series on value of output of finished manufactured farm foods was adjusted using ERS data for changes in inventories, exports, and disappearance to the military (54, 84) in order to arrive at value of civilian consumption of manufactured farm foods measured in current dollars.

A secular bias in the series on consumption of manufactured farm foods could arise from changes in census coverage. The Bureau of the Census sets a minimum size limit for establishments to be included in the Census of Manufactures. Changes in this size limit or a trend of movements out of this minimum size group can result in a secular bias in the series. In the censuses between 1919 and 1939, establishments with less than $5,000 value of products were excluded; in the post-World War II censuses, reports were required from all establishments employing one or more persons at any time during the census year. Fabricant's review (17) of the coverage problem for the interwar years indicates that neither movements in or out of the minimum size groups appreciably affected the historical comparability of the series. Similarly, the Bureau points out in the 1947 census that comparability for industries manufacturing food products was not appreciably affected by the revised limit.

Aside from the minimum size problem, the scope of the Census of Manufactures has also been affected slightly by the Census Bureau's reclassification of establishments from the Census of Manufactures to the Census of Business. The most significant reclassification is for bakery products in 1947 and again in 1954. In 1947, the Bureau reclassified into the Census of Business those retail bakeries engaged in producing and selling baked goods on the premises which were not part of retail multi-outlet bakeries. According to the Bureau, "production of such bakeries amounted to 10 percent of total [of the bakery industry] in 1939" (66). In 1939, value of output of the bakery industry accounted for about 20 percent of total consumption of manufactured farm foods. Thus, this change in coverage in the bakery products industry would amount to about 2 percent of the total for all processed foods.

In the 1954 Census of Manufactures, all establishments producing bakery products for direct sales to consumers on premises were also classified into retail trade; that is, even those that were part of a chain. According to the Bureau, "comparability between 1947 and 1954 is not significantly affected for Industry 2051 [bread and related products]. . ." (66). Thus, the effect of the 1954 reclassification on total food would again be negligible.[33]

In order to obtain the quantity series, the linked and interpolated series on value of consumption of processed domestic farm food products in current dollars was deflated by a wholesale price index for these foods. The wholesale price

[31] Kuznets' series and the OBE series were simply linked in 1929. The only significant difference between the two series was in meat products. Kuznets apparently treated total shipments of fresh meat products by food manufacturers as finished products. Actually, about 20 percent of this should have been treated as unfinished commodities destined for further processing into sausages, cooked hams, and other processed meats. Information is not available for estimating the trend in this ratio before 1929. This double-counting, however amounted to less than 6 percent of total consumption of manufactured foods in 1929. Hence, unless there was a major trend between 1919 and 1929 in the proportion of fresh meats destined for further processing, the simple linking would only result in a negligible error for this study.

[32] I also experimented with OBE data on food manufacturers' sales and, for the post-World War II years, value of shipments of food manufacturers from Bureau of Census, Annual Surveys of Manufactures, for possible use as interpolating series. The OBE corporate sales series was used because it was most closely correlated with the basic series on value of output of finished manufactured foods.

[33] Judging from data reported by the Department of Agriculture, there may also be some differences in the Census coverage of factory production of natural cheese and ice cream. In 1947, factory production of manufactured cheese reported in the Census was 15 percent below factory production reported by Agriculture, and production of ice cream was 10 percent lower. Although this difference is important for manufactured dairy products, it accounts for less than 1 percent of total consumption of manufactured farm foods.

index was constructed from published BLS wholesale price indexes for individual food groups. These price series were weighted by value of finished commodities using both 1919 and 1954 weights; the two indexes usually differed by no more than an error due to rounding. Between 1919 and 1958, the 1919 weighted index rose 143 percent and the 1954 value weighted series rose 146 percent. The price index actually used to deflate the value series was a cross-weighted index using both 1919 and 1954 weights.

In sum, there are no apparent significant errors in the index of consumption of manufactured farm foods in this study because of changes in the scope of the basic data derived from the Census of Manufactures or because of the index number problem. That is, the estimated parameters in the demand relation for manufactured farm foods would not tend to be significantly biased because of these errors in the data. Errors resulting from the quality problem and the use of reported rather than transactions prices which could bias the estimated parameters were analyzed in the section on statistical findings. These errors are reviewed further in the section on food manufacturers' services.

Farm Products Used in Food Manufacturing

The series on quantity of farm products used in food manufacturing measures the quantity of these products at the farm level (that is, it is weighted by farm prices—table 11). On the whole, it does not reflect assembly and transportation services used in moving farm products from the farm gate to the factory. It would be preferable to have these distribution services included (that is, to have the farm inputs weighted by factory delivered prices), but this is not possible with available data. The quantity series used is based on a deflated farm value series. The farm value series was constructed from ERS data on the farm value components of civilian expenditures for farm-originated products and from Census of Manufactures data on the value of meat animals slaughtered in meatpacking plants (*61*). The price deflator is based on SRS prices received by farmers (*71*) with weights of factory inputs derived from the Bureau of Labor Statistics Interindustry Study for 1947.[56]

The farm value component is based mainly on ERS estimates of cash receipts from farm marketings. The farm value is the estimated part of the cash receipts derived from food for civilian domestic use. It includes raw farm products destined for processing in factories or in retailing and wholesaling establishments, and also those processed on farms for direct off-farm sales or consumed in fresh form. It does not include food processed for "home consumption" on farms where produced. Using unpublished data available within the Department of Agriculture, the value of farm products consumed in fresh form (fresh fruits and vegetables, eggs, and so on) was subtracted from the total farm value component of civilian expenditures. The value of milk destined for use as fluid milk and cream and of poultry products was also subtracted in keeping with the scope of this study. The remainder represented the farm value of products consumed in factory and nonfactory processing of foods.

The value series for farm products consumed in factory processing only (that is, excluding commercial nonfactory processing) was derived as follows: Censuses of Manufactures include historically comparable data by species on number, weight, and delivered cost of animals slaughtered in the meat products industry. Fortunately, value of meat animals slaughtered in factories has accounted for more than half the value of all farm inputs in food manufacturing, and the meat products group is the only one where the trend from nonfactory to factory production has been significant for total manufactured farm foods. To estimate the series on the farm value of animals slaughtered in factories, trends were imposed between census years (1919, 1929, 1939, 1947, and 1954). Since the census data are in delivered prices, not farm prices, this means that the rise in the farm value of the meat products component probably is overstated to some extent. However, the cost of marketing livestock accounts for less than 10 percent of the total factory delivered price so that the effect of any overstatement on the total value of all farm foods is small and probably negligible.[57]

The value of farm products other than meat products consumed in factory processing of foods was taken directly from published and unpublished data used

[56] The price deflator was actually constructed from the same data used to derive the price deflator for cost of materials and supplies in the computations of the double-deflated value added series (see pp. 52–53).

[57] The 10-percent figure is based on calculations of the consumer's dollar for meat and meat products in 1939 (*5*).

TABLE 11.—*Index numbers: Per capita civilian consumption and prices of farm products consumed in food manufacturing, United States, 1919–41 and 1946–58* [1]
(1947–49=100)

Year	Consumption farm products [2] (X_f)	Price farm products [3] (P_f)	Year	Consumption farm products [2] (X_f)	Price farm products [3] (P_f)
1919	84.2	100.3	1938	90.3	54.7
			1939	90.3	53.4
1920	82.8	75.2			
1921	80.3	52.5	1940	95.3	54.2
1922	87.4	54.6	1941	96.3	67.2
1923	90.4	55.2			
1924	96.0	53.9	1946	103.3	94.6
1925	95.4	62.5	1947	103.5	107.6
1926	94.5	62.0	1948	98.8	105.4
1927	91.4	62.4	1949	97.8	87.7
1928	89.7	66.0			
1929	90.0	66.4	1950	98.6	94.0
			1951	92.1	104.5
1930	89.5	57.3	1952	96.8	91.0
1931	89.0	42.7	1953	102.6	79.0
1932	82.4	34.6	1954	104.0	76.9
1933	85.3	38.2	1955	109.0	68.6
1934	92.8	44.6	1956	110.0	66.0
1935	81.2	62.2	1957	105.8	70.4
1936	89.6	65.0	1958	102.4	76.0
1937	89.9	65.7			

[1] Excludes fluid milk, cream, and poultry.

[2] Quantity series is measured at the farm level; excludes assembly, transportation, processing, and other marketing services.

[3] Based on SRS prices received by farmers with weights of factory inputs derived from the BLS Interindustry Study for 1947. The farm price index was deflated by the BLS consumer price index for all products.

Source: Censuses of Manufactures (*66*); Farm-Retail Spreads for Food Products (*58*); and Agricultural Statistics (*53*).

in constructing the farm value series of the marketing bill statistics. These data include value of farm produced materials used in processing manufactured dairy products (excluding fluid milk and cream), processed fruits and vegetables, grain-mill and cereal products, bakery products, sugar and confectionery, and miscellaneous manufactured foods. Data are not available for adjusting any of these components to exclude amounts used in nonfactory processing.[58]

To obtain the series on quantity of farm products consumed in food manufacturing, the value series in current dollars was deflated by a farm price index constructed from SRS prices received by farmers, weighted by their relative importance as farm inputs in food manufacturing in 1947.[59] It was unfortunate

[58] Errors could result from using unadjusted components because of: (1) The exclusion of small factories from the Census of Manufactures because of the Bureau's rule on minimum size; (2) shifts between factory and retail baking; (3) shifts between retail and factory processing of ice cream; and (4) shifts from on-farm churning of butter to factory production of creamery butter. In the previous section, it was noted that (1), (2), and (3) were not significant for total manufactured farm foods. For the same reasons, they are probably not significant for total farm products consumed in food manufacturing. As for (4), in 1929, a year when on-farm churned butter for off-farm sale might have been a significant factor, it was less than 1 percent of total creamery butter produced. Creamery butter at this time accounted for less than 10 percent of total value of manufactured foods.

[59] SRS prices received were used rather than the farm price components of the BLS wholesale price index because the SRS series have better historical comparability. Actually, the two series move closely together.

that 1947 had to be taken as a weight-year because prices of farm food products were near an all-time high, and the relative importance was probably affected. However, there was no alternative; the weights were obtained from the BLS Interindustry Study for 1947, the only source of data for constructing the weights. The price index used to deflate the value of farm inputs was compared with a price index constructed from the farm value of the ERS Farm Food Market Basket which is based on weights for 1935–39 and for 1952. The two indexes showed about the same annual movements. This suggests that the use of 1947 weights in the input price index may not be a significant source of bias. To the extent that the index number problem is important, the price series, because it uses the Laspeyres formula, may have an upward secular bias; and the deflated value series may have a downward secular bias.

According to SRS, prices received by farmers are intended to measure average price *per unit of commodity sold* rather than prices received for a particular grade or quality of the commodity. Since there has probably been a secular improvement in the quality of farm products, the use of unit values means that the price index probably has a secular upward bias, and the quantity series probably has a downward secular bias. The Price Statistics Review Committee pointed out that on the basis of its limited evidence the SRS series on prices received are neither unit values nor specified prices but something in between (*37*).

Two rough comparisons were made in this study to test the quality problem further. Data are available from the Census of Manufactures for constructing an index of average *delivered* prices of animals slaughtered in packing plants between 1929 and 1958. This series is definitely based on unit values and includes unit costs of transportation and assembly, which rose at least as much as farm prices during the three decades.[59]

Thus, the Census implicit price index for meat animals should have risen as much or more than the SRS index of prices received for farm animals; in fact, they both increased by the same percentage (about 105 percent). Next, the farm products price component of the BLS Wholesale Price Index, which at least purports to be based on specified prices, was compared with the index of prices received for all farm products; the former rose 62 percent between 1929 and 1958, and the latter 69 percent. Although those comparisons are crude, they suggest that the aggregate farm price index used in this study is probably close to a unit value index and reflects quality improvements in farm products to some extent.

In sum, there are three potential sources of secular bias in the price and quantity series for farm products consumed in food manufacturing: (1) the index number problem, (2) the quality problem, and (3) an upward bias in the quantity series because Census data on *delivered cost* of live animals slaughtered in factories was used to estimate the trend in the *farm value* of meat products slaughtered in factories. Biases resulting from (1) and (2) are in the same direction, the bias resulting from (3) is in the opposite direction. Thus, the price series is probably biased upward, and the quantity series is, on net, probably biased downward.

Food Manufacturers' Services

By far, the most difficult and time consuming part of this study was measuring the quantity of food manufacturers' services. Ideally, to construct aggregate price and quantity indexes of food manufacturers' services it would be desirable to have individual quantity series which measure the host of activities that food manufacturers perform in transforming farm products into finished processed foods. The ideal price index would be constructed using the prices of these processing *activities;* the prices would be weighted by quantities of *activities* in some base period.

There is *obviously* no reasonable hope of directly measuring these prices and quantities at this time. Therefore, we will do what other makers of index numbers do—accept the judgment of the market. To oversimplify the essential idea underlying the measurement of food manufacturers' services, the spread between the factory price of the processed food product and the purchase price of the materials and supplies bought by manufacturers measures the value of manufacturers' services per unit of physical product. Thus, the difference in the price spread between cooked and fresh ham in a given market at a given time measures the value of the cooking services.

[59] The index of railroad freight rates for livestock products increased about 165 percent from 1919 to 1958, whereas farm prices of livestock rose about 70 percent (*58*).

Conceptually, the method actually used also measures changes in the amount of services per unit of physical product as well as changes in services resulting from changes in the product mix. Hopefully, this makes it possible to measure the total quantity of manufacturers' services without being able to specify the infinite variety of specific services included in the total; obviously, nothing can be said about changes in the service mix.[61] It is also necessary to assume that relative prices—including implicit prices—of goods and services included in the aggregate do not change over time (*26*).[62]

As defined in the model, manufactured farm food products are the sum of manufacturers' services, farm materials consumed in processing, other materials, and supplies and services purchased by food manufacturers. The quantity of manufacturers' services was measured as the difference between deflated value of output of manufactured farm foods and deflated costs of materials and supplies consumed in manufacturing.[63] This is the so-called double-deflated value added measure of output.[64] Symbolically, the value of food manufacturers' services, V_{at}, as defined in this study is

$$V_{at} = \Sigma_i p_{it} q_{it} - \Sigma_i P_{it} Q_{it}$$

where, p_{it} and P_{it} refer to current prices of factory (gross) output and materials and supplies, respectively, and q_{it} and Q_{it} refer to the respective physical quantities.[65] Note that the indexes of the summations are different: Farm raw milk is used in making butter, ice cream, cheddar cheese, and a host of other processed farm products; and bread is made from wheat, dairy, and other farm products.

If the value of gross output and the costs of materials and supplies are deflated by price indexes based on the Paasche index-number formula, the result is a Laspeyres quantity index

$$(78) \qquad X_{at} = \frac{\Sigma_i p_{it} q_{it}}{\Sigma_i p_{it} q_{it}} - \frac{\Sigma_i P_{it} Q_{it}}{\Sigma_i P_{it} Q_{it}} = \frac{\Sigma_i p_{it} q_{it}}{\Sigma_i p_{io} q_{it}} - \frac{\Sigma_i P_{it} Q_{it}}{\Sigma_i P_{io} Q_{it}}$$

or

$$(79) \qquad X_{at} = \Sigma_i p_{io} q_{it} - \Sigma_i P_{io} Q_{it}$$

In index number form

$$(80) \qquad \frac{X_{at}}{X_{ao}} = \frac{\Sigma_i p_{io} q_{it} - \Sigma_i P_{io} Q_{it}}{\Sigma_i p_{io} q_{io} - \Sigma_i P_{io} Q_{io}}$$

The index of civilian consumption of manufacturers' services related to domestic farm food products is essentially based on Bureau of Census data on "value added by manufactures," adjusted for changes in prices. The Bureau derives value

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[61] This approach to measuring processing services is essentially the same as that used to quantify quality changes in construction of a quantity index where we seek an equivalent unit of measurement for commodities that differ only with respect to quality. For a discussion of the problem related to measuring quality differences in housing, see Muth (*25*).

[62] The problems implicit in this assumption are, of course, the usual economic and statistical index-number problems and are common to virtually all time series studies.

[63] In another context, Ladd (*29*) has argued that an index of the prices of marketing services be constructed directly. This index would then be used to deflate the value of services in order to measure the quantity of services. As pointed out in the text, there is little hope at this time of constructing an index of prices of services directly. The literature on net output and double-deflated net output is too extensive to cite here. For the original development of these measures, see Fabricant (*15*) and Geary (*19*).

[64] Using the theory of the firm, long-run equilibrium conditions, and Euler's theorem, it can be shown that value added in manufacturing also measures the value (price x quantity) of all inputs, except materials and supplies, used in manufacturing. A more simple interpretation is that used by Marschak and Andrews (*32*); they assume that materials and supplies are used in *fixed* proportion to output and that markets are perfectly competitive.

[65] The symbols are different than those used in the demand relations in order to avoid confusion in terminology.

added by manufactures by subtracting the cost of materials, supplies and containers, fuel, purchased electric energy, and contract work from the value of shipments for manufactured products and receipts for services rendered. In 1958, this definition was revised to include the effect of value added by merchandising operations and the net change in finished goods and work-in-process inventories (that is, "adjusted value added").

The series employed in this study is based on value added related to output—that is, adjusted value added. Census value added measured in current dollars was adjusted for price changes by deflating the value of output by specially constructed output price indexes and by deflating the cost of materials and supplies by a special—and laboriously—constructed input price index. This double-deflated value added series was then adjusted to relate to civilian consumption only; the series excludes manufacturers' services related to farm foods for commercial and Government stocks, for export, for Government purchases for relief and other programs, and for military use. Actually, the study includes experiments with two output series: (1) A double-deflated value added index using a price deflator for value of output constructed from BLS wholesale prices (the value added series are from Decennial and Biennial Censuses of Manufactures and from postwar Bureau of Census Annual Surveys of Manufactures); and (2) a double-deflated value added index using a price deflator for value of output based essentially on unit values of gross output derived from the Census of Manufactures (this series is for selected normal census years).

Some Conceptual Problems

For purposes of the Census of Manufactures, value added does not include certain contributions to the value of farm products which are made outside the manufacturing plant. The series (a) excludes some value added by processing in factories; and (b) includes some value added by distribution services performed by food manufacturers. Value added excludes the contribution of some nonfarm resources such as fuel, electric power, and other intermediate goods and services used in processing farm food products. Judging from data in the BLS Interindustry Study for 1947 and from the Census of Manufactures, value added accounted for about three-fourths of the total margin between value of finished commodities and costs of farm and other materials consumed in food manufacturing; it accounted for about 85 percent of the margin excluding packaging supplies.[66] Hence, within the scope of the Census of Manufactures, Census value added probably includes nearly all of the value of food processing services.[67]

The evidence on the magnitude of distribution services included in Census value added is fragmentary. Without attempting definitions of distribution and processing services, it might simply be noted that Census value added reflects buying and selling activities, transporting, storing, packaging, standardizing and grading, and probably a host of other distribution services. Conceptually, Census value added is only supposed to reflect output of plants proper; distribution services performed through central administrative offices, branch wholesaling houses, and so on are not supposed to be reflected in value added.

The only data that I know for suggesting the importance of this conceptual problem for food manufactures are from the Census of Business for 1935 and the Census of Manufactures for 1939; there is nothing, as far as I know, for the post-World War II years. In the Business Census for 1935, the Bureau asked a selected number of manufacturers to report selling expenses (*66*). This included

[66] According to these two sources, farm products and other materials consumed in food manufacturing (within the scope of this study) accounted for about 60 percent of the value of finished commodities; Census value added by manufacturers accounted for about 30 percent; and purchased supplies and services not included in value added accounted for about 10 percent. Packaging supplies which are usually considered under distribution accounted for roughly half of the 10 percent.

[67] A related problem is that the Census reports value added by establishments rather than by commodities. Establishments are classified by commodity specialization. The resulting "secondary-products" problem is fortunately negligible for purposes of this aggregative study. Nearly all food processing is done in factories specializing in food manufacturing; and, nearly all food manufacturing within the scope of the Census of Manufactures is performed within factories classified in food industries. That is, the "specialization" and "coverage" ratios as defined by the Census (*66*) and computed by the author were both *at least* 98 percent in 1954 for all manufactured farm foods.

(1) payrolls of employees who devoted all or a major part of their time to distributive activities, and (2) other expenses for distribution such as traveling expenses of salesmen, advertising, and credit. Both of these items of selling expenses were supposed to be *exclusive* of selling expenses in sales offices operated apart from the plant.

Calculations using ratios of selling expenses to value of sales reported in this survey and value of shipments and value added data from the Census of Manufactures suggest that sales expenses of food manufacturers could have accounted for as much as 10 percent of the total value of sales and about 30 percent of value added in 1935. In the Census of Manufactures for 1939, the Bureau reported employment and payrolls separately for distribution and manufacturing workers in plants, excluding salaried officers of corporations. In factories processing farm foods, payrolls of distribution workers accounted for 15 percent of total payrolls and about 6 percent of value added. According to the data from the 1935 Census of Business, payrolls accounted for about half of total selling expenses; these figures suggest that value of distribution services accounted for 12 percent of value added of farm food manufactures in 1939.

The most that can be deduced from these two sources is that the value of distribution services probably accounts for a substantial fraction of Census value added by food manufacturers. Unfortunately, evidence for gaging even the direction of the trend in this fraction is mixed.[68]

Manufacturers' Services Using BLS Wholesale Prices

The basic series used to measure quantity of food manufacturers' services is the double-deflated value added index using BLS wholesale food prices (table 12). Data on value of gross output and on cost of materials and supplies are those reported in the Decennial and Biennial Censuses of Manufactures and in the Annual Surveys of Manufactures made by the Census Bureau since World War II. These data were thus available biennially between 1919 and 1939; for 1947, and annually beginning with 1949. Except for the Biennial Census of 1933 where there were limitations in the coverage, there are no serious errors in the Census data for purposes of this study.[69] The significant errors are in the price deflators.

Price deflators for value of gross output by industry were constructed first from BLS wholesale food prices because these are the most finely specified factory price series available. Industry price deflators for value of gross output consistent with the Census Bureau classification of food industries were developed by reweighting and reaggregating BLS prices.[70] The output price deflators are based on the Laspeyres index number formula. The industry price deflators for costs of materials and supplies were based on SRS prices received by farmers for farm products and on BLS wholesale prices for other materials and supplies. These prices were laboriously weighted by data on value of materials and supplies consumed in food manufacturing derived from the BLS Interindustry Study for 1947. Farm products accounted for roughly 90 percent of the total cost of materials and supplies. The costs of materials and supplies, like the value of gross output, were deflated by a Laspeyres price index. Hence, if the index-number problem tends to bias the two deflated value series it tends to bias them in the same direction so that the effect on the double-deflated value added series would be at least partly canceled.

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[68] The ratios of selling expenses to total sales by individual food industries reported in the Business Census for 1935 were used to see if interindustry shifts in output might have sharply affected the ratio for the total. According to these calculations, if the 1935 industry selling expense to sales ratios had prevailed in 1919 and 1958, selling expenses would have accounted for about the same percentage of total sales in both years despite changes in the relative importance of different food industries. Within individual industries, packaging has certainly shifted from retail stores to factories; but delivery by wholesale bakeries to retail stores (which is included in census value added by manufactures) has probably declined because of increased average size of retail stores.

[69] Problems in using Census data for computing quantity of food manufacturers' services are essentially the same as those already discussed in the previous section on consumption of manufactured farm foods.

[70] More precisely, the classification for developing the output price deflators was the same as that used in the BLS Interindustry Study for 1947 (I–O codes) in order to be consistent with the price deflators for costs of materials and supplies. Except for dairy products, the classifications for manufactured foods are essentially the same as the Census 4-digit industries in the 1947 Census of Manufactures.

TABLE 12.—*Index numbers: Per capita civilian consumption of food manufacturers' services based on benchmarked and unbenchmarked series, United States, selected years 1919–58* [1]

(1947=100)

Year	Unbenchmarked [2]	Benchmarked [3] X_a	Year	Unbenchmarked [2]	Benchmarked [3] X_a
1919	86.5	72.7	1947	100.0	100.0
			1949	74.0	75.6
1921	62.0	53.2			
1923	81.2	71.2	1950	89.4	92.5
1925	78.4	70.3	1951	90.0	94.6
1927	88.1	80.7	1952	88.3	93.7
1929	91.1	85.1	1953	93.5	100.3
			1954	92.7	100.5
1931	73.1	70.1	1955	91.7	102.5
1933	72.6	70.9	1956	87.7	101.1
1935	70.1	69.8	1957	87.7	104.4
1937	76.9	78.2	1958	87.3	106.8
1939	94.0	93.9			

[1] Excludes fluid milk, cream, and poultry.

[2] Based on double-deflated value added using a price deflator of value of gross output constructed from BLS wholesale prices for processed foods. The price deflator for costs of materials and supplies was based mainly on SRS prices received by farmers and, for nonfarm inputs, BLS wholesale prices; weights are based on the BLS Interindustry Study for 1947.

[3] Unbenchmarked index was benchmarked using double-deflated value added index in table 13. That is, the unbenchmarked index was "inflated" by the ratio of the double-deflated value added index in table 13 to the double-deflated value added index used to obtain the series on per capita civilian consumption of food manufacturers' services.

Sources: Censuses and Biennial Censuses of Manufactures (*66*, *67*); and Annual Surveys of Manufacturers (*68*); Bureau Labor Statistics, weights for constructing the price deflator for costs of materials and supplies were derived from the BLS Interindustry Study for 1947.

Double-deflated value added was obtained by industry, aggregated to the total for all manufactured farm foods and transformed to indexes. The series was finally adjusted for changes in exports, inventories, and disappearance to the military in order to derive the series on quantity of food manufacturers' services related to domestic civilian consumption only (*54*).

Figure 4 dramatizes the importance of specification errors in the data on food manufacturers' services. The three quantity indexes are inconsistent with each other during the post-World War II period. If manufactured farm foods increased at the same rate or faster than farm products consumed in food manufacturing, then the sum of manufacturers' services and nonfarm materials used in food manufacturing should have risen as much or more than farm inputs. (Nonfarm materials used in food manufacturing accounted for about one-fifth of the difference between manufactured foods and farm inputs.) Common observation indicates that factory processing per unit of farm product used in food manufacturing probably increased during the postwar years, not decreased as shown in the figure. In sum, the index of food manufacturers' services using BLS wholesale prices to deflate the value of output has an apparent secular downward bias.

The series on food manufacturers' services also exhibits marked short-term fluctuations paralleling changes in the business cycle (fig. 4). The index declined sharply during the depression of the early twenties; during the depression of the thirties; and during each of the postwar recessions—1947–49, 1953–54, and 1957–58. Although a positive income elasticity for food manufacturers' services implies some cyclical fluctuations in the series, there are reasons to believe that the amplitudes of these fluctuations are overstated.

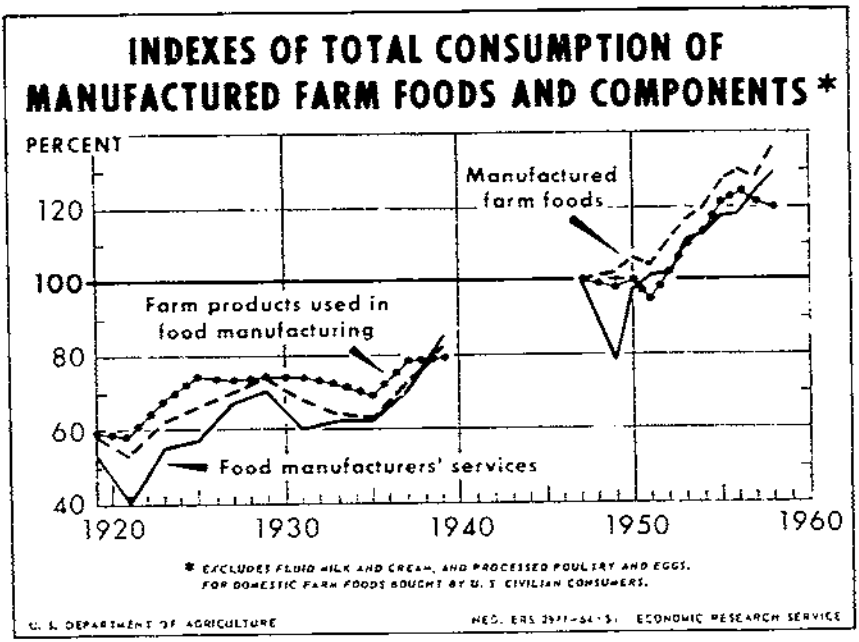

Figure 4

Thus, it is difficult to explain such large short-term changes in the amount of manufacturers' services per unit of manufactured foods (or per unit of farm products). These data show that the ratio of manufacturers' services to manufactured foods declined 20 percent in just 2 years, 1919–21. Also, during years of sharp declines (1921, 1931, 1949, and 1954) the implicit price of food manufacturers' services increased. Since these years were marked by declining incomes, it would be expected that the declines in food manufacturers' services would have been accompanied by decreases, not increases, in the price index for services. The presumption is that the dominant factor was a decrease in demand, not a decrease in supply.[71] This countercyclical behavior for the prices of food manufacturers' services was also counter to the cyclical behavior of the price index for manufactured foods and the price index for farm products consumed in food manufacturing.

In sum, the series on food manufacturers' services based on an output price deflator derived from BLS wholesale prices probably has a downward secular bias. Perhaps less obviously, the series also tends to have a cyclical bias in that it overstates fluctuations during periods marked by sharp changes in income. As indicated in the section on statistical findings, these two kinds of errors in the data tend to bias the estimated parameters in opposite directions: The secular error tends to bias the price and income elasticities downward (in absolute value); the cyclical error tends to bias the price and income elasticities upward (in absolute value).

The earlier review of the index of manufactured farm foods pointed out that there were no significant errors in the Census data on value of output. The same is true for Census data on costs of materials and supplies. Consequently, the trend and cyclical errors in the index of food manufacturers' services are mainly due to errors in the price deflators. The understatement of the trend in food

[71] The calculations of double-deflated value added for two of the industries (meats and grain-mill products) for 1931 turned out to be negative. In these industries and a few minor ones where the calculations were obviously unreasonable, the series were corrected by interpolating double-deflated value added per unit of manufactured foods between adjacent years. Except for these industries and the trend experiments reported in the chapter on the Statistical Findings, there was no attempt to smooth the data. These corrections certainly did not change the *direction* of the bias.

manufacturers' services probably results from the commonly held presumption that BLS wholesale prices used to deflate value of gross output reflect secular improvements in quality (including additional processing services).[72] The price deflator for cost of materials and supplies, based mainly on SRS prices received by farmers, also reflects secular quality improvements (*37*). However, this error would tend to bias the double-deflated index upward.

As for the cyclical errors, the Price Review Committee of the National Bureau of Economic Research (*37*) has some convincing evidence that reported BLS wholesale prices are rigid and not completely responsive to cyclical fluctuations.[73] There is no reason to believe that there is a significant difference between reported and transactions prices in the farm prices used to deflate the costs of materials and supplies. Reported prices are those paid by buyers, not prices at which producers hope to sell.[74] Farm prices are also largely determined on fairly well organized markets rather than between individual buyers and sellers. The U.S. Department of Agriculture and State governments maintain Market News Services which report farm prices regularly and widely.

The statistical evidence to support the explanations of the trend and cyclical errors in the series on food manufacturers' services is certainly not overwhelming. The following simple mathematical formulation of the problem for estimating the income elasticity may make these explanations more convincing. It indicates, among other things, that even if the cyclical and trend errors in the price deflators are small, they become magnified in estimating the income elasticity of the double-deflated series.

Simplifying equation (79), page 50, and omitting t's in indexes let

(81) $V_m = \Sigma_i p_{it}\, q_{it}$ (82) $V_f = \Sigma_i P_{it}\, Q_{it}$

(83) $P_m = \dfrac{\Sigma_i p_{it} q_{io}}{\Sigma_i p_{io} q_{io}}$ (84) $P_f = \dfrac{\Sigma_i P_{it} Q_{io}}{\Sigma_i P_{io} Q_{io}}$

(85) $X_m = \dfrac{V_m}{P_m}$ (86) $X_f = \dfrac{V_f}{P_f}$

Double-deflated value added, X_v, can now be written

(87) $$X_v = \frac{V_m}{P_m} - \frac{V_f}{P_f}$$

The analysis assumes that there are no random errors in measuring any of the variables, that the Census data V_m and V_f are measured without specification errors, but that the price index P_m, based on reported BLS wholesale food prices, is rigid relative to P_m, the "true" index based on transactions prices. It assumes also that P_m and the price index P_f, based largely on reported SRS prices received by farmers, are both subject to a secular upward bias relative to "true" transactions prices, P_m' and P_f'. A simple model that describes these relations and is

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[72] As far as I know, the only empirical studies of the quality problem are for durables. Although the magnitudes of the errors *are* probably different, essentially the same reporting problems (observing and accounting for changes in specifications) probably apply to prices of processed foods as well as to those for durable goods. On the quality problem in BLS retail prices, see Griliches (*23*); on the quality problem in BLS wholesale prices, see deLeeuw (*13*).

[73] Again, none of the evidence was specifically for manufactured foods. However, the reporting problems reviewed by the Price Review Committee appear general to most BLS prices so that there is a strong presumption that the Committee's findings apply to manufactured foods. See, particularly, Flueck and McAllister (*37*).

[74] According to SRS: "Price reporters generally are buyers of farm products; such as operators of country mills and elevator operators, managers of creameries and milk receiving stations, managers of cooperative marketing organizations, and local dealers in other types of farm products. In addition, some local bankers, well-informed farmers, and other persons with knowledge of prices of farm products are on the list of voluntary reporters. In 1955, reports were received from about 10,000 regular price reporters each month. Supplementary data are also obtained from many buyers and handlers of farm products, such as creameries, dairy plants, livestock auctions, and marketing cooperatives."

sufficient to show the effects of the specification errors on the estimated income elasticity is

(88) $$P_m = P_m^{*\alpha_m} T^{\beta_m}$$

(89) $$P_f = P_f^{*} T^{\beta_f}$$

where $\alpha_m [0 \leqq \alpha_m \leqq 1]$ indicates the (elasticity of) rigidity of the index of reported prices with respect to the index of transactions prices. If $\alpha_m = 1$, there is no rigidity between the two price indexes; this is the assumption underlying P_f.[75] The closer α_m is to zero, the greater the rigidity.

$\beta_m \geqq 0$ and $\beta_f \geqq 0$ indicate the secular (exponential) rate of growth in P_m and P_f as a result of reflecting quality improvements in foods (P_m is also assumed to reflect additional processing services). $\beta_m = \beta_f = 0$ means that there is no such secular bias in the two series.

From equation (7), the income elasticity of food manufacturers' services, X_s, is

(90) $$\frac{Y}{X_s}\left(\frac{\partial X_s}{\partial Y}\right) = \left[\frac{X_m}{X_s}\left(\frac{\partial V_m}{\partial Y}\right)\frac{Y}{V_m} - \frac{X_f}{X_s}\left(\frac{\partial V_f}{\partial Y}\right)\frac{Y}{V_f}\right] - \left[\frac{X_m}{X_s}\left(\frac{\partial P_m}{\partial Y}\right) - \frac{X_f}{X_s}\left(\frac{\partial P_f}{\partial Y}\right)\frac{Y}{P_f}\right]$$

Income elasticities for P_m and P_f are derived from (8) and (9), and the reciprocal of the exponential rate of growth in income, $\left(\frac{\partial Y}{\partial T}\frac{T}{Y}\right)^{-1}$, is designated by γ_y. After substitution in equation (10) the result is,

(91) $$\frac{Y}{X_s}\left(\frac{\partial X_s}{\partial Y}\right) = \left[\frac{X_m}{X_s}\left(\frac{\partial V_m}{\partial Y}\right)\frac{Y}{V_m} - \frac{X_f}{X_s}\left(\frac{\partial V_f}{\partial Y}\right)\frac{Y}{V_f}\right] - \left[\frac{X_m}{X_s}\alpha_m\left(\frac{\partial P_m}{\partial Y}\right)\frac{Y}{P_m}\right] - \gamma_y\left[\frac{X_m}{X_s}\beta_m - \frac{X_f}{X_s}\beta_f\right]$$

Let $\frac{\partial X_s^*}{\partial Y}\cdot\frac{Y}{X_s^*}$ indicate the "true" income elasticity when there are no specification errors in the price deflators (that is, $\alpha_m = 1$ and $\beta_m = \beta_f = 0$), then the bias in the estimated income elasticity because of the specification errors is,

(92) $$\left[\frac{Y}{X_s}\left(\frac{\partial X_s}{\partial Y}\right) - \frac{Y}{X_s^*}\left(\frac{\partial X_s^*}{\partial Y}\right)\right] = \left[\frac{X_m}{X_s}(1-\alpha_m)\left(\frac{\partial P_m^*}{\partial Y}\right)\frac{Y}{P_m^*}\right] - \gamma_y\left[\frac{X_m}{X_s}\beta_m - \frac{X_m}{X_s}\beta_f\right]$$

The first group of terms in brackets shows the bias due to the cyclical error in P_m; the second bracketed group shows the bias due to the trend errors in P_m and P_f. The results indicate that the biases from the cyclical and trend errors are in the opposite direction if

$$\frac{X_m}{X_s}\beta_m > \frac{X_f}{X_s}\beta_f$$

or

$$X_m\beta_m > X_f\beta_f.$$

Judging from the previous analysis of these series (pp. 52–55), this is apparently true in food manufacturers' services.

The ratio, $\frac{X_m}{X_s}$, is particularly crucial: Even if the cyclical error in P_m, is small, its effect is magnified by $\frac{X_m}{X_s}$ in the estimated income elasticity for the double-

[75] Equations (8) [and (9)] are obviously too simple a description. The rigidity between P_m and P_m^*, for example, is probably not symmetric between periods of increasing and decreasing prices. A more accurate description might show a systematic lag. Obviously, if the empirical relationship between the reported and true prices were known, the series deflators would have been corrected.

deflated series. The ratio, $\frac{X_m}{X_f}$, is about 3. There is obviously no unbiased estimate of $\left(\frac{\partial P_m}{\partial Y}\right)\frac{Y}{P_m}$. The trend error in the index of reported prices, P_m, tends to bias the estimate upward, whereas the cyclical bias in P_m tends to bias it downward. These biases may be roughly offsetting, and the results in the chapter on the Statistical Findings [equations (15) and (16)] suggest that $\left(\frac{\partial P_m}{\partial Y}\right)\frac{Y}{P_m}$ is in the neighborhood of one or larger than one. At any rate, this elasticity is significant.

The second group of bracketed terms indicates that the bias resulting from the secular errors in P_m and P_f are partially offsetting. Interestingly, even if the two price deflators were biased to the same degree ($\beta_m = \beta_f$), the estimated income elasticity for food manufacturers' services would still be biased downward because $\frac{X_m}{X_t}$ is larger than $\frac{X_f}{X_t}$. They are about in the ratio of 3:2. The previously observed downward secular bias in the double-deflated series, however, strongly suggests that P_m, based on BLS wholesale food prices, must have a substantial upward secular bias. In sum, the significant specification errors in measuring the quantity of food manufacturers' services, X_t, are mainly due to the inadequacy of BLS reported wholesale food prices.

Manufacturers' Services Using Census Unit Values

The second series developed for measuring the quantity of food manufacturers' services was also based on double-deflated value added; however, it was only constructed for selected census years (table 13).[76] Census data on value of gross output were deflated mainly by industry indexes of unit values. These indexes were obtained by dividing industry indexes of value of gross output by industry indexes of gross output (*50*). In effect, the minuend of the double-deflated value added series is based mainly on industry gross output constructed from value and product data reported in the Census of Manufactures. Industry data on costs of materials and supplies were deflated by the same price indexes described in the previous section. Thus, the only difference between this second series on double-deflated value added and the previous one is in the deflator for value of gross output.

The double-deflated series constructed for selected years was used to benchmark the index based on BLS wholesale food prices (table 13). Because it was necessary to use an index of unit values, the benchmarking only partly corrects for the secular error. It is, however, the best available series for gaging the trend in the quantity of food manufacturers' services during the period studied.

A brief summary on the quantity of food manufacturers' services follows:

(1) Accepting Census definitions, Census data on value of gross output and on costs of materials and supplies are not subject to errors which would tend to bias the demand relations estimated in this study.

(2) There is no evidence that the index number problem significantly biases the quantity index; to the extent that it does, it is overwhelmed by the following secular error.

(3) There is an obvious downward secular bias in the quantity index presumably because BLS wholesale prices reflect secular quality improvements in food products and a secular rise in the amount of manufacturers' services per unit of physical product; these errors tend to bias the estimated income and price elasticities downward in absolute value.

(4) Cyclical fluctuations in the quantity index appear overstated because of possible rigidity (or systematic lags) between BLS reported wholesale food prices and true transactions prices; this error tends to bias the estimated income and price elasticities upward in absolute value.

(5) Errors in SRS prices received by farmers used to deflate costs of materials and supplies tended to offset errors in the BLS prices, but they were apparently overwhelmed.

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[76] There was also an attempt to construct this series for the same years as the index based on BLS wholesale prices; unfortunately, it was not successful. In fact, results of initial computations of the series for even selected years sometimes defied tests of reasonableness, and other sources were searched out. In sum, construction of the manufacturers' services index based on unit values involved a good deal of checking and personal judgment.

TABLE 13.—*Double-deflated value added in manufacturing farm food products, United States, selected years 1919–58* [1]

(1947 = 100)

Year	Double-deflated value added [2]	Year	Double-deflated value added [2]
1919	55.4	1947	100.0
1929	70.6	1954	112.0
1937	68.4	1958	129.5

[1] Excludes fluid milk, cream, and poultry.

[2] Based on Census value added by food manufacturers. Value of gross output was mainly deflated by derived Census unit values; and cost of materials and supplies was deflated by specially constructed industry indexes based on SRS prices received by farmers and, for nonfarm inputs, BLS wholesale prices (weights were derived from the BLS Interindustry Study for 1947).

6. The above conclusions suggest that the estimated parameters might be made more precise with respect to the specification errors by finding a better price deflator than that based on BLS wholesale food prices. A second series on food manufacturers' services was constructed essentially from Census data on unit values for selected census years. It, too, tends to understate the secular rise in food manufacturers' services, but not as much as the index based on BLS wholesale prices.

Price Index for Food Manufacturers' Services

The index of prices of food manufacturers' services was obtained by dividing an index of value added in current dollars by the index of value added in constant dollars. This means that the benchmarked and unbenchmarked series for value added in constant prices imply different indexes of implicit prices of services (table 14). The price index of food manufacturers' services is a unit value series. Hence, it reflects not only changes in the implicit prices of manufacturers' services but also changes in the service mix.

The two kinds of specification errors noted in the previous section about the quantity of food manufacturers' services also apply to the price index for these services except in the opposite direction. That is, there is a secular upward bias in the price index because it reflects quality improvements (including additional processing services), and cyclical fluctuations in the price index for services tend to be understated because it is based on reported prices which tend to be more rigid than transactions prices. As in the estimated income elasticity, the two types of errors tend to bias the estimated price elasticity in opposite directions. In absolute terms, the secular error tends to bias the estimated price elasticity downward and the cyclical error tends to bias it upward.

Deriving the implicit price series as the quotient of value and quantity indexes can also introduce spurious correlation and tend to bias the estimated price elasticity toward minus unity. These spurious results can result from either random errors of measurement or the specification errors in the value and quantity indexes.

Income Series

The two income series used in the statistical analysis are based on the Department of Commerce definition of personal disposable income (table 15). Commerce has extended its series back to 1919 on an annual basis (*69*). The measured income series is simply the Commerce series deflated by the BLS consumer price index; per capita income was obtained by dividing total income by total civilian population as of July 1. The expected income series is an empirical approximation to Friedman's permanent-income concept (*18*). It is a weighted moving average of the deflated Commerce series (see footnote 2, table 15, for weights).[7]

[7] In order to obtain expected income for years 1919 through 1926, Commerce series of 5-year averages (*69*) were interpolated using Goldsmith's annual series (*20*) on disposable personal income.

TABLE 14.—*Index numbers: Value added (current dollars) in manufacturing farm foods, and deflated implicit price of food manufacturers' services, United States 1919–58* [1]

(1947=100)

Year	Value added (current dollars)	Deflated implicit price index based on—	
		Unbenchmarked index [2]	Benchmarked index [3] P_2
1919	32.9	67.4	80.1
1921	28.2	75.7	88.0
1923	33.6	69.9	79.5
1925	36.5	73.8	82.2
1927	38.7	68.5	74.7
1929	45.2	76.7	81.9
1931	35.8	83.1	86.9
1933	28.7	78.3	80.2
1935	33.0	86.9	87.2
1937	38.6	87.3	85.9
1939	41.3	78.2	77.9
1947	100.0	100.0	100.0
1949	101.6	124.8	121.9
1950	111.1	109.8	106.1
1951	117.8	104.8	100.1
1952	129.3	112.8	106.5
1953	132.8	107.0	99.9
1954	128.4	102.2	94.3
1955	142.4	112.9	101.1
1956	147.2	118.0	102.5
1957	150.2	113.8	96.1
1958	158.7	115.8	95.1

[1] Excludes fluid milk, cream, and poultry.

[2] Derived by dividing index of value added in current dollars by index of double-deflated value added using BLS wholesale prices for food to deflate value of output. Implicit price index is deflated by BLS consumer price index for all commodities.

[3] Derived by dividing index of value added in current dollars by index of double-deflated value added benchmarked for deflated selected census years. Implicit price index is deflated by BLS consumer price index for all commodities.

Price Spread Series [78]

The retail-wholesale price spread is the weighted difference between an index of retail prices and an index of wholesale prices of manufactured farm foods. The retail price index was derived from ERS series on the retail cost component of the market basket of farm food products (*53, 62*). The wholesale price index is the one previously described (pp. 52–53). The weights are for 1939 (*58*), the only year for which data are available.

The farm-retail price spread used in this study is for manufactured foods only. The price series and weights are based on ERS published data on the farm food market basket (*58*).

[78] The scope of these indexes is the same as that of the index of consumption of manufactured farm foods; that is, they exclude fluid milk, cream, and poultry.

TABLE 15.—*Per capita real disposable and expected income, United States, 1919–41, 1946–58* [1]

(1947–49 dollars)

Year	Disposable income (Y)	Expected income [2] (Y_e)	Year	Disposable income (Y)	Expected income [2] (Y_e)
	Dollars	*Dollars*		*Dollars*	*Dollars*
1919	813.5	827.5	1938	839.0	862.5
			1939	906.0	888.3
1920	783.1	820.7			
1921	726.3	793.5	1940	961.4	926.1
1922	764.8	790.9	1941	1,107.9	1,003.8
1923	853.6	819.9			
1924	856.3	838.9	1946	1,361.4	1,369.3
1925	840.2	847.2	1947	1,235.9	1,334.7
1926	872.2	855.1	1948	1,255.8	1,319.2
1927	876.5	877.1	1949	1,248.7	1,306.4
1928	877.2	886.0			
1929	931.0	912.9	1950	1,331.6	1,327.0
			1951	1,327.1	1,336.7
1930	846.5	901.6	1952	1,339.5	1,347.7
1931	791.9	875.8	1953	1,382.8	1,369.7
1932	667.5	813.8	1954	1,378.1	1,382.0
1933	658.4	769.1	1955	1,450.1	1,416.0
1934	719.1	761.6	1956	1,498.8	1,457.2
1935	781.4	778.0	1957	1,500.6	1,484.8
1936	872.0	820.8	1958	1,478.5	1,495.4
1937	897.5	859.2			

[1] Current disposable income was deflated by the BLS consumer price index for all commodities. Population figures are as of July 1.

[2] Expected income is a weighted moving average of per capita real disposable income; the weights are 0.330 for the current year and 0.221, 0.148, 0.099, 0.067, 0.045, 0.030, 0.020, 0.013 for the 8 preceding years. The mean of the expected income series was made equal to the mean of the disposable income series.

Sources: Historical Statistics of the United States (*69*); Survey of Current Business (*71*); Goldsmith, Brady, and Mendershausen (*20*); and Friedman (*18*).

Consumption of On-Farm Manufactured Foods [79]

The index of consumption of on-farm manufactured foods measures (in 1947–49 *farm* prices) the quantity of processed foods produced on farms for both home consumption and direct off-farm sale. It comprises farm slaughter of animals, farm churned butter, and consumption of fruits and vegetables on farms where produced (*53, 65, 60*). Part of the home consumption of fruits and vegetables is in fresh form. Data are not available for subtracting fresh consumption from the total; its inclusion apparently does not significantly affect the analysis.[80]

[79] It excludes on-farm slaughter of poultry and also home consumption and direct off-farm sales of fluid milk and cream. Since on-farm production of cheese for home consumption was relatively small during the period studied, it was also excluded from the series.

[80] In both 1920 and 1958, fruits and vegetables accounted for about 40 percent of the consumption of on-farm manufactured foods measured by the series. According to the Household Food Consumption Survey for 1955 (*59*), about 40 percent of home produced vegetables grown by rural farm households were consumed in fresh form. If we assume that this ratio was about the same for fruits and vegetables combined and that it was only half as large in 1920 as in 1955—certainly an extreme assumption—then the index of total consumption of on-farm manufactured foods shows a decline of 53 percent between 1920 and 1957; the decline in the series actually used in the analysis was 48 percent.

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