AN INVESTIGATION OF DIFFERENCES IN INCOME ELASTICITIES OF DEMAND FOR FOOD IN HOUSEHOLDS OF DIFFERING SIZE AND COMPOSITION

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ABSTRACT

AN INVESTIGATION OF DIFFERENCES IN INCOME ELASTICITIES OF DEMAND FOR FOOD IN HOUSEHOLDS OF DIFFERING SIZE AND COMPOSITION

by Robert O. Herrmann

The few past studies of the income-expenditure elasticities of demand for food in United States households of differing size and type found evidence of significant differences in elasticities between household types. Certain other studies, however, indicated that the significance of these differences might be, at most, small. The existence of such differences has important implications for analyses of the demand for food, for research and theory construction in economic development and for the estimation of age-sex specific equivalence scales from household food consumption data. Work in these areas generally has proceeded on the assumption that the differences in income elasticities for food between household types are not significant and that a single income elasticity may be employed as representing the behavior of all types of households. Because of the importance of this assumption in the choice of research methods and techniques in these areas, it was felt that an investigation of the significance of the differences in income elasticities of demand for food between household types would prove worth-while.

In the course of testing the hypothesis that the differences in income elasticities between household types are significant, it was necessary first to examine the relationship between certain concepts of consumption theory and the concepts which have been employed in empirical analyses of household expenditures. It also was necessary to specify precise definitions suited to the purposes of this study for some of these empirical concepts. The concepts and classifications which resulted were

instrumental in developing the household types for which income elasticities for food were estimated. The economic and statistical significance of the differences in income elasticity for food which were found to exist between household types were then evaluated.

The study is based on observations selected from the urban portion of the United States Department of Agriculture's 1955 Household Food Consumption Survey. Income-expenditure elasticities of demand for food for home consumption were estimated for twenty-six household types of varying age-sex composition and ranging in size from one to five persons. Income elasticities for each household type were estimated with four functional forms:

(1) $Y = a + b_1X_1 + b_2X_2 + u$

(2) $\log Y = a + b_1 \log X_1 + b_2 \log X_2 + u$

(3) $Y = a + b_1 \log X_1 + b_2X_2 + u$

(4) $\log Y = a - b_1 \frac{1}{X_1} + b_2X_2 + u$

Where Y is total weekly expenditure for food for home consumption, X_1 is 1954 disposable income after Federal and State taxes and X_2 is total meals served to members of the household during the week.

The elasticities estimated by equations (1), (2) and (3) were considered generally reliable. The elasticity estimates obtained with equation (4) were unsatisfactory for household types which contained households which reported zero or low incomes. Ninety-five percent confidence intervals were estimated for the elasticities obtained with equations (1), (2) and (3). Household types with confidence intervals which did not overlap those of another household type were considered to have income elasticities which were significantly different.

Although statistically significant differences were found to exist between the elasticities of different household types, it was felt that such differences were of little importance unless they could be shown to be economically significant also. The differences which were found to exist

would be of little economic significance in a period in which incomes were stable and population composition changed little. An illustrative projection of the demand for food was employed to show that the differences are, however, sufficient to be significant in a period like the present in which incomes and population composition are changing rapidly.

The results indicate that the assumption of a single income elasticity for all household types which has been employed in most recent demand projections is not warranted. The magnitude of the errors introduced by this assumption depends on the size of the changes in the distribution of household types which occur during the period covered by the projection and on changes in the distribution of income between household types. The results also indicate that the techniques employed by J. A. C. Brown and by S. J. Prais and H. S. Houthakker to estimate consumption equivalence scales from British household food consumption data, may not be useful for recent United States data, because of the assumption of a single income elasticity for food for all household types which these techniques require.

The results suggest that some of the recent changes in historical per capita food consumption series which have been laid to changes in "tastes" may be due, in fact, to changes in the distribution of household types and in the age-sex composition of the population. However, a full evaluation of the effect of changes in population composition on per capita food consumption requires substantial further study.

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CHAPTER I

INTRODUCTION

Economists have long sought to control for the effect of household size and composition on food expenditure in estimating the relationship between income and the demand for food. Most past studies have concentrated their efforts on eliminating these effects from the data. The actual nature of the effects of household size and composition on food expenditure has seldom been considered.

Large numbers of studies of income-expenditure elasticities for food have been made in which various adjustments have been used to eliminate size-consumption effects. Only a few studies have been made of the income elasticities of households of differing size and age-sex composition.[1] Such studies as have been made seem to indicate that important differences may exist between the income elasticities for food of different sizes and types of households. The existence of such differences would suggest that aggregative measures of income elasticity for food are perhaps an oversimplification. Differences in income elasticity for food between household types would have important implications not only for the estimation of short and long run demand for food and thus for national policy, but also would be of concern in economic development. Furthermore, such differences would have important implications for the choice of techniques to be employed in the estimation of consumption equivalence scales.

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[1]A compilation of recent studies of the income elasticity for food is given in Theodore W. Schultz, The Economics of Agriculture (New York: McGraw-Hill, 1953), pp. 60-61. Size-composition effects have been eliminated or ignored in all of the studies included.

Let us first examine the evidence of such differences in past studies and then consider more fully the implications of the existence of such differences for several areas of economic study.

Studies Giving Direct Evidence of Differences in the Income Elasticity for Food Between Household Types

The few past studies of the income elasticity for food in United States households of differing size and composition which have been made have distinguished only a few general household types or have distinguished on the basis of household size alone. The most recent of these studies of the elasticity of food expenditures with respect to income for households of different types uses the least detailed household type classification and distinguishes types only by size.[1] The study by Margaret Reid, the results of which are given in Table 1.1, was based upon 1950 Bureau of Labor Statistics data for urban families. The results show marked differences in the elasticities of the different household size types, especially for food for home consumption. In the size-types studied the elasticity coefficient increases with the size of the household in all but one instance.

The results for one person households, showing a high elasticity for all food including alcoholic beverages and a very low elasticity for food for home consumption differ from the general pattern for the other household sizes. This difference was explained as arising from the large number of males in the upper income range of the one person households who ate all of their meals out. Despite the nature of the household type classification employed, which Miss Reid herself recognized as crude, the results of this study indicate that the differences between the income elasticities of households of differing size may be significance.

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[1]Margaret G. Reid, "What We Do Know and Do Not Know About Food Consumption of American Families," Journal of Farm Economics, XL, No. 5 (December 1958), 1309.

Table 1.1 - Income Elasticities of Demand for Food in Urban United States Households of Differing Size, 1950 B. L. S. Survey[a]

Household Type	All Food Including Alcoholic Beverages	Food for Home Consumption
One person	.577	.061
2 persons	.476	.291
3 persons	.482	.319
4 persons	.500	.328
5 persons	.577	.426
6 or more persons	.607	.486

[a] Margaret G. Reid, "What We Do and Do Not Know About Food Consumption of American Families," Journal of Farm Economics, XL, No. 5 (December, 1958), 1309.

Four income elasticities for different family sizes were estimated from data collected in the 1948 U.S.D.A. survey of the food consumption of urban households.[1] The income elasticities obtained using a double log equation form,

$$\log Y = a + b \log X + u \qquad (1.1)$$

where Y is expenditure for food and X is income after Federal income tax, were:

2 person families	.46
3 person families	.35
4 person families	.38
5 and over person families	.37

[1] Faith Clark, Janet Murray, Gertrude S. Weiss, and Evelyn Grossman, Food Consumption of Urban Families in the United States--With an Appraisal of Methods of Analysis, U. S. Department of Agriculture, Agriculture Information Bulletin No. 132 (Washington: U. S. Government Printing Office, 1954), pp. 36-37.

Although the household type classifications of this study are also broad, the results give further evidence of the existence of differences in elasticity between household types, the difference between the elasticities of the two person families and the larger families being especially marked.

The next most recent study of differences in elasticities for food in different types of households was made by R. G. D. Allen, using data on the household expenditures of wage-earner and clerical families in the Eastern and Midwestern United States.[1] The data was part of that collected by the Bureau of Labor Statistics in their 1935 survey of urban family expenditures. The elasticities obtained were estimated using the linear equation form

$$Y = a + bX + u \qquad (1.2)$$

where Y is expenditure on food, and X is household income. While this equation form may be satisfactory for estimating elasticities in groups in which the range of income is small, logarithmic equation forms generally are preferred at the present time.[2] The results obtained by Allen (Table 1.2) show fairly marked differences in the elasticity of demand for food within each city and class group studied. There are also important differences in the elasticities of the same household type between the different city and class groups. Elasticities estimated with the linear equation form are equal to the product of the regression coefficient and the ratio of mean income to mean expenditure on food, when the elasticity is evaluated at the means of income and expenditure. The differences in the elasticities for a given household type in the different city and class groups are due

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[1]R. G. D. Allen, "Expenditure Patterns of Families of Different Types," Studies in Mathematical Economics and Econometrics, ed. O. Lange, F. McIntyre and T. O. Yntema (Chicago: University of Chicago Press, 1942), pp. 190-207.

[2]The choice of functional forms for the estimation of elasticities will be discussed in Chapter Four.

Table 1.2 - Income Elasticities of Demand for Food in Urban United States Families of Differing Size and Composition, 1935-36 B. L. S. Survey[a]

Household Type	Chicago Wage-Earner Families	Columbus, Ohio Wage-Earner Families	Muncie, Ind., New Castle, Pa., Springfield, Ill., Wage-Earner Families	Chicago Clerical Families	Columbus, Ohio Clerical Families
Couple only	.59	.49	.59	.49	.59
Couple, 1 child under 16	.64	.53	.44	.69	.50
Couple, 2 children under 16	.63	.68	.45	.58	.64
Couple, 3 or 4 children under 16	.57	.55	.56	.54	.64
Couple, 5 or 6 other persons (at least 1 child)	.67	.69	.59	.55	.67
Couple, 1 other adult (perhaps 1 other person)	.56	.64	.58	.60	.61

[a] R. G. D. Allen, "Expenditure Patterns of Families of Different Types," Studies in Mathematical Economics and Econometrics, ed. O. Lange, F. McIntyre, and T. O. Yntema (Chicago: University of Chicago Press, 1942), pp. 190-207.

both to the differences in the regression coefficients obtained, and the differences in the ratio of mean income to mean expenditure, between groups. While the household types distinguished are more homogeneous than those of Miss Reid's study, the age of the data employed in the study and the use of the linear equation form limit any current use of Allen's results.

The only other study of income elasticities for different household types is primarily of historical interest now, since the data used are from the 1901 Bureau of Labor Statistics survey of household expenditures of wage-earner and low-salaried families in urban industrial centers. The results for the food expenditure portion of this study by H. Gregg Lewis and Paul H. Douglas are given in Table 1.3.[1] They show no clear pattern of change with increasing size. The results for equation forms two and three do illustrate the decline in the elasticity of demand for food with increased income within a household type. This decline in the elasticity of demand for food is similar to the results which would be expected for Engel curves of the shape usually hypothesized.

The income elasticities obtained in these four studies are the extent of information now available on the income elasticities of demand for food in different types of United States households. These studies indicate without much question that differences in elasticities existed in the past and that these differences apparently have persisted over time. They can, however, tell us little about the nature of current differences in income elasticities. The usefulness of these studies is limited by the household type classifications employed, the equation forms used to estimate the elasticities as well as by the age of the data itself. The changes in living patterns, eating habits, real incomes and in food products which have occurred since even the most recent of these studies make a more current and detailed study of the problem desirable.

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[1]H. Gregg Lewis and Paul H. Douglas, "Studies in Consumer Expenditures (1901, 1918-19, 1922-24)," The Journal of Business, XX, No. 4, Part 2 (October, 1947), 20-21.

Table 1.3 - Income Elasticities of Demand for Food in United States Households of Differing Size and Composition for Wage-Earner and Low-Salaried Families in Urban Industrial Centers, 1901 B. L. S. Survey[a]

Household Type	Total Family Income	Equation 1[b]	Equation 2[c]	Equation 3[d]
Couple, no children	$ 250	.57	.54	.64
	750	.57	.52	.50
	1250	.57	.38	.43
Couple, one child under 14	250	.55	.53	.52
	750	.55	.54	.54
	1250	.55	.41	.53
Couple, two children under 14	250	.60	.59	.58
	750	.60	.52	.53
	1250	.60	.31	.48
Couple, three children under 14	250	.65	.60	.69
	750	.65	.62	.60
	1250	.65	.49	.52
Couple, four children under 14	250	.56	.41	.39
	750	.56	.58	.57
	1250	.56	.53	.61
Couple, five children under 14	250	.64	.51	.79
	750	.64	.65	.59
	1250	.64	.60	.37
All families	250	.61	.57	.61
	750	.61	.57	.56
	1250	.61	.41	.52

[a] H. Gregg Lewis and Paul H. Douglas, "Studies in Consumer Expenditures (1901, 1918-19, 1922-24)," The Journal of Business, XX, No. 4, Part 2 (October, 1947), 20-21.

[b] Equation 1 form: $\log Y = a + b \log X$, where Y is expenditure and X is income.

[c] Equation 2 form: $Y = a + bX + cX^2$.

[d] Equation 3 form: $\log Y = a + b \log X + c (\log X)^2$.

Indirect Evidence of Differences in Elasticities Between Household Types

In addition to the four studies just discussed there is further evidence of differences in food expenditure behavior with family size and composition. Thomas N. Moss, in considering the effects of size of income, household size, age and education of housewife and the occupation of the household head on food expenditures, found that size of family and income were the only two of these factors associated with significant variations in per capita expenditures.[1] George R. Rockwell, Jr., has derived an elasticity of expenditure for all food with respect to household size which is independent of the effects of income.[2] He found the size elasticity of demand for urban households for all food and beverages to be .41. The income-expenditure elasticity for the same group was .27. These two studies of United States households indicate that changes in size, as well as changes in income have an important effect on household food expenditures and provide indirect evidence of the existence of important differences in income elasticity between households of different size and composition.

The differences in the income elasticities of the household types in the United States studies discussed seem to indicate that important differences do exist in the food expenditure behavior of different household types. The existence of differences in income elasticities between households of different size and composition is supported by J. L. Nicholson's findings in his study of 1937-38 data on expenditures by British working-class households.[3] In his study, Nicholson classified households into four types,

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[1]Thomas N. Moss, "Some Relationships of Selected Socio-Economic Factors to Food Consumption and Expenditures, Lansing, Spring, 1950" (unpublished Ph.D. dissertation, Department of Agricultural Economics, Michigan State College, 1952), p. 141.

[2]George R. Rockwell, Jr., Income and Household Size: Their Effects on Food Consumption, U. S. Department of Agriculture, Marketing Research Report No. 340 (Washington, U.S. Government Printing Office, 1959), p. 51.

[3]J. L. Nicholson, "Variations in Working Class Family Expenditure," Journal of the Royal Statistical Society, CXII, Series A, Part IV (1949), 370.

couples with no children and couples with one, two or three children all under 14. Each household type was cross-classified into three income classes (total expenditures were used as an estimate of income) and income elasticities were estimated for food, other household budget items and certain food groups for each of the 12 household type-income class cells. Income elasticities, in general, were found to increase with household size within an income class, and were found to decline with increasing income within each household type. The maximum range of the income elasticities within an income class was in the lower income class, where elasticities increased from .69 to .92 as household size increased. Income elasticities were also found to vary substantially within each household type with increases in income, the maximum range was in the households with one child where income elasticities decreased from .98 to .30 as income increased.

Other British and European studies, however, have concluded that no differences in income elasticities exist between household types, or that these differences are not of major importance. J. A. C. Brown concluded from his study of 1951 British data that there is no significant difference in income elasticities between household types.[1] Brown did note, however, that "there is a tendency for households containing adults and adolescents only to show greater elasticities than those containing children and infants."[2] The rationing and price controls still in effect at the time of the study may have affected some households more than others[3]

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[1]J. A. C. Brown, "The Consumption of Food in Relation to Household Composition and Income," Econometrica, XXII, No. 4 (October 1954) 452-54.

[2]Ibid., p. 454.

[3]J. A. C. Brown, "The Consumption of Food in Relation to Household Composition and Income: An Analysis of Postwar British Budgets," abstract of paper presented before Innsbruck meeting of Econometrics Society, August 31-September 2, 1953, and discussion, Econometrica, XXII, No. 1, (January, 1954), 107.

and may perhaps have reduced the differences in elasticities between household types. Brown's findings seem to be supported by an FAO evaluation of the income elasticities for total food by size types determined in ten different studies, chiefly European.[1] In only two of the ten studies were the elasticities of the size types found to be significantly different. In the other eight cases a single aggregate elasticity developed by summing the individual type elasticities weighted inversely to their variances, was preferred. These eight aggregate elasticities were statistically more efficient and unbiased as compared to the overall elasticities computed without distinguishing household types, however.

Further study of the income elasticity of demand for food in households of different size and age-sex composition would be of interest if only because of the disagreements which do exist on the subject and for comparison with past studies in order to gain some historical perspective on changes in the demand for food. The question of the existence of differences in income elasticities between households of different size and composition has an importance which goes beyond these considerations because of its bearing on several other types of economic problems. The implications of the existence of differences in income elasticities of demand for food between household types for some particular areas of economic study will be considered in the next three sections.

Implications of Differences in Income Elasticity Between Household Types in the Forecast of the Demand for Food

If consumer behavior is related to such demographic variables as age and household size and composition, changes through time in the distribution of these variables may produce important changes in total

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[1]Economic Commission for Europe, Committee on Agricultural Problems, in cooperation with United Nations Food and Agriculture Organization, Income Elasticity of the Demand for Food-Household Survey Analysis, prepared by L. M. Goreux (Rome: United Nations Food and Agriculture Organization, 1959), p. 39.

economic behavior. If, for example, continuing differences in behavior exist between households of different size and composition, then changes over time in the distribution of household types may produce economically significant changes in aggregate consumer behavior.

Recent projections of the demand for food have not considered the possible effects of changes in population composition. The possible effects of these changes have been ignored or dismissed or the forecasts have been made on the basis of per capita consumption trends in which changes in population composition are implicit. Schultz in forecasting the demand potentials for United States farm products, considered the effects of population increases at some length, but did not take up the possibility of changes in the structure of demand with changes in population composition.[1] James T. Bonnen, in considering the probable relation of agricultural production to consumption needs in 1965, forecasts the demand for food from projections of per capita consumption rates and thus does not deal with the effects of changes in population composition which are implicit in changes in per capita consumption.[2] Rex F. Daly, in 1956, projected the demand for food on the basis of anticipated increases in real income and the income elasticities of the major farm products, dismissing the possible effects of changes in population composition:

> Some trends in the age composition and regional distribution of population may modify the effect of population on demand for farm products. But the uptrend in numbers of both younger and older persons, the decline in farm population, and regional shifts in population are not expected materially to influence total demand.[3]

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[1]Schultz, pp. 24-27, 30-43.

[2]James T. Bonnen and William A. Cromarty, "The Structure of Agriculture," Agricultural Adjustment Problems in a Growing Economy, ed. Earl O. Heady, Howard G. Diesslin, Harald R. Jensen, and Glenn L. Johnson (Ames: Iowa State College Press, 1958), pp. 117-18.

[3]Rex F. Daly, "The Long-Run Demand for Farm Products," Agricultural Economics Research, VIII, No. 3 (July, 1956), 77.

In a more recent study, Daly laid observed changes in consumption chiefly to changes in real income and relative prices but granted that changes in per capita consumption were due in part to other factors, such as nutritional and medical advances, food fads, changes in supply and population shifts.[1]

The nature of the relation of economic behavior to demographic variables has particular importance because of the substantial changes in population composition and household numbers which have been projected for the next two decades.[2] U. S. Census Bureau Series B projections forecast a 45 percent increase in the number of households between 1958 and 1980, an absolute increase of 22 million. An 11.3 percent increase in the number of households is projected for the 1958-1965 period (see Table 1.4). The greatest percentage increase during the 1958-1965 period is expected to be for households with heads under age 25. The next greatest increase is expected to be in households with heads age 55 and over; this latter group is expected to increase by 17.2 percent in the seven year period. The number of households with heads of intervening ages is expected to increase by only 5 percent.

Another important change projected for 1958-1980 is the increase of 42 percent in the number of families headed by women. The number of women living alone or with non-relatives is expected to increase by 72 percent during this period. The number of households with female heads will thus increase about proportionately with the increase in total households,

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[1]G. T. Barton and R. F. Daly, "Prospects for Agriculture in a Growing Economy," Problems and Policies of American Agriculture, published under sponsorship of Iowa State University Center for Agricultural Adjustment, (Ames: Iowa State University Press, 1959), pp. 29-39.

[2]U. S. Bureau of the Census, "Illustrative Projections of the Number of Households and Families: 1960 to 1980," prepared by David M. Heer and Paul C. Glick, Current Population Reports, Series P-20, No. 90 (Washington: Bureau of the Census, December 29, 1958), pp. 1-10.

while the number of households maintained by women living alone or with non-relatives will increase substantially more rapidly than the total number of households. The number of households headed by men living alone or with non-relatives is expected to increase by only 31 percent in the twenty year period. The proportion of such households will thus decline in relation to total households.

Table 1.4 - United States Census Series B Projections for 1965 of Number of Households by Age of Head[a]

	All Households	Age of Head (years) Under 25	25 to 54	55 and Over
March 1958 (thousands)	50,402	2,393	31,239	16,770
July 1965 (thousands)	56,076	3,635	32,793	19,648
Absolute Increase 1958-1965 (thousands)	5,674	1,242	1,554	2,878
Percentage Increase 1958-1965	11.3	51.9	5.0	17.2

[a]U. S. Bureau of the Census, "Illustrative Projections of the Number of Households and Families: 1960 to 1980," prepared by David M. Heer and Paul C. Glick, Current Population Reports, Series P-20, No. 90 (Washington: Bureau of the Census, December 29, 1958), p. 3.

Implications of Differences in Income Elasticity Between Household Types for Economic Development

Historical evidence shows that in the course of economic development the age distribution of the population undergoes several changes. As incomes and population increase in the initial stages of development the age distribution changes under the effects of the changes in fertility and age-sex specific mortality which take place. Death rates decline most in

the youngest age groups and as the ratio of young to old increases, the ratio of the labor force to the total population falls. Average income tends to fall as the proportion of the population which is not in the labor force increases. However, if the increases in average income do, for some reason, continue, Leibenstein holds that sooner or later declines in fertility will set in.[1] The economic burden of dependency is thus decreased and the pressure on average income is eased. At some point this new shift in population will make escape from a Malthusian equilibrium easier, with increased average incomes making some savings possible.

Marked changes in demand associated with these shifts in population composition may either inhibit or aid in economic progress. More information is needed as to what the extent of these changes may be. If the needs of the increased proportion of children in the population are small, the effective pressures on average income in the earlier stages of development may be smaller than are usually supposed.

Changes in population composition with resultant changes in consumption may also have an important effect on the economies of developed nations. There is evidence that in more mature economies consumption may be as important a determinant of income and growth in income as investment is. Thus, an understanding of the sources of changes in consumption behavior is as important in constructing a theory of economic growth for mature economies, as it is for analyzing the problems of countries in the early stages of development. The differences in economic behavior which are associated with demographic characteristics may well be one important source of changes in consumption behavior during the course of economic development in both underdeveloped and mature economies.

The changes in population composition which occur during economic development can also be viewed as changes in the distribution of household types. There is, in fact, a good case to be made for considering these

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[1]Harvey Leibenstein, A Theory of Economic-Demographic Development (Princeton: Princeton University Press, 1954), pp. 95-96.

changes in such a way when studying consumption problems. Since individuals consume as a member of a household unit rather than separately, it seems more useful to consider changes in the distribution of the household types in which consumption behavior is centered than to consider only the changes in the age-sex composition of the population. Studies of differences in income elasticities of demand for food in different household types for a more mature industrial society, such as the United States, should give some clues as to the possible importance of differences in elasticities between household types in both mature and developing societies, and should also provide useful information on the possible influence of changes in the age-sex composition of the population on United States growth.

Implications for Consumption Research of Differences in Income Elasticity Between Household Types

In addition to the implications of differences in income elasticities between household types in forecasts of the demand for food and economic development problems, the existence of differences in elasticities between household types also has important implications for the choice of analytical methods in consumption research.

Two recent British studies, in which consumption equivalence scales measuring the relative food needs of different types of individuals were estimated, used methods which required the assumption of the same income elasticity of demand in all household types. In their analysis of 1937-39 British household budgets S. J. Prais and H. S. Houthakker used one equation of the form

$$Xm^{-h} = A\Sigma K_i n_i \qquad (1.3)$$

to obtain the equivalence scale coefficients, K_i, for the i types of individuals which they distinguished, where X is household expenditure on food, m is

income per member and n_i is the number of individuals of the i-th type in the household.[1] Coefficients A and h are constants, h is the income elasticity for food. Since only the ratio of the K_i was required, the constant term A was kept on the right hand side. The K_i were estimated by first selecting the value of h which maximized the correlation between the composite variable on the left-hand side and the determining variables n_i on the right-hand side. The K_i corresponding to the value of h selected were then calculated. The other equation employed was of the semi-logarithmic form

$$\frac{X}{(c + \log m)} = b\Sigma K_i n_i \qquad (1.4)$$

where b and c are constants, with c = a/b. The procedure used was similar to that for equation (1.3) except that in this case it was the variable c for which various values were inserted until the one which maximized the correlation of the left-hand side and the n_i was found. Equation (1.3) thus requires the assumption that income elasticity h is constant across household types, just as equation (1.4) requires the assumption that parameter c is constant across household types.

J. A. C. Brown, in estimating equivalence scales for total food expenditure from 1951 British data, first calculated the income elasticities for each of the sixteen household composition types which he distinguished, using a double-logarithmic equation of the form

$$X = P_k m^{h_k} (\Sigma n_i)^{d_k} \qquad (1.5)$$

where X is household food expenditure, m is net household income, n_i

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[1]S. J. Prais and H. S. Houthakker, The Analysis of Family Budgets ("University of Cambridge, Department of Applied Economics Monographs," No. 4; Cambridge: Cambridge University Press, 1955), pp. 134-42. See also, S. J. Prais, "The Estimation of Equivalent Adult Scales From Family Budgets," The Economic Journal, LXIII (December, 1953), 799-802.

the number of individuals of the i-th type in the household and p_k, h_k, and d_k are constants to be estimated for each of the 16 household types, h_k being the income elasticity of the k-th household type.[1] After testing the homogeneity of disturbances, Brown used an F test for differences between the sixteen partial elasticities. The differences were found to be significant at the five percent level, but not at the one percent level for the observations gathered between June and August and insignificant at both levels for those gathered between September and December.

On the basis of these tests, Brown accepted the hypothesis that the elasticities were equal. It will be noted that in order to be able to accept the hypothesis of equality for the first group of observations, Brown found it necessary to go to the one percent level of significance. The probability of rejecting a true hypothesis, a Type I error, is thus only one percent. The use of the one percent level, however, makes the probability of accepting a false hypothesis (Type II error), high. The probability of Type II error appears not to have been examined by Brown. Because of the test employed the probability of Type II error was undoubtedly high, since the smaller the level of significance used, the greater is the probability of a Type II error. Thus there is some question as to whether the hypothesis of equality should be accepted and whether Brown was justified in doing so.

After accepting the hypothesis that the partial elasticities did not differ between household types, Brown proceeded to estimate the equivalence scale coefficients using the common income elasticity estimate. The estimates of the equivalence coefficients obtained by Prais and Houthakker and by Brown thus depend on whether the assumption of constant elasticity across household types is a valid one or not. Since Prais and Houthakker did not examine elasticities within household types before proceeding on the assumption of their constancy and because of the nature of the test for

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[1]Brown, Econometrica, XXII, No. 4 (October, 1954), 444-60.

differences used by Brown, there would seem to be reason to question the methods used and the usefulness of these methods in any future studies of a similar nature. Unless income elasticities can be shown to be the same for all household types the use of these methods of deriving equivalent scales cannot be supported on a priori grounds because of the assumption of constancy which they require.

Scope and Objectives of the Study

The first goal of this study was to clarify the relationship between certain concepts of consumption theory and the concepts which have been employed in empirical analyses of household expenditures and to specify more precise definitions for some of the empirical concepts. The concepts and classifications which resulted were instrumental in the development of the household types for which income-expenditure elasticities of demand for food for home consumption were estimated. The second goal of the study was to determine the statistical and economic significance of such differences as were found to exist in the income elasticities of households of differing size and age-sex composition. One of the particular goals in this connection was to determine whether the assumption of a single income elasticity for all household types, which was employed by Brown and by Prais and Houthakker in their estimations of equivalence scales, would be warranted for recent United States data.

In Chapter II, certain theoretical problems which arise in applying existing consumption theory are considered. These problems are a result of the formulation of consumption theory on the basis of individual rather than household behavior. Problems involved in grouping households into types which satisfy the requirements of theory for estimating income elasticities are also discussed. In the next chapter, the actual consumption unit whose behavior is under consideration is specified more closely.

The individual household observations included within the set of household types employed are also discussed. These observations are drawn from the urban portion of the 1955 U.S.D.A. Household Food Consumption Survey.

The empirical variables which have been found to influence consumption behavior and the variables of consumption theory are discussed in Chapter IV. The different regression equation forms which have been employed in the estimation of elasticities are also considered. In Chapter V, the process of analysis is related, and the elasticities estimated are presented. Methods of testing income elasticities for significant differences and the results of one such test for the elasticities estimated in this study are presented. In the final chapter, the economic significance of the results is considered in an attempt to determine whether household classifications by age-sex composition are useful or necessary in the study of food consumption behavior. The final chapter also examines the justification for the acceptance of the hypothesis that economically and statistically significant differences exist in the income elasticities for food of households of differing size and age-sex composition.

An attempt was made to hold this study to matters central to the solution of the problem. Of necessity, many important related considerations were examined only in part. Problems such as are involved in the permanent income hypothesis, the existence of an economic life cycle and others were considered only briefly as they relate to the problem. No attempt was made to refine further or improve upon existing methods of estimating elasticities, nor was the question of the usefulness of elasticities in comparison with other possible expressions of relationship between economic variables considered.

It is felt that those interested chiefly in the empirical results of this study may prefer to refer to Chapter V immediately. They can thus omit the discussions of the concepts and classifications which underlie the

analysis and the discussion of the choice of functional forms and variables, which are contained in Chapters II, III, and IV. Those who are interested in the development of the concepts underlying the analysis as well as in its empirical results will probably prefer to read the chapters in the order in which they are presented.

CHAPTER II

PROBLEMS IN THE ESTIMATION OF ELASTICITIES FOR HOUSEHOLDS

The Individual and the Household in Consumption Theory

The usefulness of consumption theory in the study of observed behavior has been limited to some extent by its formulation as a theory of the behavior of the individual. Empirical studies, however, have, of necessity, focused on the household, the unit in which individual consumption occurs, rather than on the individual himself. The result of this difference between theoretical formulation and empirical practice has been a certain confusion about whose behavior is being studied. Empirical investigators have proceeded in the general belief that observations of household behavior may be regarded as the behavior of the "individual" of economic theory, rather than as the combined behavior of a group of separate individuals. Consumption studies which discuss theory have generally used a theory of individual behavior, observed household behavior, and then made statements about individuals on the basis of these observations of a group. However, as Cochrane and Bell have pointed out, we should not regard the individual as the basic decision-making unit of consumption, paralleling the position of the firm as the decision-making unit on production side of the market.[1] The confusion in this matter is exemplified in the use of the term "theory of the household" in referring to theories of the economic behavior of the individual.

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[1]Willard W. Cochrane and Carolyn S. Bell, The Economics of Consumption (New York: McGraw-Hill, 1956), p. 13.

The reasons for the development of economic theory on the basis of individual behavior probably lie in the origins of economics within philosophy and in the physiological and psychological bases which have been assumed to underlie individual behavior. Despite the individual and subjective nature of these bases, early utility theorists presumed that utilities could be compared between individuals. The idea of comparability lost favor as utility theory developed and the individual basis of the assumptions became more clearly recognized. Marshall notes Jevons' error in comparing the utilities of the members of a trading body and corrects him, stating that the things which the body gives up "represent equal purchasing power to all its members, but very different utilities."[1] But Marshall himself advances the proposition that the marginal utility of money is greater for the poor than for the rich,[2] tempting one to raise questions about starving misers and spendthrift office boys. Pareto seems to have recognized the individual basis of his theory and has distinguished between theories which compare the sensation of an individual under different conditions and theories in which the sensations of two different individuals are compared.[3] The shift from utility to indifference analysis permitted the elimination of statements about the intensity of desire for a particular commodity and substituted a scale of preferences instead. This scale was clearly recognized as the "given wants" of a single individual.[4] Although theoretical emphasis has shifted from the physiological, psychological and introspective views of utility in which utility was regarded as

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[1]Alfred Marshall, Principles of Economics (8th ed; London: Macmillan and Co., 1947), p. 818.

[2]Ibid., p. 95.

[3]Vilfredo Pareto, Manuel d'Economie Politique, trans. Alfred Bonnet (2d ed.; Paris: Marcel Giard, 1927), pp. 148-149.

[4]J. R. Hicks, Value and Capital (2d ed.; London: Oxford University Press, 1950), pp. 18-19.

an introspective magnitude, the ordinal preference scale which has succeeded it must also be regarded as uniquely individual.[1]

Recent theories of consumer behavior which have been developed on psychologically based assumptions consider behavior as arising out of the individual's perceptions of his own needs, his perceptions of reality and his own subjective system of valuations, and are likewise uniquely individual in basis.[2] Studies such as Bilkey's,[3] which have developed out of these theories, have leaped from a theory of individual behavior to empirical study of household behavior without considering the intervening steps which may be involved, in the same manner that other studies of consumer behavior of more traditional form have jumped from utility and indifference theories of individual behavior to empirical studies of household behavior.

We can relate empirical studies of household behavior to received theory if we can assume that the concepts of utility and indifference analysis may be applied to households as well as to individuals. Implicit in such an assumption is the assumption of the existence of a common utility function or set of indifference curves for each group of individuals composing a household. Such an assumption can be made only if we postulate a certain unanimity of preference[4] or authoritarian allocation of the group's resources. With the assumption of a common household

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[1]Paul A. Samuelson, Foundations of Economic Analysis (Cambridge: Harvard University Press, 1958), p. 91.

[2]See for example Joseph Clawson, "Lewin's Vector Psychology and the Analysis of Motives in Marketing," Theory in Marketing, ed. Reavis Cox and Wroe Alderson (Chicago: Richard D. Irwin, 1950), pp. 51-56.

[3]Warren J. Bilkey, The Basic Relationships in Consumer Expenditure Behavior, ("Harvard Studies in Marketing Farm Products," No. 4-H; Cambridge: Harvard University, 1951).

[4]H. S. Houthakker, "The Econometrics of Family Budgets," Journal of the Royal Statistical Society, CXV Series A Part I (1952), 2.

utility function or set of indifference curves, however, the way is cleared for the proper use of such theoretical concepts as income elasticity in the study of household as well as individual behavior.

Assumptions Required for the Estimation of Income Elasticities

In estimating the income elasticity of a household, it is necessary first to estimate the Engel curve or regression of food expenditure on income. The product of the slope of this regression line and the ratio of income to food expenditure at a particular point on the line equals the income elasticity for food at the particular point. In consumption theory such a line is estimated by observing the food expenditure of a single household as income is varied through successive levels, with all other factors influencing food expenditure held constant. The empirical estimate of the Engel curve of a household is at best only a crude approximation of the Engel curve of theory because of the methods required for its estimation.

Cross-sectional income elasticities, such as were estimated in this study are derived from observations of the food expenditures and incomes of different households at a particular point in time. The assumption is made that the regression fitted on the expenditures of different households at differing levels of income approximates the expenditure behavior of a single household at these successive levels of income. It is assumed that the influences affecting food expenditure, other than income, are the same for all of the households observed.

In the estimation of an empirical Engel curve, the observations which are employed should be those from households which could be expected to have similar Engel curves if we were able to observe their entire curve. Observations of households with widely differing tastes

or food requirements cannot be regarded as observations for the estimation of the same Engel curve. For example, the food expenditures of a single individual and a household of five can be expected to differ widely at all levels of income, because of differences in food requirements if for no other reasons. Observations of these two households are more properly regarded as estimates of two different Engel curves rather than a single one.

Some method of eliminating differences in expenditure behavior due to differing food requirements is needed if observations from households of differing size and composition are to be regarded as estimates of points on a single Engel curve. The use of households which differ in size and composition in the estimation of a single Engel curve appears warranted in two instances. The first is when the effects of differences in size and composition on behavior have been eliminated in some manner. The second instance in which the use of households of differing size and composition in the estimation of an Engel curve appears warranted is when the similarity of expenditure behavior of the particular group of households has been established in some way. In both instances, the households observed may be regarded as having similar theoretical Engel curves, and observations of their food expenditure may be regarded as estimates of points on a single empirical Engel curve.

Methods of Obtaining Households with Similar Engel Curves

As has been noted, if the observation of the behavior of different households are to be used in the estimation of elasticities, some means must be found to eliminate the effects of differences in size and composition so that the observations can be regarded as estimates of points on the same Engel curve. Or alternatively, some means of measurement must be found so that similarities of the Engel curves of different household

types can be established. Households of varying sizes and composition can be regarded as having similar Engel curves if the observations of their income and expenditure are deflated so as to eliminate the effect of these differences. The observations of households are thus reduced to become what is, in effect, observations of some standardized individual. The two different types of standardized individuals which have often been employed in past studies are the per capita unit and the adult male equivalent. The per capita unit is obtained by using absolute measures of household size as deflators, while the adult male equivalent is obtained by using relative measures of household size and composition as deflators.

The per capita unit measures of income and expenditure are obtained simply by dividing these variables by the number of individuals in the household. This operation reduces the observations on all the households to a common per capita unit measure. The use of the absolute size of the household in individual members as a deflator does not take account of important differences in individual needs, requirements and behavior. The use of household size as a deflator implicitly assumes that the consumption of any two individuals is equal, since all individuals are weighted equally in this procedure. The use of the per capita measure is particularly unsatisfactory for food expenditures, because of the wide variation of intake between different age and sex groups.

The adult male equivalent is the standardized individual type which has been most often used in recent studies employing relative measures of household size and composition as deflators. The first measure of relative size was developed by Ernst Engel, an early student of household expenditure budgets.[1] This scale for food expenditures assigned the weight of 1.0 to a child under one year and corresponding weights of 1.1 to two year-olds, 1.3 to three year-olds, 3.5 to adult males, and so forth, depending on their relative share in household food consumption.

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[1]Cochrane and Bell, p. 188.

The sum of these coefficients for a household divided into its food expenditure reduces expenditure to a per equivalent basis. The expenditure per equivalent is thus considered to be freed of the effects of differences in size and composition. Since Engel's time, a variety of similar measures have been developed for various types of individuals.[1] Such scales may provide coefficients for a few types of individuals or many, and are developed on the basis of age, sex, occupation and other classifications. Most of the more recent scales have been developed using the adult male equivalent as the basic category. In these scales the adult male is assigned a coefficient of 1.0, rather than the infant, as in Engel's scale.

Relative scales for food expenditure have been developed on the basis of estimated requirements or recommended allowances, as well as observed behavior. The difference between scales developed on the basis of requirements and those developed from actual expenditures is probably slight since relative scales are ratios rather than absolute quantities.[2]

The derivation and use of equivalence scales requires the assumption that behavior is fairly uniform within the individual types distinguished. If the coefficient of the individual type has not taken the number and kinds of meals eaten at home into account, these are assumed to be comparatively uniform within a particular type, although they may vary widely between types. In addition to the necessity of these assumptions, other problems arise in the use of equivalence scales.

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[1]A general discussion of equivalence scales, their uses and the coefficients produced by important studies is given by Robert M. Woodbury, "Economic Consumption Scales and Their Uses," Journal of the American Statistical Association, XXXIX, No. 228 (December, 1944), 455-68.

[2]Woodbury, 464.

Allen has questioned the accuracy of some of the scales obtained, noting that the appropriate scales for food expenditures appear to be different for families of varying social position and for the first or second child as compared with later children.[1] Allen observed that children in clerical families seemed to have greater weights in the food scale than those in wage-earner families, and the first or second child seemed to have greater weight than the third or fourth. Scales derived for one group of households may not be applicable to other groups. Woodbury noted that scales are likely not uniform between places because of differences in local habits and prices and that scales are also likely to change over time.[2] A further problem in the use of equivalence scales arises from the assumption of constant elasticities across household types which is used in the Brown and Prais and Houthakker techniques of estimating scales. Such an assumption presupposes the solution of the very problem to which this study is addressed.

Besides the use of per capita and equivalence scale deflations, another method of obtaining groups of households which may be expected to have similar Engel curves is available. This other method is the separation of the observations into groups in which all of the households have similar consumption characteristics and therefore may be expected to have similar Engel curves. If sufficient observations are available in each of these groups, the Engel curve line and the elasticity may then be estimated for each one. The use of such a method permits us to avoid the patent oversimplification of per capita measures and possible inaccuracies of equivalence scale measures.

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[1]R. G. D. Allen, "Expenditure Patterns of Families of Different Types," Studies in Mathematical Economics and Econometrics, ed. O. Lange, F. McIntyre, T. O. Yntema (Chicago: University of Chicago Press, 1942), p. 201.

[2]Woodbury, 459, 466-67.

The method of grouping households which have similar consumption characteristics into types which may be assumed to have similar Engel curves has an important further advantage. This study has undertaken to estimate the income elasticities for food in households of differing size and age-sex composition. The compositional types for which elasticities may be estimated because of the similarity of their Engel curves, may perhaps also serve as the system of household types required for this study. The criteria for the selection of the final system of household types for which elasticities are to be estimated will be discussed in the next chapter.

This study, therefore, proceeded first to combine households into groups which would be assumed to have similar Engel curves. The households which were combined were assumed to have similar food consumption behavior by reason of the similarity of the consumption behavior of the individual types composing them.

The Use of Individual Types in Grouping Households with Similar Engel Curves

Types of Individuals in the Household

The behavior of households of a particular size and composition can be expected to be uniform, if the behavior of the individual types of which the household type consists is reasonably uniform.[1] In the development of individual types, age and sex categories are grouped according to the similarity of their behavior with respect to the commodity under consideration. These groupings should be expected to differ from

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[1]Throughout this study "individual type" will be used to refer to individuals of a particular age and sex category, such as males age 15-64. "Household type" will be used to refer to households made up of a particular combination of individual types. For example, two person households made up of a male age 15-64, and a female age 15-64, could be regarded as a particular household type, which is made up of two distinct individual types.

commodity to commodity. In distinguishing individuals on the basis of age and sex alone, it is assumed that these characteristics are the principal determinants of food consumption behavior and that other influences such as occupation and climate may be omitted from consideration. Since few urban workers are employed at heavy labor and the effects of climate are mitigated by central heating and air conditioning it seems not unreasonable to assume that the effects of occupation and climate on food consumption are small.

Ideally the food consumption behavior of each member of an individual type should be more like that of other members of that type than it is like the behavior of any member of another type. This cannot be expected to be the case in the real world if we distinguish types by age and sex alone. Individual consumption behavior is probably more accurately described as lying along a continuum in which consumption behavior patterns overlap and shade into each other, than as classifiable into a set of discrete behavior types with significantly different consumption characteristics. Each individual could be regarded as constituting a separate type, but such an approach is hardly useful. Economic principles and relations if they are to be of any use must have some degree of generality. It is only by grouping individuals into more or less homogeneous types that we may ascertain principles and relations of economic behavior which may be said to have some generality. The fact that the divisions between these groups must be drawn somewhat arbitrarily does not weaken the validity of the economic relations which may be found to exist. However, after deciding that consumption behavior does not fall naturally into any limited number of age-sex types, and accepting the necessity of establishing somewhat arbitrary type divisions, we are confronted with the problem of the number of types which it is useful to distinguish.

In addition to the need to aggregate individuals into a limited number of types in order to obtain useful generalizations about economic behavior, the requirements of analytical simplicity and the limitations of total sample size also make such aggregation necessary. As the number of individual types distinguished is increased the number of household types which can be constructed from these individual types increases rapidly. For example, the number of resulting two person household types can be seen to increase rapidly as the number of individual types distinguished is increased:[1]

5 individual types produce 15 household types
6 individual types produce 21 household types
7 individual types produce 28 household types
8 individual types produce 36 household types
9 individual types produce 45 household types
10 individual types produce 55 household types

In going from 5 to 7 individual types the number of different resulting household types is almost doubled. In doubling the number of individual types distinguished from five to ten the number of household types produced is almost quadrupled. Certain combinations of the types which are distinguished are unlikely to occur for sociological, biological and economic reasons. Two person households consisting of a male over 65 and an infant are unlikely to occur in the population from which we are sampling, as are ones consisting of two infants. The problem of the multiplication of household types with increases in the number of individual types must be recognized, however, and the number of individual types distinguished must be limited in order to keep the number of resulting household types manageable.

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[1]The number of household types of a given size r is the number of different possible samples of size r which can be drawn with replacement from n individual types, or n^r, less all but one of any duplicated combinations. Thus the duplicated combination (Male 15-64, Female 15-64) and (Female 15-64, Male 15-64) would be counted as only one household type. In this example r equals 2 throughout.

Since little information is available about actual individual food intake behavior, we are forced also to use other criteria for the development of individual type divisions. In addition to observed behavior, nutritional requirements and certain economic and social considerations will be used in the construction of a classification of individual types.

In the use of nutritional requirements to separate individual types it must be remembered that these are measures of what should be consumed rather than of actual consumption. Since few persons in this country are barred from attaining the requirements by low income, the recommended levels and actual intakes can be expected to be closely related. Individual types may be separated on the basis of widely differing requirements, which can be expected to be closely related to actual consumption and thus to food expenditures in behalf of the individual. Calories will be used as a general measure of intake for the purposes of this study since they provide the best general measure of total intake. Table 2.1 presents the National Research Council's (N.R.C.) recommended caloric allowances by age and sex.

Table 2.1 seems to suggest that on the basis of requirements, individuals over age 12 should be distinguished by both age and sex. The absolute changes in requirements being greatest in the first 20 years of life, several different child types should be distinguished, while it should be possible to group adults into types covering a much wider age range. Because of the large absolute increase in requirements of males age 16-19 over the 13-15 age group, these two types should be held distinct if possible. The large increases between each of the children's recommended levels would indicate that each of these classes should also be held distinct if possible. Pregnant and lactating women should be a separate type. Because of the accelerated decrease in requirements after age 50, adults over 50 should be distinguished and the group over age 70 should probably also be distinguished for the same reason.

Table 2.1 - Recommended Daily Calorie Intake by Age and Sex[a]

Men		Women[b]		Children		Infants	
Age	Calories	Age	Calories	Age	Calories	Age	Calories
13-15	3100	13-15	2600	4-6	1700	Under 1 month	1000 calories to mother if breast fed
16-19	3600	16-19	2400	7-9	2100		
25[c]	3200	25[c]	2300	10-12	2500	1-6 months	720
45[c]	3000	45[c]	2200			6-12 months	900
65[d] [e]	2550	65[d] [e]	1800				

[a] National Academy of Science, National Research Council, Recommended Dietary Allowances (Washington: National Research Council, 1958), p. 18.

[b] Add 300 calories during second half of pregnancy.

[c] Requirements are reduced by 3 percent per decade between 30 and 50.

[d] Requirements are reduced by 7.5 percent per decade between 50 and 70.

[e] Requirements are reduced by 10 percent in the 70-80 decade.

Individual types may also be distinguished on the basis of differences in costs in the food budget plans designed to fulfill N.R.C. recommendations. These plans give costs for several different family types and a variety of individual types for low-cost, moderate cost and liberal levels of expenditure. Table 2.2 gives costs for individual types for the moderate-cost food plan developed by the United States Department of Agriculture.

The conclusions based on the estimated cost of a week's food for various individual types are substantially the same as the ones drawn from the allowances on which the estimated costs are based. The slight change in costs with age among adult types seems to indicate that wide groupings by age is not likely to result in any serious heterogeneity of expenditure behavior within the groups produced. The wide differences in costs between the different children's age groups indicate that a number of child types should be used, however.

In considering the available information about observed individual food consumption behavior, we find it to be largely of two types, food intake data and equivalent adult coefficient scales. Only a few studies of individual's food nutrient intakes exist because of the problems and expense involved in amassing sufficient data to ensure some degree of reliability. One study of individual intakes in farm, rural non-farm and village families in Southeastern New York by Young and Pilcher provides information on calorie intakes in all age and sex categories.[1] The authors' finding that the diet of the average family in the study was essentially a reflection of the dollar value of food eaten would seem to support the belief that the calorie intake of an individual provides some measure of expenditures in his behalf.[2] Calorie intakes by age and sex are given in Table 2.3.

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[1]Charlotte M. Young and Helen L. Pilcher, "Nutritional Status Survey, Groton Township, New York," Journal of the American Dietetic Association, XXVI, No. 10, (October 1950), 776-81.

[2]Ibid., 780.

Table 2.2 - Estimated Cost of One Week's Food by Age-Sex Categories, April 1959[a]

Men		Women		Children	
Age	Cost	Age	Cost	Age	Cost
75 years and over	$8.25	75 years and over	$6.50	10-12	$8.00
55-74	8.50	55-74	6.75	7-9	6.75
35-54	9.00	35-54	7.25	4-6	5.50
20-34	9.50	20-34	7.50	1-3	4.50
16-19	11.00	(Pregnant)	8.75	Under 1 year	3.75
13-15	9.50	(Nursing)	10.75		
		16-19	8.50		
		13-15	8.50		

[a]U. S. Department of Agriculture, "Estimated Cost of One Week's Food," Family Economic Review (June, 1959), p. 31. Estimates are based on 1958 N.R.C. recommended dietary allowances and average prices per pound paid by middle-income nonfarm survey families. Estimates have been rounded to nearest $0.25.

Table 2.3 - Calorie Intakes by Age and Sex, Groton Township Study[a]

Age	Male	Female
1-3	1569	1697
4-6	2028	1849
7-9	2193	2026
10-12	2557	2275
13-15	3654	1945
16-20	3375	1976
21-29	3321	2066
30-39	2999	2047
40-49	2821	1982
50-59	2730	1843
60-69	2032	1982
70 years and over	2341	1614

[a]Charlotte M. Young and Helen L. Pilcher, "Nutritional Status Survey, Groton Township, New York," Journal of the American Dietetic Association, XXVI, No. 10, (October 1950), 779.

The Groton Township Study results indicate that while male and female calorie intakes differ throughout life the differences become marked after age 13. The differences in intake between the age categories for children suggest that several child types should be used. Children's types should be differentiated by both age and sex after age 13. The differences between the intakes of males in the 16-20 and those in the 21-29 age groups is slight, indicating that these groups could be combined. Females in these age groups could also be combined. The decline in adult male intakes suggest that several adult male types are needed, and that those over 59 should be a separate type. Female intakes fall only slightly up to age 69, but women above this age should be a separate type.

Additional information on the intakes of women is provided by a North Central regional study of over 2000 women.[1] The results indicate that women over 70 should definitely be a separate type, their intakes being far lower than those in the 60-69 age group. The next greatest change in intake occurs between the 40-49 and 50-59 age groups. This suggests the use of three types for adult women, a type for ages 30-49, one from 50-69 and a third for over age 70.

The results of the North Central project and of other Federal-State cooperative nutritional status research have been summarized by Morgan and Odland.[2] The combined results indicated that the maximum intake for males occurs at age 16, after an almost linear increase from age 7 to 16. The maximum intake for females was at age 11, with a sharp increase in intake from age 8 to 11. The intake of females was found to

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[1]Iowa State College, Food Intakes of 2,189 Women in Five North Central States, Research Bulletin 468, North Central Regional Publication No. 83, (Ames: Iowa Agricultural and Home Economics Experiment Station, 1959).

[2]Agnes Fay Morgan and Lura M. Odland, "The Nutriture of People," Food--The Yearbook of Agriculture 1959, U. S. Department of Agriculture (Washington, U. S. Government Printing Office, 1959), pp. 201-206.

decline after age 11 with the decline becoming more marked after age 17. The intakes of adult males were found to decline linearly with age, with the decline becoming sharper after age 65. The intakes of adult women were found to decline slowly up to age 45 and decline more sharply thereafter. These studies included some 8,400 individuals throughout the United States and lend further support to the general conclusions reached on the basis of the smaller studies which have been cited.

A number of consumption scales, or adult equivalent scales, such as were discussed previously have been derived. We will consider here only those based on actual studies of food intakes, disregarding those based on the N.R.C. dietary allowances, since the differences in requirements between age-sex types have already been considered. Differences in coefficients between the types distinguished will be considered to mean that these types should be maintained. Large differences in coefficients between age types indicate that the differentiation of additional types may be in order. Only more recent scales will be considered in light of the changes in scales which have been noted by Woodbury:

> The outstanding difference between the later and earlier scales is the increased values assigned to children. This doubtless reflects the change in food habits in accordance with the modern tendency towards an increase in provision of relatively more expensive protective foods in the diet, especially for children.[1]

For this reason attention will be confined to only a few of the many studies which have derived scales. These are presented in Table 2.4 and include both United States studies and the two recent British studies by Prais and Houthakker and by Brown.

The United States scales indicate that while important differences exist between the coefficients for boys and girls from about 6 years of age onwards, these differences become marked at about age 12 or 13.

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[1]Woodbury, 459.

The slight changes with age in the coefficients for young children suggest that children under 4 or 5 years could be included in one type. The scales also suggest that children between 13 and 20 should be regarded as a class separate from adults or younger children. The classification of those between 13 and 20 as adults would be a more satisfactory approximation in the case of females than for males, the scales indicate. The changes between age 3 and 13 would make the division of this period into at least two age groups desirable. The differences between the two British scales lend support to Woodbury's comments on the increased weight of children in more recent scales. The Brown scale from 1951 data more closely resembles prewar United States scales than does the Prais scale which is from 1937-1938 data, suggesting that some of the same changes which Woodbury noted in United States scales occurred in Britain between 1937 and 1951.

Certain economic and social considerations are also important in our development of individual types. It will be useful to place type divisions at ages where changes in economic or social status affect eating behavior. Child types should probably be divided at age 6, for instance, the age when many children begin to eat lunch at school rather than at home. We will also want to establish a break between child and adult types at the age at which the formation of independent households begins. This is the period of increasing financial independence and the beginning of the accumulation of a stock of consumer durables. Another important change in eating behavior probably occurs at retirement age. Lunch is no longer eaten at work, energy requirements are lower and income has declined.

The preliminary system of individual types which was decided upon after consideration of differences in intake and differences in eating behavior with social and employment status will be presented in the next section.

Table 2.4 Food Consumption Scales for Individual Types, Recent United States and British Studies

	Wage Earner Study 1935 United States[a]		Consumer Purchases Study 1936-37 United States[a]		Heller Committee--1937 United States[a]		Working Class Households Study 1937-38 (Prais) Great Britain[b]		National Food Survey--1951(Brown) Great Britain[c]	
	Male	Female	Male	Female	Male	Female	Male	Female	Male[d]	Female[d]
Under 1	.48		.51		.765		.35		.59	
1	.48		.54		.765		.52		.59	
2	.51		.55		.765		.52		.59	
3	.51		.59	.58	.754		.52		.59	
4	.58		.61	.60	.754		.52		.59	
5	.58		.65	.63	.754		.57		.68	
6	.58		.73	.67	.776		.57		.68	
7	.76	.58	.80	.73	.776		.57		.68	
8	.76	.76	.87	.79	.776		.57		.68	
9	.84	.76	.91	.84	.929		.57		.68	
10	.84	.76	.95	.88	.929		.71		.68	
11	.90	.84	.98	.90	.929		.71		.68	
12	.90	.84	1.03	.93	.929		.71		.68	
13	1.00	.84	1.07	.97	.929		.71		.68	
14	1.00	.90	1.12	1.01	1.235	1.00	.81	.65	1.01	
15	1.00	.90	1.12	1.01	1.235	1.00	.81	.65	1.01	
16	1.02	.90	1.14	1.01	1.235	1.00	.81	.65	1.01	
17	1.02	.90	1.14	1.01	1.235	1.00	.81	.65	1.01	
18	1.02	.90	1.14	1.01	1.235	1.00			1.01	
19	1.02	.90	1.14	1.01	1.00	.902			1.01	
20	1.00[e]	.90[f]	1.00[g]	.92[h]					1.01	
Adult:							1.00	.88	.90[i]	.87[i]
Adult: Sedentary					.902					
Adult: Moderately Active					1.00	.902				

[a] Robert M. Woodbury, "Economic Consumption Scales and Their Uses," Journal of the American Statistical Association, XXXIX, No. 228 (December, 1944), 458, citing:

Wage Earner Study - 1935: F. M. Williams and Alice C. Hanson, Money Disbursements of Wage Earners and Clerical Workers 1934-36, Summary Volume, U. S. Bureau of Labor Statistics, Bulletin 638, p. 363;

Consumer Purchases Study 1936-37: Hazel K. Stiebeling, Day Monroe, Esther F. Phipard, Sadye F. Adelson and Faith Clark, Family Food Consumption and Dietary Levels, Five Regions, U. S. Department of Agriculture, Misc. Publication No. 452, p. 251;

Heller Committee - 1937: Emily Harriet Huntington and Mary Gorringe Luck, Living on a Moderate Income: The Incomes and Expenditures of Street-Car Men's and Clerk's Families in the San Francisco Bay Region, with an Introduction by Bruno Lasker, ("International Research Series of the Institute of Pacific Relations"; Berkeley: University of California Press, 1937), Appendix A.

[b] S. J. Prais, "The Estimation of Equivalent-Adult Scales from Family Budgets," The Economic Journal, LXIII (December, 1953), 803. Table II, Semi-logarithmic formulation for all food.

[c] J. A. C. Brown, "The Consumption of Food in Relation to Household Composition and Income," Econometrica, XXII, No. 4 (October, 1954), 454. Table IV, Weighted solution with no constants.

[d] Couple equals 2.00.

[e] Full time employed; unemployed and part-time employed, .89.

[f] Moderately active; for women 20 and over active, .92.

[g] Moderately active; for active, 1.12. For ages 75 and over, .90 for moderately active, .95 for active.

[h] Moderately active; for active 1.00. For ages 75 and over, .85 for moderately active, .90 for active.

[i] Adults in household other than couple.

The Combination of Individual Types to Obtain Household Types

After determining individual types which can be assumed to contain individuals with similar consumption characteristics, we are then able to begin combining these individual types into household types. The households which constitute a household type contain the same number and types of individuals. Because the behavior of the individuals in the individual types has been assumed to be similar, it will also be assumed that households made up of the same number and types of individuals will display similar behavior, and have similar Engel curves.

In order that the household types distinguished be broad enough to contain sufficient cases for study, attention must be given both to the number of individual types employed and the boundaries of these types. Individual types which, in addition to distinguishing age-sex categories with distinctive consumption characteristics, permit the construction of "typical" household types containing a large number of observations will be preferred. If we choose to distinguish several types of children it will be desirable to employ broad age classes for adults in order to limit the number of types of households consisting of parents and children. Since adult intakes vary less with age than those of children, this analytical necessity presents few problems.

The individual types chosen for a preliminary construction of household types were:

Infant - under 1 year
Pre-school child - 1 to 5 years
School age child - 6 to 11 years
Adolescent male - 12 to 14 years
Adolescent female - 12 to 14 years
Young male - 15 to 19 years
Young female - 15 to 19 years
Young adult male - 20 to 49 years
Young adult female - 20 to 49 years
Mature male - 50 to 64 years
Mature female - 50 to 64 years
Older male - 65 and over
Older female - 65 and over

Infants were separated from pre-school children because the average calorie requirement for infants under one year of 830 calories is substantially below that for older pre-school children. It also was hoped that it would be possible to parallel the infant classification in J. A. C. Brown's scale and other studies. The division between age 5 and 6 takes account of changes in eating patterns with the commencement of schooling. It divides younger children with substantially lower observed intakes from the school-age group with its higher intake levels. The division is also at about the midpoint of the age 1 to 11 interval in which calorie requirements increase linearly. The first differentiation between the sexes is not made until age twelve in order to reduce the number of types, although there is evidence of differences as early as age 8 or 9. The 12 to 14 age group distinguishes the period of highest recommended allowances for females, except for the periods of pregnancy and nursing. Observed intakes for females were generally observed to reach a maximum just prior to this period, declining somewhat in the period itself. It was expected that if necessary this group could be combined with the age 15 to 19 group. The 15 to 19 age group covers the period in which the recent nutritional status studies reported by Morgan and Odland found observed intakes of males to reach a maximum.[1] This is also the period in which both the United States consumption scales reported in Table 2.4 and male calorie requirements reach a maximum. This group was expected to be somewhat under-represented in this study, with many of those in this category away from home at school or in the Armed Services. The division at age 20 was selected to separate young adults with more stable levels of intake from the older adolescent group. This division also allows the classifications of the greater part of those maintaining independent households as adults. The young adult age category was

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[1]Morgan and Odland, pp. 201-206.

extended to age 49 so that the parents of younger children would fall into one category. The division provides a break in the linear decline of male intakes observed in recent Federal-State cooperative nutritional studies, and comes a few years after the age at which female intakes were observed to begin to decline more sharply. The 50 to 64 age category separates mature adults with established households from the younger households and the households of the retired. This group contains adults with more rapidly declining requirements and separates them from the younger adult groups. The division at age 65 was chosen to permit the separate study of the households of the retired and to separate older adults with still declining energy requirements and observed lower intakes from the mature adult group. This break is at the age at which the Federal-State cooperative nutritional status studies and the Groton Township Study found male intakes to begin to decline more sharply.

Some 550 distinct size, age-sex composition types of household were produced when the households of the urban portion of the 1955 U.S.D.A. Household Food Consumption Survey were classified using the 13 proposed individual types. Only a very few of the household types produced contained over 75 observations, suggesting immediately that the combination of individual types would be necessary.

The second set of individual types developed was:

Pre-school child - birth to 5 years
School age child - 6 to 14 years
Young adult male - 15 to 39 years
Young adult female - 15 to 39 years
Mature male - 40 to 64 years
Mature female - 40 to 64 years
Older male - 65 and over
Older female - 65 and over

For this second set of individual types the age 6 to 11 and the age 12 to 14 groups were combined, while individuals in the age 15 to 19 type were combined with the appropriate young adult group. The new young

adult category produced was for ages 15 to 39 inclusive. The mature adult group was enlarged to run from age 40 to 64. The older adult group remained unchanged, including those 65 and over. The number of individual types distinguished was reduced from 13 to only 8. While the categories are more gross, two categories of children are still distinguished. Older adolescents were classified as adults, since on the basis of observed intakes it was felt that their consumption more resembled that of adults than that of the school age children. The enlarged category of mature adults includes the group whose intakes have declined from previous levels and are beginning to decline more sharply. The age break at 40 still classifies most parents of younger children in a single age category.

The second set of individual types was found to provide a substantial number of household types containing a sufficient number of observations to permit study. This second group of eight individual types is the basis for all the household types selected for the study. It was necessary, however, to combine individual types in a few instances in order to obtain a sufficient number of observations for study. The selection of the households to be included in each of the household types and the household types chosen for study will be discussed in the next chapter.

CHAPTER III

THE HOUSEHOLD TYPES

Criteria for the Selection of the Set of Household Types for which Elasticities Are To Be Estimated

In the last chapter, it was pointed out that the income elasticity for food of a group of households can be estimated properly only if the households can be regarded as having similar Engel curves. It was expected that the Engel curves of households of a particular size and composition could be expected to be similar if the behavior of the individual types of which the households consist is reasonably uniform. A set of individual types, containing individuals with similar food consumption characteristics was constructed. These individual types were then combined to obtain household types composed of households which could be assumed to have similar Engel curves. The set of household types chosen was, it must be noted, designed to produce groups which could be expected to have similar Engel curves. This set of types thus may not fulfill certain other requirements which arise out of the objectives of this study.

This study undertook to determine the income elasticities of demand for food in households of varying size and age-sex composition. The set of household types which is implicit in this objective is based on criteria other than the expectation of similar Engel curves. The household types for which elasticities should be estimated should be chosen so that the results will best show such differences as do exist and so that the results will have the greatest meaning and usefulness in the consideration of other economic problems. Such a set of types should be based on the

natural and typical household types which are found in our society. Further, they should be such that they can be related easily to other economic data on households and to available census information and projections.

Available census data and projections, however, provide few criteria for the selection of a set of household types for which income elasticities should be estimated. Projections are made for individual types by age, sex, and marital status, but no attempt is made to project numbers of households by size and composition.[1] The principal projection for household numbers is by age of the male head and is similar to the one given in Table 1.4, in Chapter I.

Current numbers of households are available in a somewhat more detailed set of categories than are used in projections. Information from the 1960 Census on households gives numbers by age of head, size of family and number in certain children's age categories.[2] Thus, if we wish to relate our results to the available projections, only the age of the household head is of concern. If we desire to match the categories of the projections, we shall want to employ the same three age categories: under twenty-five years, twenty-five to fifty-four years, and those fifty-five and over. If we wish to match the categories used in detailing current numbers a more elaborate set of types would be required.

The choice of types, however, should also be related to the typical or natural type categories of our society. This would suggest in a most

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[1]It was learned in an interview with Paul C. Glick, Chief of the Social Statistics Branch, Population and Housing Division, U. S. Bureau of the Census, that the projection of numbers of households by size and age-sex composition is regarded as a most difficult problem and that no official estimates of this nature are being attempted.

[2]Such a description of current numbers is given in U. S. Bureau of the Census, "Household and Family Characteristics: March 1960," Current Population Reports, Series P-20, No. 106 (Washington: Bureau of the Census, January 9, 1961), p. 15.

general way that types should be distinguished by their location in the economic and family life cycle.[1] Young married couples and couples with young children just starting their families and likely involved in acquiring the set of durable goods considered necessary for housekeeping should be distinguished from older couples with children. Both these household types should be distinguished from older families in which the children are grown, or have left home. And all of these should be distinguished from the households of the retired and the aged.

Recent consumption research provides increasing evidence of changes in consumption behavior with changes in the economic and family life cycle.[2]

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[1]The concepts of the family life cycle and the economic life cycle have not yet been developed to the point where either may be stated in other than a rather general way. The family life cycle details the changing membership of a family group from its formation by marriage to its dissolution by divorce or the death of the surviving spouse. Demographers considering the family life cycle have concerned themselves particularly with the ages of the husband and wife at such stages as first marriage, birth of last child, marriage of last child, death of husband and death of surviving spouse. See for example, Paul C. Glick, American Families ("Census Monograph Series"; New York: John Wiley and Sons, 1957), p. 55.

The concept of the economic life cycle has been sketched only in broad outlines to date. The economic life cycle concept when further developed should provide information on changes in family economic behavior with the changing family responsibilities and occupational status of its head.

[2]Among the studies which have found changes in expenditure behavior with changes in the economic or family life cycle are:

Charles Zwick, "Demographic Variation: Its Impact on Consumer Behavior," Review of Economics and Statistics, XXXIX, No. 4 (November 1957), 451-56.

Janet A. Fisher, "Income, Spending and Saving Patterns of Consumer Units in Different Age Groups," Studies in Income and Wealth, Vol. XV, Conference on Research in Income and Wealth (New York: National Bureau of Economic Research, 1952), pp. 75-102.

Harold Lydall, "The Life Cycle in Income, Saving and Asset Ownership," Econometrica, XXIII, No. 2 (April, 1955), 131-50.

Vernon G. Lippitt, Determinants of Consumer Demand for House Furnishings and Equipment ("Harvard Economic Studies," Vol. CX; Cambridge: Harvard University Press, 1959).

The evidence for the existence of such changes makes this a central consideration in the choice of a system of household types. This study can best build on this previous work and perhaps make some contribution to knowledge in this area if life cycle stages are the basis of the household type system employed. It is felt that such considerations as matching existing census projections are only of secondary concern, especially in view of the types of projections which are available. It seems more reasonable to proceed in hopes of developing a useful type system and then modify available projections to fit it. It is expected that an experienced demographer could make any required changes in the one relevant projection, numbers of households by age of head, if it is desired to use the results of this study in connection with projections.

Because the existing knowledge of the effects of stage in the economic and family life cycle is of only the most rudimentary nature, it seems desirable to use life cycle categories in the most simple manner possible. The four categories mentioned previously are probably as many as we can hope to distinguish at this stage in the development of this approach. These basic categories were: Young couples with no children or with young children, couples with older children, older couples whose children may or may not have left home, and couples of retirement age.

It will be remembered that in the last chapter, in constructing the types of households which could be expected to have similar Engel curves, no attempt was made to aggregate households of greatly different composition, or of different sizes even though in many cases certain types undoubtedly could have been assumed to have similar Engel curves. The household types produced, it is felt, generally conform to the categories of the economic and family life cycle. The household types for two or more persons fall in the four life cycle categories discussed. These categories are roughly younger households with and without children in which the wife is under forty, those with and without children in which the

wife is under sixty-five, the households in which all members are fifteen or over but under sixty-five and the households maintained by those sixty-five and over or including such individuals. While certain of the age categories for adult members of the household are broader than those which would be most desirable, the age of the child household members is more closely detailed and can be used to fix the location of the type in the economic and family life cycle.

Because size and age-sex composition were the basis for aggregating households into types with similar Engel curves it will be possible to use this same system of household types as the types for which income elasticities are estimated. We must now turn to another important problem, that of clearly identifying the consumption unit whose behavior is under consideration.

Identifying the Unit of Inquiry

Studies of consumption behavior have used a variety of names for the micro-economic group on which they focused their attention. This group has been labeled the "household," the "family" and sometimes the "economic family." This variety of names for the unit of consumption, each with its own somewhat different meaning, have caused investigators to lose sight of the fact that the group whose behavior we wish to observe is an economic group, whose boundaries must be precisely described if empirical studies of consumption behavior are to have real economic meaning. This unit is often closely related to groups defined on a biological, legal and sociological basis. In our society certain groups such as the household and the family, which are defined in non-economic terms, are usually coterminous with the economic group in which consumption takes place. Because the family and the household often have the same boundaries as the consumption group they are easily mistaken as identical.

"Family" is a term used to describe a social-biological relationship and living arrangements. Its census definition as "a group of two or more persons who live together and who are related by blood, marriage, or adoption,"[1] contains no economic dimension and makes the term unsuitable for defining the boundaries of an economic group. "Household" as defined by the Census is similarly an unsuitable definition of the consumption group we wish to observe. Its census definition as "the entire group of persons who occupy a dwelling unit,"[2] i.e., a group of rooms or a single room occupied as separate living quarters with separate cooking equipment or a separate entrance, is on the basis of living arrangements. It does define the group which jointly consume a set of housing facilities, but lacks full economic dimension as far as the consumption of food and other goods is concerned.

The group which is most nearly coterminous with the consumption unit is the "economic family" as defined in the U. S. Department of Agriculture Household Food Consumption Survey in 1955. The "economic family" is defined as "a person living alone or a group of persons who lived together and drew from a common fund for their major items of expense. Family members temporarily away from home--at school, at work, or on vacation, were considered members of the economic family, although not residing in the dwelling unit at the time of the interview."[3] This group, however, does not include members of the consumption unit who live apart on a permanent basis. If the consumption behavior of a group is to be understood, the entire number of those dependent on its

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[1]Glick, p. 210.

[2]Ibid.

[3]U. S. Department of Agriculture, Food Consumption of Households in the United States ("Household Food Consumption Survey 1955," Report No. 1; Washington: U. S. Government Printing Office, 1956), p. 193.

income for support should be known. In neglecting family members living apart permanently, "economic family" likely understates the demands on the income of the group, since members who live apart from the group are often dependent on it (e.g., aged parents in nursing homes). Those living apart may also be sending money home, thus giving rise to another complication.

Because the terms used to delimit the group in which consumption occurs do not always precisely define economic boundaries, it becomes desirable to adopt some new term which can be used to describe the unit we wish to observe. For this purpose the term used by Cochrane and Bell, "consuming unit," seems particularly suitable. "This is a unit whose members pool their funds (or incomes) and where decisions with respect to the use of those funds are made as a unit."[1]

Just as we cannot understand the behavior of the consuming unit without knowing its entire membership, in the study of the consumption of particular commodities we must know which members of the group consume the commodity. Not all members of the group participate in the consumption of every commodity used within the group. The level of cigarette consumption is more easily understood if we know the number of adults in the group, and baby food consumption is best understood in relation to the number of infants present. In order to further refine our study of consumption behavior, we must know the size and composition of the consuming unit and the size and composition of the subset which consumes a particular commodity or group of commodities.

Since this thesis is concerned with expenditures for food consumed at home, we will consider the behavior of the subset of the consuming unit in which home food consumption occurs. This subset hereafter will be referred to as the "eating unit."

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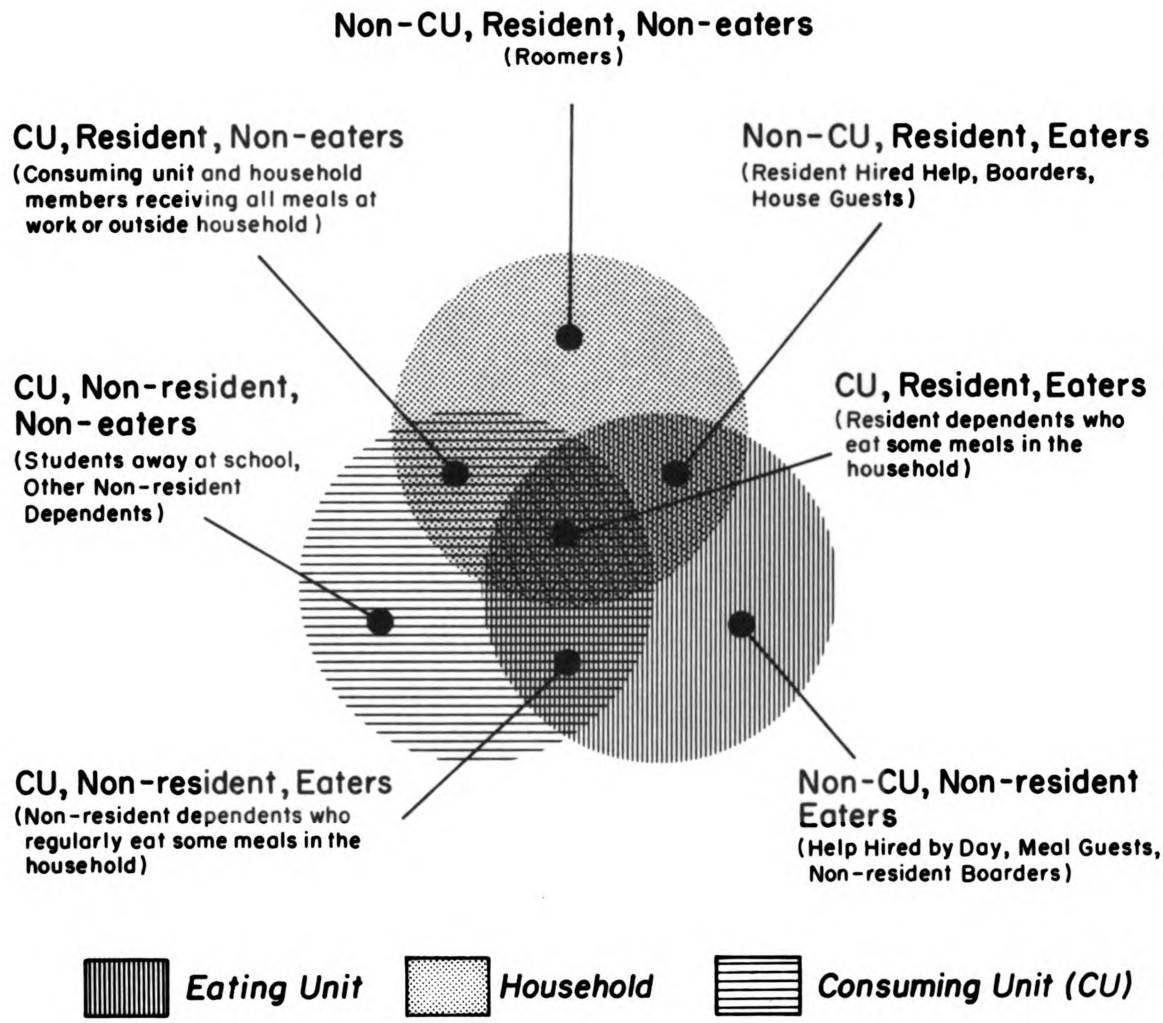
[1]Cochrane and Bell, p. 14.

The "family" is a socially defined kinship group whose members do not from its definition necessarily have any economic relationship to each other. We will turn from it to consider the interrelationships among the household, the consuming unit and the eating unit, groups which do have an economic dimension. Since the household consists of a group of individuals who jointly consume a set of living facilities, it may in a sense be considered to be at least partly economically defined. The consuming unit is defined in a purely economic dimension as the group of individuals who meet their living expenses from a common shared income. To be most useful in the study of consumption behavior the membership of the eating unit should not be restricted to members of the consuming unit but should also include all others who share in the home consumption of the food provided by the consuming unit. Here it is assumed that guests will share without direct repayment, while boarders will receive their share in return for payment and that hired help receive their share in lieu of pay. In so defining the eating unit we include all those who are making demands upon it, rather than ascribing all the expenditures in behalf of the entire eating unit to the members of the consuming unit alone.

The interrelationships between the household, the consuming unit (CU) and the eating unit (EU) are illustrated in Figure 3.1. The household consists of all those resident in the dwelling. The EU includes all who draw on the food supplies of the CU, and the CU includes all those who pool their incomes and share the goods and services purchased with this income. Each of these three groups is made up of four sub-groups, three of which overlap or intersect with one or both of the other groups. The CU, for example, is made up of (1) members of the CU, who are not resident in the household and do not eat in the household, and are thus not included in the EU or household, (2) members of the CU who eat in the household but are not residents, and thus are included in the EU but not the household, (3) members of the CU who are resident in the household

FIGURE 3.1

GROUPS ASSOCIATED WITH HOME FOOD CONSUMPTION



but do not eat there, and thus are included in the household but not the EU, and (4) members of the CU who are residents of the household and eat there, and are thus included in all three groups, the CU, household and EU. The EU and household are each similarly composed of three sub-groups which overlap with one or both other groups and one sub-group which does not.

For most CU, the three groups, the CU, the EU and the household will be coterminous. The EU will consist solely of resident members of the CU and will include all members of the household and the CU. In most other cases only a few of the other sub-groups mentioned are present. Figure 3.1 represents all possible intersections of the three groups. Although the existence of the CU is a necessary condition of the existence of sub-groups, its existence is not a sufficient condition for the existence of the household or the EU. An individual who by himself constitutes a CU may have no permanent dwelling unit and may eat all his meals in restaurants. In this case, no household or EU exists, despite the existence of a CU. The situation of many inmates of institutions and members of the Armed Forces is of this type.

This study will be concerned chiefly with the behavior of the consuming unit and its expenditures on behalf of the eating unit. However, since the survey data used in this study was collected on the basis of household groups, it will be necessary to bear in mind the differences in the memberships of the consuming unit, the eating unit and the household in setting out to determine the relationship between income and expenditure on food.

Households Included Within the Household Type Classifications

Only a portion of the households in the urban sample of the 1955 Household Food Consumption Survey were included in this study.[1] The households eliminated were those for which income information was not available and those in which differences in the size of the consuming unit, eating unit, and household obscured the relationship of food expenditure to income. In addition, households of six or more persons were eliminated because the number of households of any particular type was insufficient for analysis.

Many households in the urban sample contained more than one "economic family" or group living together and drawing from a common fund for major items of expense. The group in these households with primary responsibility for maintaining the dwelling unit was designated as the "primary economic family."[2] Other resident family members outside the primary economic family were labeled as the "secondary economic family."[3] In the households which contained more than one economic family and in those which included roomers, boarders and resident hired help, income information was collected only for the primary economic family. No information on the income of the secondary economic family or other residents of the household was requested. Income information was thus available only for a part of the group eating regularly within the household, while food expenditures are dependent on the size and composition of the entire group.

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[1]The objectives of the survey and the sampling techniques which were employed are discussed in Appendix I.

[2]U. S. Department of Agriculture, Food Consumption of Households in the United States ("Household Food Consumption Survey 1955," Report No. 1; Washington: U. S. Government Printing Office, 1956), p. 193.

[3]Ibid.

Any relationship of the food expenditures of households containing a secondary economic family or other individuals to the income of the primary economic family understates the total income which in fact governs the food expenditures of the group. Even if the secondary family's contributions to the food budget and boarder's payments are included in the income of the primary family, only a part of the income of the entire group is included in the available income figures. To avoid the problems of understatement of income, only households which consisted solely of the members of a single and thus primary economic family were considered. All households which contained a secondary economic family, roomers, boarders or resident hired help were eliminated. In the group of households retained for study the size of the primary economic family was equal to the size of the household, all households which contained more than one economic family having been eliminated. The households retained were those for which exact income information covering every member of the household was available.

The Survey definition of the primary economic family is closely related to that which was put forward for the "consuming unit." The chief difference in these two groups is the omission of members who are living apart on a permanent basis from the primary economic family. Since this difference is important in only a very few cases, the members of the primary economic family will be considered to be a consuming unit, in households which consist only of a primary economic family. The income of the primary economic family will be regarded as the income of the consuming unit for the purposes of this study.

A few households were found in which a member of the consuming unit ate no meals in the household. It was decided that these households should also be eliminated from the study, since the household composition overstated the demands on the food supplies of the eating unit. Comparisons of the expenditures of households of the same compositional type would be

clouded by the differences in the actual number and types of individuals being fed. If households containing non-eaters had been retained with the non-eaters eliminated from household composition, in order that household composition reflect only the demands on food expenditures, the demands of other items in the family budget and thus on total income would likely be understated. To avoid such complications these households were eliminated altogether.

After eliminating all households in which the consuming unit differed from the household size, and those in which a member of the household ate no meals in the household during the survey week, a residual group is obtained in which the consuming unit, the non-guest portion of the eating unit and the household are equal in size and of identical composition. This group of households is represented graphically in Figure 3.1 by the darkest shaded area, consisting of resident members of the consuming unit who eat at least some meals at home. For this group of households we have complete information on income, and full information on the age and sex of each of the individuals who make regular demands on the consuming unit. It should be noted that households which had entertained guests during the survey week were not excluded from the study for this reason. Although it was recognized that guest meals would increase total expenditures no attempt was made to adjust for this factor because of the difficulties in arriving at a basis for adjustment and the expectation that its effects would be minor.

Certain other households for which complete income information was not available were also eliminated. These households were those who refused to provide information on their incomes and others which had been recently established and were not asked for the information. The lack of data for recently established households may have an important effect on the results for certain household types, especially for the type including young married couples. It will be necessary to remember

that this group is not included in interpreting the results of the analysis. In addition, households which reported negative incomes, under the income definition of the survey, were eliminated. These households were not included because of conceptual and computational difficulties in handling negative incomes.

The number of households eliminated from the urban portion of the survey for each of the reasons discussed is given in Table 3.1. A total of 444 households were excluded from the household types constructed for the reasons which have been discussed. In addition, 241 households of six persons and over were not utilized in this study. These larger households were not studied because the number of households included of any particular compositional type was not sufficient for analysis. A total of 2140 households remained and were classified according to the system of household types which was employed. After the households had been classified into types, types containing a sufficient number of observations to permit analysis were selected for further study.

The exclusion of certain observations included in the survey sample from the household types of this study raises the possibility of biases beyond those present in the survey sample itself. This study is concerned with the behavior of individual household types and is not concerned with the biases of the survey sample arising from under-representation of certain household types.[1] The biases of concern to this study are those within household types. For the purposes of this study it is not necessary to preserve the proportional relationship of household types found in the population from which the survey is drawn, but only the proper proportions of characteristics of particular household types within the population.

The biases of the survey sample resulting from refusals to supply income information may result in under-representation of households with

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[1]The biases noted in the survey sample are discussed in Appendix I.

Table 3.1 - Numbers of Households Excluded from the Household Types Constructed in the Study

Consuming Unit Size	Total Observations in Survey (Urban)	Excluded Observations				Number of Observations Included in Types Constructed
		Households Including a Non-Meal Eater	Households Not Reporting Income	Households Reporting Negative Income	Households Including Individuals Not Members of the CU	
One person	258	--	30	--	23	205
Two person	820	7	120	2	44	647
Three person	622	15	47	--	32	528
Four person	576	13	45	--	22	496
Five person	308	13	20	--	11	264
Totals	2584	48	262	2	132	2140

employed homemakers within any given household type. The bias of the survey sample resulting from not asking recently established households to supply income information will result in the under-representation of such households in all household types. This under-representation will be most important in the household types for smaller and younger families.

It is held that the results will not be biased by the other exclusions discussed, if we remember in considering the results that we are no longer considering all households of a particular size or of a particular size and composition, but only a subset of them. This subset has certain specified characteristics, which were the basis for the selection of the households included in the subset. After the exclusions, the results for a particular household type should be representative of all households of that size and composition, consisting solely of members of one consuming unit, all of whose members eat at least some meals at home. For each such household type it should be possible to estimate the relationship of food expenditures to income free from disturbances arising from heterogeneity in the number of meal eaters and family dependents after the eliminations which have been discussed have been made.

CHAPTER IV

THE ECONOMIC VARIABLES AND EXPRESSIONS OF THEIR RELATIONSHIP

Having selected a method of classifying individuals with similar consumption characteristics into individual types and having within the limits of the data combined these types into household types of uniform size and similar composition, we can proceed to study the relationship between income and expenditure on food within each household type assuming the influence of household size and composition on expenditure to be constant within each household type.

The Variables of Economic Theory

The variables derived from static consumption theory for consideration in this study are income and total food expenditure. It is desired to observe the relationship between these two variables at varying levels of income in households of each particular type. In order to isolate this interaction so that it can be observed independently, some means must be found of holding the other variables of the system constant. Since the data to be employed were obtained in a cross-sectional survey many of the variables which must be held or assumed constant in static analysis are fixed by the nature of the data collection method; others require study to determine their possible effects.

Consumer prices must be assumed to have remained constant throughout the survey period, and to have been the same to all households in all of the areas represented by the survey. Food supplies must be assumed to have remained at the same level throughout the survey period.

Food expenditures must be assumed to have been a function only of the income received in the income period specified by the survey and uninfluenced by any recent changes or changes in the more remote past.

The effects of certain factors which have been found in empirical studies to influence the level of expenditures, must either be removed or be assumed to be negligible, so that the Engel curves of different households within a given household type may be regarded as similar. Unless their effects are removed or can be assumed to be negligible, these so-called "empirical variables" may produce substantial unexplained variability in the relation of expenditure to income. The influence of these variables, education, occupation, social status, employment of the homemaker, ethnic background, urbanization, region and others, is discussed in the next section. All of the effects of differences in household size and composition are assumed to have been eliminated by the system of household type classification which is employed.

Institutional factors, technology and population numbers are considered to be fixed by the use of the cross-sectional method.

Empirical Variables

Empirical studies of consumption behavior have focused on a number of variables which have been found to be useful in explaining differences in expenditure behavior in addition to those prescribed by utility and indifference formulations of consumption theory. In addition to income, which is taken as the determining variable of consumption theory in cross-sectional studies, family size and composition, stage in the economic life cycle, occupation, social class, education, employment of the homemaker, ethnic background, region and urbanization have been used as partial explanations of differences in tastes and preferences.[1] These empirical

[1]Cochrane and Bell, pp. 196-202. See also, Irma H. Gross and E. W. Crandall, Management for Modern Families (New York: Appleton-Century-Crofts, 1954), pp. 94-131.

variables are highly interrelated, and only part of the effects of any one variable are independent of the others. Income, level of education, occupational status and social class can be seen to be quite closely related, as are race or ethnic background, income and education. For example, differences in negro and white expenditure behavior may be due to differences in income, education and occupation rather than to any racial differences.

In our consideration of the expenditure behavior of differing household types we will be able to deal with some of these variables, but will be forced to assume that the effects of the others are negligible. Since the data used in this thesis include only urban households, the independent effects of urbanization can be considered to be constant. The system of household types which will be used takes account of the size and composition of the household and should also hold constant most of the independent effects of age of the homemaker and family stage in the economic life cycle. The effects of occupation, social class and education are related so closely to income that it was felt that these factors could be ignored, since income was being treated as a variable.[2] Education, social class and occupation, however, probably should be considered more carefully in any study of the allocation of total food expenditure between food groups. Three other empirical variables, employment of the homemaker, region and race, will not be controlled and may have an important effect on expenditure behavior.

It is generally expected that food expenditures will be higher in households in which the homemaker is employed because of the use of more highly processed and more costly time-saving prepared foods. The results of a study of the total sample from which the data for this study was drawn does show food expenditures per person were greater in

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[2]Moss, pp. 140-141. In his study Moss found no significant differences in food expenditures per capita with education of homemaker or occupation of household head when income and family-size were controlled.

households in which the homemaker was employed.[1] It does not appear that the difference can be laid solely to this factor with any certainty, however. Expenditures for the week were $8.33 per person in urban households in which the homemaker was employed as compared to $7.65 in the households in which the homemaker was not employed. The households in which the homemaker was employed were smaller, had a smaller proportion of children under 16 and a larger proportion of adults and had higher total incomes than did the other households. All of these factors are generally associated with higher expenditures per person. The employment of the homemaker may have had little or no net effect on expenditure independent of these influences, all of which are included as variables in this study. For this reason it is felt that the omission of a control for employment of the homemaker will have little effect on this study.

Regional differences in food expenditures are of some importance, however, as compared to the probable influence of employment of the homemaker. One indication of the extent of this difference is the wide variation in the cost of a week's food in the four Census regions of the United States. Estimates for the cost of a week's food in July 1959 based on the United States Department of Agriculture low-cost food plan gave the following regional estimates for a family of four (husband, wife, boy, age 10, girl, age 8):[2]

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[1]U. S. Department of Agriculture, Food Consumption and Dietary Levels of Households As Related to Employment of Homemaker, United States, by Region ("Household Food Consumption Survey 1955," Report No. 15; Washington: U. S. Government Printing Office), pp. 1-2.

[2]Eloise Cofer, "Estimated Cost of One Week's Food--U. S. A. Average and Four Regions," U. S. Department of Agriculture, Family Economics Review (September 1959), p. 11.

South	$20.80
Northeast	$26.50
North Central	$25.30
West	$26.10
U. S. Average	$24.00

A special adaptation of the low-cost food plan which takes the larger quantities of grain products and fats consumed in the South more fully into account estimated the cost of a week's food in the South for a family of four at $19.80, instead of $20.80.[1] The lower cost of a week's food in the South arises out of the consumption of the less expensive foods within a given food group,[2] e.g., a preference for pork rather than beef, and a higher consumption of grains and fats and a lower consumption of dairy products, meat and milk in comparison with other areas,[3] in addition to such price differences as may exist.

The differences in actual expenditure between urban households in the four regions is somewhat less marked, as can be seen in Table 4.1. When the effect of income differences between regions is removed by considering a single income class, in this case the households of two or more persons with incomes between $4000 and $4999, the differences between food expenditures in the four regions are further diminished. Although important differences can still be seen to exist in food expenditure behavior between regions, in order to maintain the number of cases available for study it was necessary to proceed on the assumption that these known differences in behavior would not seriously damage the results.

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[1]Cofer, "An Adaptation of the Low-Cost Food Plan for the South," U. S. Department of Agriculture, Family Economics Review (September 1959), p. 17.

[2]Cofer, "Estimated Cost of One Week's Food - U. S. A. Average and Four Regions," p. 11.

[3]Cofer, "An Adaptation of the Low Cost Food Plan for the South," p. 15.

Table 4.1 - Average Weekly Food Expenditures in Urban Households of Two or More Persons, By Region, 1955.

Region	All Incomes		Income $4000-$4999	
	Expenditure per Household	Expenditure per Person	Expenditure per Household	Expenditure per Person
South[a]	$21.50	$6.34	$23.23	$6.87
Northeast[b]	27.48	8.36	28.04	8.07
North Central[c]	28.10	8.31	27.34	7.61
West[d]	26.97	8.23	25.97	7.45
U. S. Average[e]	26.15	7.83	26.67	7.63

[a] U. S. Department of Agriculture, Food Consumption of Households in the South ("Household Food Consumption Survey 1955," Report No. 4; Washington: U. S. Government Printing Office, 1956), p. 17.

[b] U. S. Department of Agriculture, Food Consumption of Households in the Northeast ("Household Food Consumption Survey 1955," Report No. 2; Washington: U. S. Government Printing Office, 1956), p. 16.

[c] U. S. Department of Agriculture, Food Consumption of Households in the North Central Region ("Household Food Consumption Survey 1955," Report No. 3; Washington: U. S. Government Printing Office, 1956), p. 17.

[d] U. S. Department of Agriculture, Food Consumption of Households in the West ("Household Food Consumption Survey 1955," Report No. 5; Washington: U. S. Government Printing Office, 1956), p. 15.

[e] U. S. Department of Agriculture, Food Consumption of Households in the United States ("Household Food Consumption Survey 1955," Report No. 1; Washington: U. S. Government Printing Office, 1956), p. 17.

Information available on the effects of race and ethnic background on food expenditures seems to indicate that the influence of this factor on behavior may be declining. Earlier information is drawn chiefly from the Bureau of Labor Statistics 1935-1936 study of family expenditures. In the New York City portion of the study it was found that expenditures for food by low-income negro families were smaller than those of white families of comparable incomes.[1] The meaning of these food expenditure figures is complicated by the employment of many negroes as domestic servants and kitchen help in restaurants where meals were part of the wage. Sufficient other differences existed between the negro and white families studied to indicate real differences in consumption behavior between the two groups, for example, negro families were found to save more at the same level of current income than did white families. A more recent B.L.S. study of food expenditures in Washington, D. C. and Richmond, Virginia in 1947 and 1948 found the differences in the food expenditures of negro and white households to be greatest at the lowest income level.[2] Less difference could be noted for households with over $2,000 a year income. The negro households were, it should be noted, larger than the white households in most cases. The consumer expenditures study of 12,500 urban households conducted by the Bureau of Labor Statistics in 1950 and early 1951 also reported average expenditures for home food to be generally larger in white households than in negro households at a given income level, the difference being greatest at lower income levels.[3] The results of these studies would seem to indicate that as negro

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[1]Cochrane and Bell, pp. 199-201.

[2]Helen M. Humes, "Family Food Expenditures, 1947 and 1948," U. S. Department of Labor, Monthly Labor Review, LXVI, No. 6 (June 1949), 621-30.

[3]University of Pennsylvania, Study of Consumer Expenditures, Incomes and Savings, Vol. III: Expenditures for Food, Beverages and Tobacco, tabulated by the Bureau of Labor Statistics for the Wharton School of Finance and Commerce (Philadelphia: University of Pennsylvania, 1956), pp. 138-40.

households move to higher income levels differences in behavior become less important. Since the living standard of negro households can be expected to have further improved between the B.L.S. 1950 study and the U.S.D.A. Household Food Consumption Survey in 1955, differences in behavior can be expected to be somewhat smaller than noted here. In order to preserve the size of the sample of each household type, data for households of both races will be used on the assumption that the net effects of racial differences in behavior will be small.

The urban portion of the U.S.D.A. survey contained 11 percent negro households.[1] Because of characteristic compositional differences between negro and white households it cannot be expected that this proportion of negro households will be present in most of the household types to be considered. The household types to be considered in this study are chiefly smaller-sized, husband and wife households with some children present. Non-white urban households average somewhat over a half a person larger than white households, include lodgers in about three times as many cases, average fewer male heads, have fewer dependent children present and have many more married couples without their own households present.[2] Because of these variations it is expected that there will be a high proportion of negro households among households excluded from the study because the consuming unit, eating unit, and household were not of equal size. It should be expected, however, that a high proportion of the small households will be negro. Glick has related the high proportion of small negro households to the high proportion of childless non-white women.[3]

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[1]U. S. Department of Agriculture, Food Consumption of Households in the United States, ("Household Food Consumption Survey 1955," Report No. 1; Washington: U. S. Government Printing Office, 1956), p. 190.

[2]Glick, pp. 19, 24, 61, 196.

[3]Ibid., p. 24.

In studying the data to be used in this thesis it became clear that another variable, the total number of meals eaten in the household, had to be taken into consideration. This variable has not been generally used in studies of household food expenditure except in some recent studies by the U.S.D.A.[1] Apparently the effects of differences in the total number of meals eaten on expenditures independent of differences in the size and composition of the household have been considered to be small. This, however, can no longer be considered to be the case, since with increasing incomes in recent years, the proportion of meals eaten out by household members has increased producing substantial variability in the number of meals eaten at home.

In the households eligible for inclusion in the household types used in this study the following results were found:

	Number of Meals Eaten at Home	
	Mean	Standard Deviation
One person households	19.7	5.8
Two person households	40.4	10.7
Three person households	59.9	12.4
Four person households	78.6	10.0
Five person households	100.3	9.9

The substantial standard deviations seemed to indicate that the variability in the number of meals eaten, even after household size was controlled, was of such a magnitude that it was certain to exert an important influence on the level of expenditures. For this reason it was considered most important that some method be found of dealing with the meals variable

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[1]The number of meals served as a variable has been dealt with through the use of household size in "equivalent persons" in these studies. The number of equivalent persons in a household is determined by dividing total meals served by 21, to obtain the number of full-time, 21 meals-a-week eaters. The measure is thus, in effect, a measure of total meals served. The use of this variable will be discussed more fully later in this chapter in the section Forms of the Variables.

in this study. Some of the possible methods are discussed later in this chapter.

Economic Expressions of the Relationship Between Income and Expenditure

The relationship between income and food expenditure has been expressed by economists both in the form of income-expenditure elasticities of demand for food and as Engel curves representing food expenditures at increasing levels of income.

Graphic representations of food expenditure with increasing income are referred to as Engel curves, since the curve forms obtained in studies of consumption in Western nations have borne out Engel's law:[1] "The poorer the family, the greater the proportion of income that must be used for food."[2] Most budget studies have found food expenditure to increase less than proportionally to income, giving the Engel curve a slope which decreases as the level of income increases.

Economists have also utilized the concept of income elasticity to express the relationship between the income and expenditure variables. Income-expenditure elasticity is defined as the ratio of the percentage change in expenditure to the percentage change in income and is expressed mathematically as

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[1]Findings of Asian studies of food expenditure which contradict Engel's Law and suggest the need for a more general formulation of the law are discussed by Carle C. Zimmerman, "Ernest Engel"s Law of Expenditures for Food," Quarterly Journal of Economics, XLVII (November 1932), 78-101.

[2]Ernest Engel, "Die Lebenskoster Belgischer Arbeiter-Familien Fruher Und Jetzt-Ernittelt Aus Familien-Hauschaltrechnungen," Institute of International Statistics Bulletin, IX (1895), 26, as translated and cited in Marguerite C. Burke, "A Study of Recent Relationships Between Income and Food Expenditures," U. S. Department of Agriculture, Agricultural Economics Research, III, No. 3 (July, 1951), 87.

$$\frac{dY}{dX} \cdot \frac{X}{Y}$$

where Y is expenditure and X is income.[1] The Engel curve for total food expenditure and the income elasticity of demand for food are mathematically related since the slope of the Engel curve, $\frac{dY}{dX}$, is part of the mathematical expression for income elasticity. The slope of the Engel curve may be regarded as the marginal propensity to consume for total food, since it is the derivative of food expenditure with respect to income.

Graphic representations of the change in the physical quantity of a particular food purchased with changes in income have also been referred to as "Engel curves." This study is confined to the consideration of the relationship between income and food expenditure and the expression of this relationship in the form of Engel curves and income elasticities. It does not deal with physical quantities of food purchased.

Regression Equation Forms

Studies of household budget data have produced Engel curves from the observation of the food expenditure behavior of many households at various levels of income. It is assumed that while a single household's Engel curve might be kinked and discontinuous, it can be represented by a curve derived from a large number of observations which will be smooth and continuous and which can be approximated by a continuous function.

There are two theoretical criteria which must be considered in the search for an appropriate functional form to approximate the Engel curve. The first such requirement is that the functional form chosen take account of the satiability of wants. Theory assumes that the demand for any particular commodity is eventually satiated as the individual consumes increasing quantities of it. The marginal rate of substitution

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[1]Herman Wold and Lars Jureen, Demand Analysis (New York: John Wiley and Sons, 1953), p. 98.

of a given good for all other types of goods is expected to increase as the individual acquires increasing quantities of it. There is, however, less reason to assume that demand for a broad group of commodities, such as total food, is in fact satiable. As income increases the possibility arises of replacing inferior foods with those of successively higher qualities and of adding more exotic types of food to the diet. While the demand for a particular quality of a particular food may be satiable, there is perhaps less intuitive necessity to assume that wants for a broad group of commodities are satiable.[1] The second criterion derived from theory concerns the existence of negative income and expenditure. The functional form specified for the Engel curve may be such that it is defined in quadrants in which either income, expenditure or both are negative. Forms intercepting the income axis at negative values imply positive levels of consumption at zero income. Such a formulation has no meaning in traditional consumption theory. For this reason forms which intercept the income axis at the origin or at positive values are sometimes preferred. However, if we consider the functional form as applicable only for the range of the data, this requirement assumes less importance. Other than these considerations theory prescribes no certain form which the Engel curve for a broad commodity group can be expected to take. The choice of a functional form must therefore also be governed by the results of previous investigations of forms which approximate the Engel curve and by certain technical criteria.

Prais has listed additivity, homoscedasticity and ease of numerical estimation as technical criteria on which functional forms being used to

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[1]The probable forms of Engel curves for groups of complementary goods, such as different articles of clothing and substitute goods, such as different qualities of tea, are discussed by H. S. Houthakker "La Forme des Courbes d'Engel," Centre Nationale de la Recherche Scientifique (France) Cahiers du Seminaire d' Econometrie (1953 Volume), pp. 65-66.

approximate the Engel curve should be considered.[1] If the same functional form is being used to approximate the Engel curves for many commodities, the additivity criterion requires that the sum of the expenditures on individual commodities including saving, equal income at each income level. If the equation is of the form

$$Y_i = a_i + b_i X + u_i \qquad (4.1)$$

where Y_i is expenditure on the i-th commodity (saving is included as a commodity) and X is total income,

$$\Sigma a_i = 0 \text{ and } \Sigma b_i = 1 \qquad (4.2)$$

so that the sum of the expenditures on individual commodities is equal to total income, i.e.,

$$\Sigma Y_i = X \qquad (4.3)$$

at all levels of income. This criterion indicates that when considering all expenditures, we cannot postulate an asymptotic functional form for every commodity if saving is included, since the use of such a form for every expenditure category would violate the additivity criterion at upper income levels. Since this study is considering only total food expenditures rather than all of the components of total expenditure, the additivity criterion seems of little importance and in view of Nicholseon's proof that any least squares estimation will satisfy the additivity criterion, will not be considered further.[2]

The least squares requirements include the specification that the variances of the disturbances from the functional form employed shall be equal or homoscedastic. If the variance of the disturbances varies

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[1]S. J. Prais, "Non-linear Estimates of the Engel Curves," Review of Economic Studies, XX (1952-1953), 89-90.

[2]Nicholson, 388-89.

systematically with the exogeneous variable, income in the present case, Valavanis has noted that the least squares method yields maximum likelihood, unbiased, consistent but inefficient estimates.[1] Prais has taken the position that the prior problem is the establishment of the form of the Engel curve and that, if upon completion of least squares estimation the residuals are found not to be homoscedastic, appropriate correction procedures should be employed.[2] The study will proceed on this basis.

The final technical criterion in the choice of a functional form to approximate the Engel curve is ease of numerical estimation. This criterion leads to a preference for forms which are suitable for least squares estimation. Equation forms which require graphical estimation are unsuitable for use in mass data problems. Others which require the use of special computer programs must also be eliminated from consideration because of the time delay and expense involved in writing new programs.

The most frequently used equation forms have been simple linear functions or linear functions in which all or some of the variables have undergone logarithmic transformations. The simple linear form

$$Y = a + bX + u \qquad (4.4)$$

where Y is total expenditure per family or expenditure per equivalent adult and X is household income was used by Allen and Bowley as a first approximation of the Engel curve in their pioneering study.[3] Although this form seems to have produced good fits in the homogeneous social class

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[1]Stefan Valavanis, Econometrics, edited from manuscript by Alfred H. Conrad (New York: McGraw-Hill Book Co., 1959), pp. 47-49.

[2]Prais, "Non-linear Estimates of the Engel Curves," p. 90.

[3]R. G. D. Allen and A. L. Bowley, Family Expenditure ("London School of Economics and Political Science: Studies in Statistics and Scientific Method," No. 2; London: Staples Press, 1935), pp. 1-58.

groups which Allen and Bowley studied, these groups covered only narrow ranges of income. In samples covering wider ranges of income there is less reason to believe that the simple linear form provides an adequate approximation of the Engel curve.

Two equation forms involving logarithmic transformations of the variables which meet the theoretical requirement that expenditure take place only at positive values of income are:

$$\log Y = a + b \log X + u \qquad (4.5)$$

$$Y = a + b \log X + u \qquad (4.6)$$

since logarithms are defined only for positive values of the income variable X. An additional form involving a logarithmic transformation is:

$$\log Y = a - b\left(\frac{1}{X}\right) + u \qquad (4.7)$$

The semi-log form (4.6) has no upper asymptote. The use of the logarithmic scale for the X variable has the same effect as if the abscissas were compressed near zero.[1] The curve will be convex from above when b is positive. When both variables are expressed in logs, as in the double-log form (4.5), both variables are affected as if the axes were compressed near zero. The curves may be either convex or concave from above when b is positive.

The log-inverse form (4.7) produces a sigmoid curve, as a result of the logarithmic transformation of the dependent variable, expenditure. This form differs from the linear form, and the two logarithmic forms in that it has an upper asymptote. The form is of interest because it provides a sigmoid or S-shaped curve form by transformations of the variables of a linear function. Other sigmoid curve forms such as the lognormal form are difficult to employ since they require graphical

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[1]Mordecai Ezekiel and Karl A. Fox, Methods of Correlation and Regression Analysis (3rd edition; New York: John Wiley and Sons, 1959), pp. 72-3.

estimation, or an iterative process of estimation using deck calculators or special computer programs.[1]

Certain other forms which have been used in the estimation of elasticities should also be mentioned. Parabolic forms have been found to provide the best approximation to the Engel curve for certain individual commodities, such as canned peaches.[2] Parabolic curves

$$X = -a + by - cY^2 + u \qquad (4.8)$$

$$X = -a + b \log Y - c (\log Y)^2 + u \qquad (4.9)$$

seem suitable only for a particular quality of a good, which with increasing income has the characteristics of an inferior good. Equation forms which include a quadratic term or terms of a higher degree have been held to be little superior to linear forms. Prais noted in this connection, that "while a polynominal of sufficiently high degree can assume any required shape such flexibility is only an advantage in cases where the degree of scatter is small enough to allow the precise determination of the curvature," and that since household budget data lacks such regularity it is desirable to choose a simple regression form which imposes a suitable degree of curvature.[3] General hyperbolic forms of the type devised by Tornquist[4] require graphical estimation, unless certain assumptions are made about parameter values which make the equations linear in form. A simplified linear hyperbolic form

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[1]J. Aitchison and J. A. C. Brown, The Lognormal Distribution (University of Cambridge, Department of Applied Economics Monographs," No. 5; Cambridge: Cambridge University Press, 1957), pp. 31-34, 141-45. See also, Aitchison and Brown, "A Synthesis of Engel Curve Theory," Review of Economic Studies, XXII (1954-1955), pp. 23-46.

[2]Economic Commission for Europe, Committee on Agricultural Problems, Income Elasticity of the Demand for Food--Household Survey Analysis, p. 31.

[3]Prais, "Non-linear Estimates of the Engel Curves," p. 90.

[4]Prais and Houthakker, p. 86. See also, Wold and Jureen, pp. 107-108.

$$Y = a - b\frac{1}{X} + u \qquad (4.10)$$

was used by Prais and Houthakker who found that while it produced only a slightly lower correlation of income and expenditure than most of the other forms used, it produced a fit which was generally less satisfactory than that for any of the other forms including the simple linear form since it had too much curvature and flattened out at too low an income.[1] In light of Prais' criticism and the poor results which they have produced, the parabolic forms (4.8), (4.9), and the simplified linear hyperbolic form (4.10), do not seem to merit further attention.

Equation forms may also be evaluated on the basis of the results which they have produced when used in analyzing the same data. Lewis and Douglas[2] in their study of 1901 BLS data on food expenditure for particular household types used four equation forms, the simple linear (4.4) and the double-log (4.5) form, plus two parabolic forms.

$$Y = a + bX + cX^2 + u \qquad (4.11)$$

$$\log Y = a + b \log X + c (\log X)^2 + u \qquad (4.12)$$

The log parabola form (4.12) produced the highest coefficient of multiple determination followed by the parabolic form (4.11). The double-log (4.5), and the linear form (4.4) produced coefficients of determination which were only slightly smaller, the lowest being .957. Although all of the forms fitted the data well, Lewis' and Douglas' preference was for forms (4.11) and (4.12), since they produced elasticities and marginal propensities to consume which in general, varied with changes in the value of income.[3] The similarity of the results for the four forms employed

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[1]Prais and Houthakker, pp. 95-96.

[2]Lewis and Douglas, Appendix A - Table IV.

[3]Ibid., p. 13.

give little reason for preferring the more complicated parabolic forms. The parabolic forms performed well in this study of 1901 data, in which the variability was small. In view of Prais' criticism of the performance of equations containing quadratic terms, the usefulness of parabolic equation forms in handling the highly variable consumer behavior recorded in recent surveys is questionable. Prais and Houthakker expressed a preference for the use of the semi-log form (4.6) with food groups after evaluating its results along with those of four other forms, the double-log, (4.5), log-inverse (4.7), linear (4.4) and hyperbolic (4.10).[1] While the log-inverse, double-log and semi-log forms were found to produce approximately equal closeness of fit, as measured by their correlation coefficients, the semi-log form was judged superior from the standpoint of uniformity of fit along the entire curve. The semi-log form was found to be satisfactory for all the commodity groups in which the elasticity was less than unity and the best form, in general, for food commodities. The double-log form was preferred for all non-food commodities.

The selection of any equation form involves certain implicit assumptions about the income-expenditure elasticity for food and the marginal propensity to consume for food. The income elasticities and marginal propensities to consume for the four equation forms which seemed most promising after taking the factors discussed above into account, are given in Table 4.2. These assumptions must be considered to determine how well they conform to the requirements of theory and expectations formed on the basis of previous studies of food expenditures. The simple linear form (4.4) produces a constant marginal propensity to consume (MPC). It also implies that the income elasticity for all goods in the aggregate tends to unity as income increases, since if the additivity criterion is met the slope of the line must be equal to one. The double-logarithmic form (4.5) produces a MPC which is inversely related to

[1]Prais and Houthakker, pp. 93-103.

Table 4.2 - Income-Expenditure Elasticities and Marginal Propensities to Consume for Certain Engel Curve Forms

Equation	Equation Form	Marginal Propensity to Consume $\frac{dY}{dX} = MPC$	Income Elasticity $\frac{dY}{dX} \cdot \frac{X}{Y} = E$
(4.4) Linear	$Y = a + bX + u$	b	$b \cdot \frac{X}{Y}$
(4.5) Double-logarithmic	$\log Y = a + b \log X + u$	$b \cdot \frac{Y}{X}$	b
(4.6) Semi-logarithmic	$Y = a + b \log X + u$	$b \cdot \frac{1}{X} \log_{10} e$	$b \cdot \frac{1}{Y} \log_{10} e$
(4.7) Log-inverse	$\log Y = a - b \cdot \frac{1}{X} + u$	$b \cdot \frac{Y}{X^2} \log_{10} e$	$\frac{b}{X \log_{10} e}$

income, a result which conforms to requirements developed from both micro and macro economic theory. The double-log form gives a constant income elasticity, a result which runs counter to the findings of studies which have used other equation forms and have found that income elasticity for most goods declines with income. The double log form, however, has been favored by some for the very reason that it does provide a single constant elasticity coefficient which describes behavior throughout the entire income range. The semi-logarithmic form (4.6) gives an MPC which is inversely proportional to income and an income elasticity which is inversely proportional to expenditure, which seems acceptable both from the standpoint of theory and the findings of previous studies. The log-inverse equation form (4.7) produces an MPC which is inversely proportional to the square of income and an income elasticity which is inversely proportional to income.

The importance of selecting a form which permits elasticity to decline with increasing income was demonstrated by Prais and Houthakker in a comparison of income elasticities for food in working-class and middle-income households.[1] The elasticities for six food groups were estimated for each class using the double-log form and were found to be significantly higher for working-class households. The elasticities estimated for the two class groups using the semi-log form were found to differ only slightly, and these differences were explained by differences in income between the two groups. The hypothesis that both groups could be represented on a single Engel curve was not rejected. These results were considered to support the "law of diminishing elasticity" for food stuffs and demonstrate the superiority of the estimates of elasticity produced by the semi-log form over the constant elasticities derived using the double-log form.

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[1] Ibid., pp. 96-98.

Forms of the Variables

Past studies of income elasticities have used both income and expenditure as well as income and expenditure per capita or per equivalent adult as variables in their analysis. Per capita forms of the variables were used in an attempt to eliminate the effects of differences in household size when elasticities were being estimated for a group containing households of varying sizes. The equivalence scales discussed in Chapter II also have been used to deal with differences in household size by converting the expenditure variable to expenditure per equivalent adult. When this is done the same scale properly cannot be used to convert income, however. A scale for total expenditure is required.[1] The use of either per capita or per equivalent adult forms of the variables involves the implicit assumption that expenditure per person or per adult equivalent depends only on income per person or per adult equivalent. Both these forms of the variables, thus in effect deny the possibility of economies of scale in household food preparation.[2]

Since this study will be estimating elasticities for household types especially constructed to be homogeneous in size and composition, there is no need to employ special forms of the income and expenditure to control variations in household size and composition.

The "equivalent-person" has been used in some United States Department of Agriculture studies to control for differences in the number of meals eaten.[3] Household size in equivalent persons is the number of

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[1]Wold and Jureen, pp. 223-24.

[2]Prais and Houthakker, pp. 88-89.

[3]Two such studies are Faith Clark, Janet Murray, Gertrude S. Weiss, and Evelyn Grossman, Food Consumption of Urban Families in the United States, U. S. Department of Agriculture, Agriculture Information Bulletin No. 132 (Washington, U. S. Government Printing Office, 1954), and the series on the 1955 Household Food Consumption Survey, the initial report of which was U. S. Department of Agriculture, Food Consumption of Households in the United States ("Household Food Consumption Survey 1955," Report No. 1; Washington: U. S. Government Printing Office, 1956).

meals served in the household during a week, divided by 21, so as to obtain the number of full-time 21-meals-a-week eaters who could have been fed from the household's meal production. The "equivalent person" is thus not a "person" at all, but a measure of the level of household meal production. This study required some method of controlling for differences between households in the number of meals eaten, but the use of "equivalent persons" as a separate variable did not appear to provide any advantages over the use of total meals.

Another method of controlling for differences in meals eaten is to divide the expenditure variable by total meals or by equivalent persons. This, however, would result in an income-expenditure per meal (or per 21 meals) elasticity which is of little use in most economic contexts, and whose usefulness would be further confused by changes in the number of meals eaten at home with changes in income. For the purposes of this study the introduction of meals served as a separate variable is considered clearly preferable to any of these alternative methods.

The equation and variable forms chosen for employment in this study will be discussed in the next chapter.

CHAPTER V

ANALYSIS

The Variables and Equation Forms Employed

There are several measures of food consumption which are of interest to the economist. Information on quantities consumed and on nutritional levels are of interest because of the information they provide on the possibility of expanding the demand for food by improving or upgrading diets. This study however, is concerned with household expenditures on food, and therefore concentrates on food purchases from the supplies moving through commercial channels rather than on total food consumption, which also includes home produced food, food gifts, and food received as pay. The urban portion of the 1955 U.S.D.A. Household Food Consumption Survey was selected in part for the reason that urban households were observed to depend chiefly on purchased food, while rural farm and non-farm households in many cases relied heavily on home-produced food.[1] Urban households within a given income class were expected to display little variability in food expenditure due to differences in the amount of home-produced food available since virtually all were almost completely dependent upon purchased food.

Total expenditure has often been used in place of income as the determining variable where income information was not requested or where respondents refused to provide the information in household budget studies. In studies of total household expenditures it was expected that the sum of the expenditures recorded would provide a close approximation to actual income. Since income figures are available for the greatest part of the

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[1]U. S. Department of Agriculture, Food Consumption of Households in the United States, pp. 17-18.

households in the U.S.D.A. 1955 Survey and no information is available on expenditures other than food, income rather than total expenditure will be employed as a determining variable in the analysis. The income figures collected are for 1954 disposable income after State and Federal taxes. It is agreed generally that disposable income after taxes provides the best simple estimate of the resources available for allocation by the household. It should be noted however, that while this measure is satisfactory for the households of salaried and hourly workers, it is less satisfactory for self-employed businessmen and farmers whose business and household accounts are less easily distinguished. A rigorous definition of income is necessary to handle the problem of determining the income of the self-employed, and for dealing with the occurrence of negative incomes. Only two negative incomes were found in the households considered for inclusion in this study. It is likely, however, that many other incomes reported were affected by business losses and that the relationship between these incomes and food expenditure was not the same as that between the disposable income of salaried and hourly workers and their expenditures. The problem of defining income for consumption studies, although of great importance, was necessarily left unexamined. The income data of the Survey was used without adjustment, except for households with zero reported incomes; these were assigned incomes of one dollar in order to permit the use of logarithms and inverses of the income variable.

Current consumption increasingly is considered to be dependent both on current income and on habits built on the basis of past income.[1] It is not the purpose of this study to consider the problem of the suitable length of lags for consumer expenditure studies; it should be noted, however, that the income figures used here were for 1954 disposable

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[1]James S. Duesenberry, Income, Saving and the Theory of Consumer Behavior, ("Harvard Economic Studies," Vol. LXXXVII; Cambridge: Harvard University Press, 1952), pp. 76-89.

income, a period which ended 5 to 6 months prior to the interview period. The expenditures measured are thus lagged by a half year in relation to the end of the income period used.

In order better to handle the effect of differences in the number of meals eaten at home on expenditures, it was decided to introduce the total number of meals eaten as a second independent variable. The actual variable employed is the total number of meals eaten by members of the consuming unit, and does not include guest meals. Although this variable weighs each meal equally, and does not take account of the differences in the intakes of household members or differences in the costs of breakfasts, lunches and dinners, it was felt that the use of even such a crude measure was better than neglecting the independent effect of the number of meals eaten on expenditure. The use of total meals as a variable also avoids the problems involved in the use of other methods of correcting for differences in the number of meals eaten, such as were discussed in the last chapter.

It was decided that elasticities would be estimated for the household types using the four equation forms presented in Table 4.2 plus a total meals variable:

$$\text{Linear: } Y = a + b_1X_1 + b_2X_2 + u \qquad (5.1)$$

$$\text{Double Log: } \log Y = a + b_1 \log X_1 + b_2 \log X_2 + u \qquad (5.2)$$

$$\text{Semi-Log: } Y = a + b_1 \log X_1 + b_2X_2 + u \qquad (5.3)$$

$$\text{Log-Inverse: } \log Y = a - b_1 \left(\frac{1}{X_1}\right) + b_2X_2 + u \qquad (5.4)$$

where Y is total food expenditure, X_1 is disposable income after Federal and State taxes and X_2 is total meals eaten by members of the household. Since there was no clear expectation as to the form of the relationship of total meals to expenditures, the meals variable was entered in logarithmic form in equation (5.2) and without transformation in the other three equation forms. In order to obtain the desired curve form, the inverse of income was entered as a negative number in equation (5.4).

The four equation forms will continue to be designated by the names used in the previous chapters, despite the addition of the meals variable to their basic form. The names are those used by Prais and Houthakker to describe equations of the same basic types and thus have a certain general usage.[1]

The elasticities estimated from these equations with two independent variables will, of course, be partial elasticities obtained from the partial derivative of expenditure with respect to income. The income elasticities thus obtained will be independent of the effects of changes in the number of meals eaten.

The Household Types Analyzed

The classification of the household survey observations into household types was discussed in Chapters II and III. It was expected from the individual type classifications employed in constructing the household types that the households of a particular type would have similar Engel curves, but that behavior would differ between household types. The household types constructed to include households with similar Engel curves were the same system of types for which it was decided to estimate elasticities.

The 2140 household observations of households of five persons or less remaining after the necessary eliminations made up some forty-eight different household types. Many of these household types contained too few observations to merit analysis. It was decided arbitrarily that because of the high variability of expenditures at a given level of income and the known tendency of consumption survey data to cluster around the mean income, regressions would be estimated only for household types containing twenty-four or more observations. Twenty-six different household types of one to five persons were found to contain sufficient observations.

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[1]Prais and Houthakker, p. 87.

Most of the household types contained forty or more observations; only seven of the twenty-six contained fewer than forty. A total of 1829 observations were employed in the twenty-six household types for which regressions were estimated. The omission of the other household types from the study is thus not so wasteful of data as it may appear, since only 320 of the usable observations were not employed for this reason.

The composition of the household types selected and the number of observations in each is given in Table 5.1. The number-letter designation assigned to each household type is also given in this table, the initial number being the household size. For the sake of brevity each household type will be referred to by its number-letter designation in the succeeding discussion.

Analytical Process

Preparation of the Data

The portion of the data from the U.S.D.A. 1955 Household Food Consumption Survey which was made available to the study was obtained on punched cards. The sets of cards on which this study drew were obtained with the special permission of the Institute of Home Economics of the Agricultural Research Service and the Agricultural Marketing Service, agencies of the United States Department of Agriculture. Card decks duplicating those used in preparation of the results of the 1955 Survey were obtained from National Analysts, Incorporated, the organization that conducted the Survey under a contract with the U.S.D.A.

Three of these decks of cards were the source of most of the data used. Information on each individual's age, sex, number of meals eaten and economic family membership was obtained from the Individual Card (02 Deck). The Economic Family Summary Card (01 Deck) provided information on the number in the primary and secondary economic families.

Table 5.1 - Description of the Household Types Analyzed

Household Type Number	Description	Number of Observations
1A	Female (15-64)	105
1B	Female (65 or over)	71
2A	Male (15-64), Female (15-39)	113
2B	Male (15-64), Female (40-64)	266
2C	Two females (15-64)	25
2D	Male or Female (65 or over) Male (15-64)	23
2E	Male or Female (65 or over), Female (15-64)	89
2F	Male (65 of over), Female (65 or over)	98
3A	Male (15-64), Female (15-39), Child (under 6)	137
3B	Male (15-64), Female (15-39), Child (6-14)	77
3C	Male (15-64), Female (40-64), Child (6-14)	43
3D	Male (15-64), Two Females (15-64), (Wife or female head, 40-64)	66
3E	Two Males (15-64), Female (15-64), (Wife or female head, 40-64)	63
3F	Male or Female (65 or over), and Two other adults (15-64)	74
4A	Male (15-64), Female (15-39), Two children (under 6)	117
4B	Male (15-64), Female (15-39), Child (6-14) Child (under 6)	73
4C	Male (15-64), Female (15-39), Two children (6-14)	77
4D	Male (15-64), Female (40-64), Two children (6-14)	24
4E	Male (15-64), Two Females (15-64), Child (6-14)	40
4F	Two Males (15-64), Female (15-64), Child (6-14)	49
5A	Male (15-64), Female (15-64), Three children (under 6)	31
5B	Male (15-64), Female (15-64), Child (6-14) Two children (under 6)	44
5C	Male (15-64), Female (15-64), Two children (6-14), Child (under 6)	40
5D	Male (15-64), Female (15-64), Three children (6-14)	30
5E	Male (15-64), Two Females (15-64), Two children (under 15)	28
5F	Two Males (15-64), Female (15-64), Two children (under 15)	26

The Master Card provided income, urbanization, race, age of wife, and the money value of food purchased per equivalent person. In addition to this information, the number of equivalent persons in the household was obtained from Summary Card N.

The individual cards of members of the primary economic family were coded into the thirteen original individual type classifications used. The number of individuals in each of these types and the total number of meals eaten by members of the consuming unit were collected on a single card for each household. Since the number of household types produced using thirteen individual types was found to be too large, individuals were reclassified into eight types and a new set of household types was obtained. The number of individuals in each individual type, the household composition code and other information was collected on a new Economic Family Summary Card (06 Deck). Information on expenditures was collected to produce the Expenditure Card (07 Deck). The information on these last two decks was combined to produce an Analysis Card (08 Deck), which contained complete information on all the variables, the household composition, and other control and record data. The information required from Deck 08 for the estimation of the regressions, plus the logarithmic and inverse values required were collected on the MISTIC Card (09 Deck). The construction of this card completed the preparation of the punched cards for use with the computer programs written for card input of data. By this point in the preparation of the data, all of the eliminations of households in which the eating unit, consuming unit, and household were not of equal size, as discussed in Chapter III, had been made.

Estimation of the Regressions

The regressions estimated for this study were computed using Michigan State University's digital computer, MISTIC, and programs for the card input of data. The regressions with logarithmic transformations

of all three variables (Equation 5.2) were computed using the K7S Program, "Product Moment Correlations in Logarithmic Scale, Card Input," and the M13 Program, "Linear Matrix Equation Solver and Matrix Inversion." The other regression forms (Equations 5.1, 5.3, and 5.4) were estimated using the K5M Program, "Product Moment Correlations, Means, Standard Deviations, Variance-Card Input," and the M13 Program for one, two and three person households. The regressions for the four and five person households were computed using the K13 Program, a special program written by members of the Agricultural Economic Department's Statistical Pool, which combines the K5M and M13 Programs. The estimates of the regression coefficients, constant terms, standard errors of the regression coefficients, standard errors of estimate and coefficients of multiple determination were obtained using the Holz Program, a special regression program used within the Department.

The Regression Results

The Format of the Tables - The regression estimates for the four regression equations are presented in Tables 5.2 to 5.5. The household composition description for each equation number was given in Table 5.1.

The "a" term estimates the value of the constant term of the regression, the b_1 and b_2 terms estimate the coefficients for the regression of expenditure on income and total meals, respectively. The standard errors of the regression coefficients are presented in parentheses below the regression coefficients. The adjusted coefficient of multiple determination, $\bar{R}^2$ is obtained from R^2, the coefficient of multiple determination. R^2 is a biased estimate of multiple correlation for small sample sizes, to adjust for this, $\bar{R}^2$ can be used when sample sizes are small. Its relation to R^2 is

$$\bar{R}^2 = 1 - (1-R)^2 \left(\frac{n-1}{n-k}\right) \qquad (5.5)$$

where k is the total number of variables.[1] $\bar{R}^2$ indicates the percentage

[1] Earl O. Heady and John L. Dillon, Agricultural Production Functions (Ames: Iowa State University Press, 1961), pp. 118-19.

of the variation in the observed values of Y that is explained by the regression equation. The variance of the disturbances is estimated by $S^2_{Y.12}$, the standard error of estimate squared. It is the variance in observed Y for fixed values of the independent variables. Its form is, in this case,

$$S^2_{Y.12} = \frac{\Sigma(dy.12)^2}{n-3} \qquad (5.6)$$

where dy.12 is the deviation of observed Y from estimated Y. The estimate is the sum of squares of the deviations from the regression divided by the degrees of freedom.[1] This statistic is of concern since certain tests of elasticities require an assumption of the equality of the variances of the disturbances.

Regression Results for the Linear Equation Form - The results for the linear equation form, equation (5.1), vary somewhat between types (Table 5.2). Almost half of the equations produced negative estimates of the constant term; the regression coefficients estimated were all positive except in one instance. The equations with negative estimates of the constant term were concentrated in the larger household types, the four and five person households, in particular. The size of the estimated b_1 regression coefficient shows no clear pattern of change, but does appear to become larger with increasing household size. The sign of the coefficient is positive as would be expected, expenditure increasing with income. The estimate of the b_2 coefficient can be interpreted as the number of dollars spent for each additional individual meal serving. In only one case, equation 2E-1, was the sign of this coefficient negative.

The values of the adjusted coefficient of multiple determination, $\bar{R}^2$, ranged from .024 to .671. The $S^2_{Y.12}$ varies widely, but is generally greater for equations with low values of $\bar{R}^2$, as would be expected.

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[1]George W. Snedecor, Statistical Methods--Applied to Experiments in Agriculture and Biology (5th ed.; Ames: Iowa State College Press, 1956), p. 125.

Table 5.2 - Regression Estimates for the Linear Equation Form

$$Y = a + bX_1 + cX_2 + u$$

Equation Number	a	b_1	b_2	$\overline{R}^2$	$S^2_{Y.12}$
1A-1	1.009	.000596 (.000226)	.346 (.059)	.269	13.26
1B-1	2.032	.000495 (.000224)	.200 (.066)	.168	10.14
2A-1	11.447	.001245 (.000334)	.028 (.009)	.128	49.28
2B-1	13.909	.000908 (.000181)	.035 (.005)	.186	83.36
2C-1	-6.022	.000290 (.000231)	.581 (.257)	.170	38.66
2D-1	2.371	.000742 (.000271)	.281 (.083)	.133	42.16
2E-1	13.580	.001988 (.001004)	-.101 (.177)	.104	36.60
2F-1	4.272	.000514 (.000191)	.202 (.051)	.152	30.61
3A-1	5.618	.001351 (.000249)	.198 (.049)	.240	52.31
3B-1	-12.203	.001428 (.000570)	.540 (.089)	.343	73.85
3C-1	12.934	.000437 (.000235)	.195 (.081)	.135	37.27
3D-1	2.096	.000821 (.000259)	.312 (.107)	.198	61.67
3E-1	2.507	.000515 (.000269)	.368 (.071)	.296	87.59
3F-1	-13.793	.002189 (.000440)	.412 (.143)	.263	78.77

Continued

Table 5.2 - Continued

Equation Number	a	b_1	b_2	$\bar{R}^2$	$S^2_{Y.12}$
4A-1	-8.981	.001962 (.000503)	.334 (.103)	.158	77.32
4B-1	-16.465	.000250 (.000339)	.565 (.132)	.184	83.37
4C-1	-1.163	.000976 (.000347)	.328 (.116)	.136	79.46
4D-1	-17.446	.002814 (.000469)	.405 (.218)	.671	111.42
4E-1	3.763	.000455 (.000654)	.326 (.174)	.040	103.07
4F-1	-9.478	.002495 (.000558)	.354 (.154)	.326	126.54
5A-1	8.717	.001182 (.000717	.145 (.345)	.024	116.06
5B-1	4.597	.001514 (.000290)	.181 (.124)	.482	77.89
5C-1	2.446	.001821 (.000348)	.207 (.109)	.413	58.51
5D-1	-13.844	.000854 (.000432)	.422 (.340)	.103	231.27
5E-1	-14.324	.002261 (.000412)	.309 (.138)	.554	48.76
5F-1	4.783	.001654 (.000617)	.188 (.161)	.172	64.43

Regression Results for the Double-Log Equation Form - The results for the double-log equation form (5.2) were generally similar (Table 5.3). The estimates of the constant terms were negative in all but two instances, equations (3E-2), and (5A-2). The estimates of the b_1 coefficients of the regression of expenditure on income were positive in all but one instance, equation (5A-2). The negative sign of estimated b_1 for equation (5A-2) indicated that the estimated income elasticity for household type 5A was negative. The signs of the estimated b_2 coefficients of the regression of expenditure on total meals were positive in all but one instance, equation (2E-2).

The values of $\bar{R}^2$ obtained ranged from .000 to .458. The $S^2_{Y.12}$ varied substantially, the largest value being five times the smallest.

Regression Results for the Semi-Log Equation Form - The results for the semi-log equation form, equation (5.3), were chiefly of one type (Table 5.4). The estimates of the constant terms had negative values, or low positive values. The values of the estimated b_1 regression coefficient were positive, except for one case, equation (5A-3), the largest values occurring in the four and five person households. The one negative estimate of b_1 is of concern because it means that the estimated income elasticity for this household type will also be negative. The estimates of the b_2 coefficients were positive in all but two cases.

The values of $\bar{R}^2$ obtained ranged from .000 to .543. The values of $S^2_{Y.12}$ differed widely, the largest being twenty times the minimum value obtained.

Regression Results for the Log-Inverse Equation Form - The results for the log-inverse equation form, equation (5.4), were affected seriously by problems in handling the income variable (Table 5.5). The estimates of the constant terms were all positive and generally of similar value. However, the estimates of the b_1 regression coefficients differed greatly, ranging from positive values of over 900 to negative values of .09.

Table 5.3 - Regression Estimates for the Double-Log Equation Form

$$\log Y = a + b_1 \log X_1 + b_2 \log X_2 + u$$

Equation Number	a	b_1	b_2	$\bar{R}^2$	$S^2_{Y.12}$
1A-2	-.16155	.112 (.030)	.565 (.133)	.201	.02930
1B-2	-.13801	.008 (.036)	.687 (.270)	.060	.05531
2A-2	-.73522	.322 (.079)	.508 (.157)	.152	.02521
2B-2	-1.06399	.297 (.042)	.776 (.092)	.290	.02686
2C-2	-1.35407	.177 (.104)	.123 (.600)	.209	.03193
2D-2	-.62035	.108 (.049	.891 (.228)	.146	.02722
2E-2	.08129	.414 (.162)	-.216 (.440)	.194	.02163
2F-2	-.13912	.087 (.023)	.606 (.163)	.188	.02393
3A-2	-1.02140	.298 (.054)	.730 (.151)	.260	.01629
3B-2	-1.34084	.217 (.083)	1.100 (.163)	.389	.01729
3C-2	.03619	.174 (.066)	.419 (.178)	.186	.00974
3D-2	-1.08836	.282 (.067)	.804 (.240)	.252	.01768
3E-2	-.51407	.208 (.072)	.657 (.206)	.186	.02140
3F-2	-1.49206	.435 (.065)	.684 (.372)	.372	.03272

Continued

Table 5.3 - Continued

Equation Number	a	b_1	b_2	$\bar{R}^2$	$S^2_{Y.12}$
4A-2	-1.80539	.392 (.081)	.937 (.262)	.217	.01975
4B-2	-1.09351	.088 (.080)	1.170 (.312)	.154	.01770
4C-2	-.77047	.243 (.083)	.701 (.304)	.117	.01707
4D-2	-2.31032	.410 (.110)	1.189 (.521)	.451	.01660
4E-2	-.27609	.099 (.147)	.733 (.416)	.030	.02191
4F-2	-1.77650	.362 (.076)	1.017 (.313)	.373	.01303
5A-2	1.41121	-.008 (.050)	.019 (1.339)	.000	.03562
5B-2	-1.35220	.423 (.078)	.629 (.359)	.458	.01405
5C-2	-1.29184	.390 (.069	.681 (.338)	.452	.01111
5D-2	-2.54169	.404 (.121)	1.262 (.952)	.276	.03629
5E-2	-2.42144	.421 (.107)	1.154 (.542)	.391	.01367
5F-2	-1.19709	.406 (.145)	.597 (.482)	.189	.01334

Table 5.4 - Regression Estimates for the Semi-Log Equation Form

$$Y = a + b_1 \log X_1 + b_2 X_2 + u$$

Equation Number	a	b_1	b_2	$\bar{R}^2$	$S^2_{Y.12}$
1A-3	-4.435	2.033 (.617)	.362 (.059)	.295	12.80
1B-3	1.214	.363 (.508)	.223 (.068)	.115	10.78
2A-3	-42.785	14.021 (3.469)	.273 (.084)	.145	48.34
2B-3	-37.865	12.200 (2.320)	.330 (.051)	.193	82.59
2C-3	-26.657	6.845 (3.449)	.524 (.247)	.245	35.14
2D-3	5.560	.042 (.019)	.267 (.084)	.105	43.47
2E-3	-26.377	13.452 (6.570)	-.109 (.176)	.114	36.18
2F-3	-1.277	2.386 (.829)	.186 (.050)	.161	30.31
3A-3	-46.928	16.102 (3.071)	.208 (.049)	.231	52.96
3B-3	-50.460	12.302 (5.512)	.543 (.089)	.332	75.07
3C-3	-19.426	9.518 (3.976)	.190 (.078)	.178	35.41
3D-3	-49.703	14.181 (3.881)	.380 (.107)	.233	61.67
3E-3	-38.681	12.004 (4.452)	.367 (.069)	.334	87.59
3F-3	-54.780	15.003 (3.233)	.369 (.144)	.237	78.77

Continued

Table 5.4 - Continued

Equation Number	a	b_1	b_2	$\bar{R}^2$	$S^2_{Y.12}$
4A-3	-73.955	20.574 (5.061)	.325 (.103)	.166	76.56
4B-3	-42.142	7.524 (5.408)	.557 (.129)	.200	81.76
4C-3	-58.503	16.945 (5.615)	.328 (.115)	.148	78.30
4D-3	-183.359	44.536 (11.427)	.622 (.265)	.482	175.63
4E-3	-28.783	9.263 (10.035)	.333 (.173)	.049	102.06
4F-3	-129.141	33.404 (7.603)	.485 (.158)	.319	127.90
5A-3	34.263	-1.554 (2.985)	-.004 (.354)	.000	126.11
5B-3	-118.342	33.018 (5.501)	.272 (.110)	.542	68.94
5C-3	-85.817	27.091 (4.892)	.195 (.106)	.441	55.66
5D-3	-97.634	24.710 (9.213)	.398 (.323)	.189	209.06
5E-3	-125.447	32.603 (6.923)	.347 (.149)	.480	56.91
5F-3	-75.688	25.353 (9.861)	.144 (.155)	.157	65.66

Table 5.5 - Regression Estimates for the Log-Inverse Equation Form

$$\text{Log } Y = a - b_1 \left(\frac{1}{X_1}\right) + b_2 X_2 + u$$

Equation Number	a	b_1	b_2	$\bar{R}^2$	$S^2_{Y.12}$
1A-4	.67048	.325 (.124)	.0126 (.0028)	.185	.02898
1B-4	.52465	-.090 (.121)	.0121 (.0049)	.068	.05484
2A-4	1.12778	443.147 (108.572)	.0058 (.0019)	.153	.02515
2B-4	1.13952	574.539 (73.528)	.0067 (.0009)	.299	.02653
2C-4	.65528	122.542 (101.699)	.0157 (.0077)	.171	.03345
2D-4	.92078	-2.097 (13.299)	.0064 (.0021)	.075	.02948
2E-4	1.40486	338.290 (143.706)	-.0026 (.0044)	.157	.02265
2F-4	.94554	.223 (.095)	.0044 (.0015)	.115	.02608
3A-4	1.23368	352.788 (67.673)	.0035 (.0009)	.225	.01708
3B-4	.89124	179.807 (89.954)	.0092 (.0014)	.367	.01790
3C-4	1.32277	293.171 (92.339)	.0028 (.0013)	.241	.00909
3D-4	1.09526	369.227 (80.749)	.0063 (.0018)	.279	.01705
3E-4	1.26483	348.884 (104.581)	.0040 (.0011)	.252	.01965
3F-4	1.11844	287.021 (39.716)	.0044 (.0028)	.410	.03069

Continued

Table 5.5 - Continued

Equation Number	a	b_1	b_2	$\bar{R}^2$	$S^2_{Y.12}$
4A-4	1.10505	557.863 (119.250)	.0054 (.0017)	.206	.02001
4B-4	.88795	86.351 (105.182)	.0073 (.0019)	.167	.01743
4C-4	1.22497	435.139 (176.757)	.0041 (.0017)	.103	.01733
4D-4	1.15045	793.230 (255.399)	.0062 (.0027)	.371	.01902
4E-4	1.19129	241.438 (338.837)	.0043 (.0025)	.028	.02196
4F-4	1.03641	585.737 (122.382)	.0074 (.0018)	.355	.01341
5A-4	1.45678	-.253 (.187)	-.0004 (.0057)	.000	.03346
5B-4	1.25030	889.441 (174.414)	.0041 (.0015)	.444	.01441
5C-4	1.38771	556.184 (105.026)	.0025 (.0015)	.420	.01175
5D-4	1.15884	836.330 (241.437)	.0052 (.0042)	.291	.03551
5E-4	1.05848	616.682 (202.167)	.0052 (.0025)	.286	.01603
5F-4	1.48246	965.065 (346.440)	.0022 (.0021)	.187	.01336

The estimates of the b_2 coefficients were positive in all but two equations. The values of $\bar{R}^2$ ranged from .000 to .444. The lowest values of $\bar{R}^2$ generally occurred in equation numbers in which the value of the estimates of the b_1 regression coefficient were small or negative. The values for $S^2_{Y.12}$ differed rather substantially.

The widely differing values of the estimates of the b_1 regression coefficient are a result of retaining observations of low and zero income households in certain of the household types. Household types in which such observations occurred have mean inverses of income which are substantially larger than those of the other household types, due to the unusually large values of the inverse of income for the few low and zero income households included.[1] The extent of the distortion can be seen in a comparison of the harmonic means, i.e., the inverse of the mean of the inverses of income, with the arithmetic mean of income for the same household type. Household type 1A, for example, had an arithmetic mean income of $2,157.46, while its harmonic mean income was only $49.88. The deviation in the estimated b_1 coefficients appears to arise from the least squares solution property of fitting the regression line through the means of the independent variables. The means affected by the inclusion of low and zero income households thus resulted in the estimation of deviant b_1 values.

Comparison of the Regression Results of the Different Equation Forms - On the basis of a comparison of the adjusted coefficients of multiple determination, the four regression equation forms did not differ greatly in the percentage of the variation in the expenditure variable explained. In making comparisons of $\bar{R}^2$ between equation forms, it should be noted that in some cases one will be comparing the percentage of the variation in expenditure explained with the percentage of the variation

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[1]The zero income households had previously been assigned incomes of one dollar. They were assigned inverses of income of .9999999.

in the log of expenditure explained. Although, a method of correction of the correlation coefficient for this difference has been worked out, the corrections for past studies have been so small that their squared value, as required here, would scarcely affect the value of $\bar{R}^2$, if at all.[1]

The coefficient of multiple determination provides a basis for evaluating the closeness of fit of the different regression equation forms. It would also be desirable to have some evaluation of the linearity of fit in order to determine the goodness of fit throughout the length of the regression line. Since it was not the purpose of this study to determine the best equation forms for fitting Engel curves, four different forms which have performed successfully in past studies have been utilized and no attempt will be made here to further refine or improve upon these forms.

In considering the four different equation forms on the basis of closeness of fit, we are able to say that the double-log equation form (5.2) seems to have performed the best. This form gave the most highest values of $\bar{R}^2$ and the fewest lowest values. The semi-log form (5.3), was rated next best on this basis, the log-inverse equation form (5.4) performed well in a number of cases, but not so well overall as either the double-log or semi-log forms. The blame for this poor performance seems to be due in part to the problems which arose from the handling of the income variable. The linear form (5.1), generally gave low values of $\bar{R}^2$, although its performance was not erratic like that of the log-inverse form.

The Income Elasticity Coefficients

The formulas for the calculation of the income elasticity coefficients are given below:

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[1]Prais and Houthakker, pp. 95-96.

Linear form	$\hat{E} = b_1(\bar{X}_1)\ (1/\bar{Y})$	(5.7)
Double-log form	$\hat{E} = b_1$	(5.8)
Semi-log form	$\hat{E} = \log_{10}e\ (b_1)(1/\bar{Y})$	(5.9)
Log-Inverse form	$\hat{E} = b_1\overline{(1/X_1)}(1/\log_{10}e)$	(5.10)

The values of the estimated income elasticities, evaluated at the means of the variables, are given in Table 5.6.

It should be noted that the means employed in calculating the elasticities are the arithmetic means of logarithms and reciprocals as well as natural numbers. Anti-logs of the arithmetic means of logarithms are geometric means, while reciprocals of the arithmetic means of reciprocals are harmonic means. Because of the differences in their computation these three types of means should not be expected to have the same values.[1]

The Elasticities Estimated

The elasticities produced by the linear equation form (5.1) ranged from .044 to .543. The estimates are presented in Table 5.6 along with those for the other equation forms. The highest estimates of elasticity, (4D-1), (3F-1), (4F-1) and (2E-1) seem to be best explained as due to the high values of the b_1 coefficient, along with average or high ratios of mean income to mean expenditure. The lowest elasticities are due chiefly to the very low values of the estimated b_1 regression coefficient in the equations for these household types. The estimated b_1 coefficients in the household types with the lowest elasticities were one-fifth to one-tenth those of the types with the highest elasticities. The differences in elasticities between the types, thus seem to be due chiefly to differences in the estimates of the b_1 coefficients.

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[1]A discussion of the properties of geometric and harmonic means may be found in Frederick E. Croxton and Dudley J. Cowden, Applied General Statistics (2d ed.; Englewood Cliffs, N. J.: Prentice-Hall, 1956), pp. 198-99, 203.

Table 5.6 - Estimated Income Elasticities

Household Type	Linear Form (5.1)	Double-Log Form (5.2)	Semi-Log Form (5.2)	Log-Inverse Form (5.4)
1A	.147	.112	.101	.015
1B	.105	.008	.022	-.012
2A	.323	.322	.329	.261
2B	.238	.297	.264	.344
2C	.082	.177	.181	.119
2D	.163	.108	.001	-.003
2E	.413	.414	.360	.281
2F	.108	.087	.071	.016
3A	.249	.298	.295	.234
3B	.268	.217	.213	.106
3C	.093	.174	.154	.159
3D	.197	.282	.241	.196
3E	.105	.208	.183	.200
3F	.466	.435	.314	.272
4A	.326	.392	.342	.339
4B	.044	.088	.110	.048
4C	.182	.243	.247	.215
4D	.543	.410	.568	.378
4E	.088	.099	.128	.105
4F	.440	.362	.451	.308
5A	.183	-.008	-.024	-.019
5B	.297	.423	.432	.426
5C	.307	.390	.353	.312
5D	.173	.404	.314	.437
5E	.390	.421	.511	.376
5F	.288	.406	.347	.478

The income elasticities estimated by the double-log form (5.2) ranged from -.008 for equation 5A-2 to .435 for equation 3F-2. Most of the estimates were above .200.

The elasticities estimated by the semi-log from (5.3) ranged in value from -.024 to .568. The difference between the elasticities is due chiefly to differences in the b_1 coefficients, which ranged widely in value. The highest elasticity estimate of .568 for 4D-3 is due to the high estimate of b_1, which swamped the low value of the inverse of mean expenditure. The lowest elasticity estimate of -.024 for 5A-3 was a result of the negative estimate of the regression coefficient.

The elasticities estimated by the log-inverse equation form (5.4) ranged from -.019 to .478 and included three negative estimates. The three negative values are due, of course, to the negative values of the estimated regression coefficients. The differences in the elasticities estimated are due chiefly to differences in the estimated regression coefficients which varied greatly in value, although the means of the inverse of income also varied markedly. These variations are due to the difficulties which arose in handling the income variable, as was discussed previously.

Comparison of the Elasticities Estimated

In comparing the elasticities estimated by the four equation forms for particular household types, several interesting differences can be noted. The elasticity estimates produced by the double-log form (5.2) were generally the largest of those for a particular household type, followed by those of the semi-log form (5.3), the linear form (5.1) and the log-inverse form (5.4), in that order. The results for the linear form were usually either the highest or the lowest elasticity estimate for the particular household type. It should be noted in making this comparison that the elasticities being compared have not been evaluated at the

same means of income and meals served. Each one has been evaluated at the appropriate arithmetic, geometric or harmonic mean. Although the double-log form generally gave the highest estimates, its range of values was smaller than that of any of the three other equation forms.

In making comparisons between equation forms, household types with relatively high estimated elasticities for one equation form were found to occupy approximately the same position among the elasticities estimated by the other equation forms. The household types with low elasticities for one equation form were found to also have low estimated elasticities for the other equation forms. The low and negative elasticites obtained cannot be ascribed then to any failure of the equation forms, but must be considered truly descriptive of the behavior of the samples under consideration.

The elasticity estimates produced by the four equation forms thus appear to be consistent with each other. None of the results deviated from the general pattern of those of the other equation forms. It is felt, however, that the results of the log-inverse form are, as a group, the least reliable, because of the effects produced by the handling of the income variable.

Methods of Testing for Differences Between Elasticity Coefficients

Covariance Analysis

An exact test of the significance of differences in the elasticities estimated with double-log equation (5.2), is available through the use of the techniques of covariance analysis. Since the income elasticities are the estimated b_1 regression coefficients, the relevant covariance analysis test is a test of the equality of the regression coefficients. The covariance test for the equality of regression coefficients compares the

variation among the regression coefficients of the different household types with the sum of squared deviations of individual observations from their type regression lines, totaled over all types.[1] The ratio of these two values, each divided by its degrees of freedom, has an F distribution. The differences between the regression coefficients will be judged significant if the variation among the regression coefficients is large in relation to the variation of individual observations from the type regression lines.

Covariance analysis techniques require the assumption that the disturbance variances are equal or that the ratio of the real variances is known or can be assumed.[2] On applying Bartlett's test to the residual variances it was found that equality of disturbance variances could not be assumed.[3] The disturbance variances were found to be significantly different at the one percent level, with 27 degrees of freedom. On the basis of the results of the test it was decided that covariance analysis techniques could not be employed unless weighting procedures were used.

Since the ratios of the real variances were not known, some assumptions about these ratios were therefore required. Since Gustafson has found the results of F tests of regression coefficients to be sensitive to variations in the ratios assumed,[4] it was decided that other alternative methods should be considered before making such assumptions. The decision to consider other methods was also influenced by the desire to have a test which could be used with the elasticities estimated by all four

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[1]Wilfrid J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (2d ed.; New York: McGraw-Hill Book Co., 1957), pp. 216-19.

[2]Robert L. Gustafson, "Testing Equality of Coefficients in Different Regressions," Note of April 13, 1961 (Revised), Department of Agricultural Economics, Michigan State University, East Lansing (Mimeographed), p. 17.

[3]Snedecor, pp. 285-89.

[4]Gustafson, "Testing Equality of Coefficients in Different Regressions," p. 20.

of the regression forms employed. Covariance analysis techniques would have provided a test only of the elasticities estimated with the double-log form.

Confidence Intervals

The covariance analysis techniques would have provided a test of the equality of the elasticities estimated by the double-log equation form. The use of confidence intervals to determine the existence of significant differences in elasticities provides a test of somewhat different type. In dealing with a ninety-five percent confidence interval for an elasticity we are estimating bounds which we expect will include the elasticity coefficient of the population from which we are sampling, unless the sample with which we are dealing is of a divergent type that occurs only once in twenty trials.[1]

In using confidence intervals as a test for significant differences in the elasticities we will want to ascertain whether any of the confidence intervals of the elasticity estimates do not overlap. Estimates whose confidence intervals do not overlap may be regarded as significantly different.[2] For simplicity, the elasticities used in the example which follows are those estimated by the double-log equation form (5.2) for two household types containing the same number of observations. The method for the other equation forms would be similar. The upper limit of the ninety-five percent confidence interval of E_1 is less than the lower limit

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[1]Snedecor, p. 76.

[2]A general discussion of the interpretation of confidence statements as a family of tests is given in E. L. Lehmann, Testing Statistical Hypotheses (New York: John Wiley and Sons, 1959), pp. 173-76. Note that the test of the significance of the differences of the estimated elasticities assumes that the covariance of the two estimated elasticities equals zero, which appears to be a reasonable assumption. Thus the test may be inexact but is probably $\frac{\alpha}{2}$.

of the ninety-five percent confidence interval of E_2. Then $E_1 + S_{E_1} t_{.975} < E_2 - S_{E_2} t_{.975}$, where S_{E_1} and S_{E_2} are the standard errors of the respective regression coefficients, and thus of the two elasticities. The two elasticities are significantly different at the 2.5 percent level since

$$\frac{E_2 - E_1}{S_{E_1} + S_{E_2}} > t_{.975} \qquad (5.11)$$

For household types which do not contain the same number of observations, we can replace the t value, $t_{.975}$ (L), of the type containing the larger number of observations with the t value used in the confidence interval of the household type with the smaller number of observations, $t_{.975}$ (S) in order to obtain a conservative test. Remembering that the value of tabled t increases as the number of degrees of freedom declines, we note that the inequality becomes

$$\frac{E_2 - E_1}{S_{E_1} + S_{E_2}} > t_{.975}\,(S) \qquad (5.12)$$

The difference between the two elasticities can be seen to be significant at the 2.5 percent level in this case also.

The use of confidence intervals has the advantage that they may be used with all four of the regression equation forms which have been employed in this study. As has been noted, covariance analysis can be used only in testing for differences in the elasticities estimated by the double-log form (5.2) and its use for this purpose requires assumptions of doubtful validity or others which may seriously influence the outcome of the test. Under these circumstances, the use of confidence intervals as a test for significant differences between the elasticity coefficients seemed clearly preferable.

The Significance of the Differences Between the Elasticities of Different Household Types

After deciding upon the use of confidence intervals as the method for testing for differences between the estimated income elasticities of the different household types, the required confidence intervals were calculated.

Confidence intervals were estimated for the linear (5.1), double-log (5.2) and semi-log (5.3) equation forms. Because of the doubtful reliability of the regression results for the log-inverse equation form (5.4), confidence intervals were not estimated for the elasticities estimated by this equation form. Even if significant differences were found to exist in the elasticities estimated by the log-inverse equation form, these differences could not be laid to differences in behavior between household types with any degree of certainty, because of the important differences between the regression results for different household types due solely to the handling of the income variable.

The confidence intervals of the household type elasticities for each of the three equation forms are presented in Tables 5.7, 5.8, and 5.9. Ninety-five percent confidence intervals were employed in order to have confidence intervals of such width that household types having elasticity confidence intervals which did not overlap could be regarded as having significantly different elasticities with a high degree of certainty. The ninety-five percent confidence intervals can be expected to contain the income elasticity for the population of that household type, unless the sample chosen is an abnormal one such as would be expected only five times in a hundred.

The confidence intervals for the elasticities estimated by the linear equation form (5.1) are presented in Table 5.7.[1] It will be noted that the

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[1]The method employed to estimate the confidence intervals for elasticities estimated by the linear equation form (5.1) is presented in R. L. Gustafson, "Inferences about 'Elasticities' in Linear Relations,"

confidence intervals are not symmetric about the estimated elasticity, because of the skewed distribution of the elasticity estimate.[1] The confidence intervals for the elasticities estimated by the double-log form (5.2) are presented in Table 5.8. The confidence intervals for the double-log form are symmetric about the elasticity estimate. The confidence intervals for the elasticities estimated by the semi-log equation form (5.3) are given in Table 5.9. These confidence intervals are also not symmetric about the estimated elasticity.

For each of the three equation forms the confidence intervals estimated do not overlap for a number of different household types, indicating that their income elasticities may be regarded as significantly different. The number of household types with elasticities significantly different from the elasticity of a particular household type are given in Table 5.10. The number of household types whose confidence intervals lie completely above that of any particular household type are given, along with the number of household types whose confidence intervals lie entirely below that of the particular household type. The numbers are thus the numbers of household types whose elasticities are significantly greater or significantly smaller than those of the indicated type. There are household types whose elasticity is both significantly greater and significantly smaller than that of some other type only for the semi-log equation form (5.3).

Note of March 27, 1961. Department of Agricultural Economics, Michigan State University, East Lansing (Mimeographed). This method was adapted to estimate the confidence intervals of the elasticities estimated by the semi-log equation form (5.3). The confidence intervals for the elasticities estimated by the double-log equation form (5.2) were estimated by the procedures employed to estimate confidence intervals of regression coefficients, as discussed in Dixon and Massey, Introduction to Statistical Analysis, pp. 193-194.

[1] R. L. Gustafson, "Inferences About "Elasticities' in Linear Relations," Note of March 27, 1961. Department of Agricultural Economics, Michigan State University, East Lansing (Mimeographed), p. 4.

Table 5.7 - Ninety-Five Percent Confidence Intervals for the Elasticities Estimated by Linear Equations

Equation Number	Estimated Income Elasticity	Lower Limit	Upper Limit
1A-1	.147	.028	.254
1B-1	.105	.011	.199
2A-1	.323	.012	.635
2B-1	.238	.146	.333
2C-1	.082	-.053	.220
2D-1	.163	.045	.283
2E-1	.413	-.020	.870
2F-1	.108	.028	.188
3A-1	.249	.016	.483
3B-1	.268	.053	.483
3C-1	.093	.014	.170
3D-1	.197	.072	.324
3E-1	.105	-.006	.215
3F-1	.466	.278	.665
4A-1	.326	.161	.494
4B-1	.044	-.074	.162
4C-1	.182	.053	.315
4D-1	.543	.349	.756
4E-1	.088	-.169	.345
4F-1	.440	.241	.650
5A-1	.183	.046	.418
5B-1	.297	.180	.416
5C-1	.307	.186	.432
5D-1	.173	-.007	.360
5E-1	.390	.242	.544
5F-1	.288	.064	.516

Table 5.8 - Ninety-Five Percent Confidence Intervals for the Elasticities Estimated by Double-Log Equations

Equation Number	Estimated Income Elasticity	Lower Limit	Upper Limit
1A-2	.112	.058	.165
1B-2	.008	-.065	.080
2A-2	.323	.167	.478
2B-2	.297	.215	.380
3C-2	.177	-.038	.393
2D-2	.108	.011	.206
2E-2	.414	.075	.752
2F-2	.087	.041	.134
3A-2	.298	.191	.405
3B-2	.217	.050	.384
3C-2	.174	.041	.307
3D-2	.282	.147	.417
3E-2	.208	.065	.352
3F-2	.435	.304	.565
4A-2	.392	.231	.553
4B-2	.088	-.071	.247
4C-2	.243	.077	.409
4D-2	.410	.180	.641
4E-2	.099	-.199	.397
4F-2	.362	.209	.514
5A-2	-.008	-.111	.094
5B-2	.423	.265	.580
5C-2	.390	.250	.530
5D-2	.404	.155	.653
5E-2	.421	.201	.641
5F-2	.406	.107	.705

Table 5.9 - Ninety-Five Percent Confidence Intervals for Elasticities Estimated by Semi-Log Equations

Equation Number	Estimated Income Elasticity	Lower Limit	Upper Limit
1A-3	.101	.038	.164
1B-3	.022	-.036	.082
2A-3	.329	.167	.495
2B-3	.264	.164	.364
2C-3	.181	-.007	.377
2D-3	.001	0	.002
2E-3	.360	-.006	.744
2F-3	.071	.027	.117
3A-3	.295	.182	.410
3B-3	.213	.022	.406
3C-3	.154	.025	.285
3D-3	.241	.108	.376
3E-3	.183	.046	.322
3F-3	.314	.179	.455
4A-3	.342	.176	.510
4B-3	.110	-.048	.268
4C-3	.247	.084	.412
4D-3	.568	.247	.921
4E-3	.128	-.153	.413
4F-3	.451	.244	.668
5A-3	-.024	-.117	.069
5B-3	.432	.286	.582
5C-3	.353	.224	.484
5D-3	.314	.073	.571
5E-3	.511	.287	.747
5F-3	.347	.068	.634

Table 5.10 - Number of Household Types With Elasticities Significantly Different From the Elasticity of a Particular Household Type

Household Type	Number of Household Types With Significantly Smaller Elasticities			Number of Household Types With Significantly Greater Elasticities		
	Linear Equation	Double-Log Equation	Semi-Log Equation	Linear Equation	Double-Log Equation	Semi-Log Equation
1A			1	2	10	8
1B				4	13	12
2A		4	5			
2B		5	4	1		
2C				4		
2D				1	6	19
2E						
2F			1	4	12	10
3A		4	5			
3B			1			
3C			1	6		
3D		3	3	1		
3E			1	4		
3F	7	6	5			
4A		5	5			
4B				6	3	2
4C			3	1		
4D	13	4	5			
4E				1		
4F	6	5	5			
5A					13	12
5B	2	6	7			
5C	2	6	5			
5D		3	2			
5E	6	4	7			
5F		2	1			

A number of household types had elasticities which were not significantly different from those of any other household type, however, most household types had elasticities which were either significantly smaller or significantly greater than those of some other household type. The pattern of Table 5.10 suggests that for all three equation forms, the elasticities of the smaller households, especially the one and two person households, were generally significantly smaller than those of other types, while the elasticities of the larger household types were generally significantly greater than those of other types.

CHAPTER VI

CONCLUSIONS

The Economic Significance of the Results

The significance of the results has, up to this point, been considered chiefly in a statistical sense. It is, however, the economic significance of the differences between the elasticities of the household types that is of central concern. Regardless of their statistical significance, the results are of little concern unless they indicate differences in expenditure behavior which cannot be ignored safely nor validly assumed away.

It is felt that the differences in the income-expenditure elasticities for food which have been demonstrated are of such a magnitude that their effects should be borne in mind in future studies. In order to illustrate the economic significance of the results, alternative projections of 1966 average weekly food expenditure will be presented for each household type.

Our model will be based on two principal assumptions, and will be used to estimate 1966 average weekly food expenditure for the 26 household types of this study under each of two alternative assumptions about the relevant income-expenditure elasticities for food. The two primary assumptions of this naive model are that: (1) each household type shares equally in increases in personal disposable income, and that (2) the distribution of household types remains unchanged. The two alternative assumptions about the relevant income elasticities are (A) the income-expenditure elasticity for food is the same for all household types, and (B) the income-expenditure elasticity for food differs between household types.

Disposable personal income will be assumed to increase by 62.5 percent in the 1954-65 period. Since the elasticities of the household types derived from the 1955 Survey are based on 1954 income, 1965 disposable personal income will be assumed to govern 1966 food expenditure. This estimate of the increase in personal disposable income was obtained from the projection of 1965 disposable personal income (in 1958 dollars) of the "judgment model" of the Colm report.[1] The projected personal disposable income was deflated through the use of the implicit personal consumption expenditure deflator[2] to 1954 dollars and compared with 1954 personal disposable income.[3]

The income elasticity under assumption (A) that the income elasticity is the same for all household types, will be assumed to be .29. This is the estimate of income-expenditure elasticity for food at home and away for the urban United States developed from the data of the 1955 U.S.D.A. Survey, and is the available estimate which is most closely comparable to those produced by this study.[4] The elasticities of this study differ from this overall estimate of elasticity in that they are based on expenditures for home consumption only and were estimated by an equation form including total meals served as a variable. The elasticities of

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[1]National Planning Association, Long-Range Projections for Economic Growth: the American Economy in 1970 (Washington: National Planning Association, 1959), pp. 30-31.

[2]U. S. Department of Commerce, "National Income and Product Accounts of the United States in 1958," Survey of Current Business, XXXIX. (July, 1959), 40.

[3]U. S. Department of Commerce, U. S. Income and Output, A Supplement to the Survey of Current Business (Washington: U. S. Government Printing Office, 1958), pp. 144-45.

[4]Marguerite C. Burk, "Some Analyses of Income-Food Relationships," Journal of the American Statistical Association, LIII, No. 284 (December, 1958), 915. The elasticity was estimated with the double-log equation form (4.2).

assumption (B) will be those estimated by the double-log equation form (5.2) for each of the household types.[1]

The results of the projection of average weekly food expenditures with the naive model under the two alternative assumptions about income elasticities are presented in Table 6.1. It will be noted that although there is substantial difference in the projected averages of weekly expenditure, there is little difference between the weighted overall averages of expenditure under the two alternative assumptions. The overall weighted average expenditure under the assumption of the same elasticity for all household types is $24.83. Under the assumption of differing elasticities, the overall weighted average expenditure is $24.65. This might seem to indicate that the economic significance of differing elasticities between household types is slight.

It will be remembered, however, that two rather restrictive assumptions about changes in income distribution and in the distribution of household types were employed in the naive model. It was assumed that all household types would share equally in the increases in income and that the distribution of household types would remain unchanged. There is little reason to believe that these conditions will actually be the case, or that they are typical of past changes. The current projections of household numbers for 1965 by age of head presented in Table 1.4 provide little basis for an assumption that the distribution of household types would remain unchanged. The evidence of changes in the distribution in recent

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[1]We are thus employing cross-sectional elasticities rather than time-series elasticities for both projections of average weekly expenditure. Although time-series elasticities would ordinarily be employed for such projections, we will use the cross-sectional elasticities here as conservative estimates of the applicable time-series elasticities. Time-series estimates of elasticities have been larger than the cross-sectional estimates for similar groups in recent studies as pointed out by Marguerite Burk, "Some Analyses of Income-Food Relationships," pp. 919-21.

Table 6.1 - Illustrative Projections of 1966 Average Weekly Food Expenditure for Certain Types of Urban Households By the Naive Model Under Two Alternative Assumptions About Income Elasticities

Household Type	1955 Average Weekly Expenditure	Projected Average Weekly Expenditure--1966 (a) Assumption (A), Elasticity of .29 for All Household Types (b)	Projected Average Weekly Expenditure--1966 (a) Assumption (B), Different Elasticity for Each Household Type (c)	Difference Between the Two Projections of 1966 Average Weekly Expenditure (Column 3 minus Column 4)
1A	7.94	9.38	8.50	.88
1B	6.14	7.25	6.45	.80
2A	17.12	20.22	20.58	-.36
2B	18.18	21.47	21.56	-.08
2C	14.93	17.63	16.59	1.04
2D	15.40	18.19	16.45	1.74
2E	15.15	17.89	19.07	-1.18
2F	13.44	15.87	14.17	1.70
3A	22.40	26.45	26.57	-.12
3B	23.28	27.49	26.45	1.04
3C	26.04	30.75	28.88	1.87
3D	24.12	28.49	28.37	.12
3E	26.62	31.44	30.08	1.36
3F	18.48	21.82	23.51	-1.69
4A	24.47	28.90	30.47	-1.57
4B	28.18	33.28	29.73	3.55
4C	28.36	33.49	32.67	.82
4D	31.12	36.75	39.09	-2.34
4E	29.63	34.99	31.47	3.52
4F	30.27	35.75	37.11	-1.36
5A	36.29	31.05	26.16	4.89
5B	31.12	36.75	39.34	-2.59
5C	31.79	37.54	39.55	-2.01
5D	30.49	36.01	38.20	-2.19
5E	26.10	30.82	32.96	-2.14
5F	30.49	36.01	38.23	-2.22
Overall Weighted Agerage		24.83	24.65	

[a] An increase of 62.5 percent in disposable personal income is assumed.

[b] The elasticity estimate of .29 employed is for expenditures at home and away for urban households and is based on the 1955 Survey. See Marguerite Burk, "Some Analyses of Income-Food Relationships," Journal of the American Statistical Association LIII, No. 284 (December, 1958), p. 915.

[c] Elasticities estimated by the double-log equation form (5.2), as presented in Table 5.6.

years, which is presented in Table 6.2 raises further question as to the validity of such an assumption. The table shows that the proportion of households with children declined from 1940 until sometime after 1953, as did the number of households with three or more children. Both proportions then began to increase about 1953. In the period after 1953 the proportion of households with three or more children increased rapidly and by 1960 the proportion was substantially above that in 1940.

Under the naive model the two alternative assumptions about elasticities produce estimates of average weekly expenditure which differ fairly markedly for some household types, but differ little in the overall weighted average. The differences between the estimates under assumption (A) and (B) are given in Table 6.1. If either primary assumption (1) or (2) or both are relaxed to permit changes in the income distribution, the distribution of household types or both, these differences become of greater importance.

If we relax assumption (2) in light of the evidence of changes in the distribution of household types which has been presented, we can see that the naive model under assumption (A) will tend to underestimate overall average weekly food expenditure as compared to a model in which the proportion of larger household types, with their higher income elasticities, is assumed to increase. If we also relax assumption (1), and assume that the larger household types receive a disproportionate share of the increases in income, the tendency of the naive model under assumption (A) to underestimate overall average weekly expenditure as compared to our new model becomes even more marked.

In the absence of the necessary projections of income distribution and numbers by household type the above somewhat intuitive demonstration seems the best method available for showing the possible economic significance of the differences in elasticities between household types found in this study. The above demonstration indicates that the economic

Table 6.2 - Distribution of Husband-Wife Households by Number of Related Children Under 18, Selected Years 1940-60.

Number of Related Children Under 18	Percent of Total Husband-Wife Households					
	1940[a]	1947[b]	1950[a]	1953[c]	1956[d]	1960[e]
None	40.9	42.3	42.2	41.2	39.6	38.7
One	24.1	23.5	23.3	22.0	20.0	19.3
Two	16.9	17.9	18.4	18.9	20.5	19.6
Three	8.6	16.3[f]	8.8	10.1	10.8	12.1
Four or more	9.5	----	7.3	7.8	9.1	10.3
Total percent	100.0	100.0	100.0	100.0	100.0	100.0
Husband-Wife households as a percent of total households	76	78	78	76	76	75

[a]U. S. Bureau of the Census, "Marital Status and Household Characteristics: March 1950," Current Population Reports, Series P-20, No. 33 (Washington: Bureau of the Census, February 12, 1951), p. 15.

[b]U. S. Bureau of the Census, "Households by Type, Composition and Housing Characteristics: March 1947," Current Population Reports, Series P-20, No. 16 (Washington: Bureau of the Census, May 5, 1948), p. 12.

[c]U. S. Bureau of the Census, "Household and Family Characteristics: April 1953," Current Population Reports, Series P-20, No. 53 (Washington: Bureau of the Census, April 11, 1954), p. 11.

[d]U. S. Bureau of the Census, "Household and Family Characteristics: March 1956," Current Population Reports, Series P-20, No. 75 (Washington: Bureau of the Census, June 9, 1957), p. 11.

[e]U. S. Bureau of the Census, "Household and Family Characteristics: March 1960," Current Population Reports, Series P-20, No. 106 (Washington: Bureau of the Census, January 9, 1961), p. 18.

[f]Three or more children.

significance of the differences in elasticities between household types increases as changes in the distribution of household types become more marked, and as increases in income become more disproportionate between household types. In a period of rapidly rising personal disposable incomes, such as we are now experiencing, in which the distribution of household types is also changing substantially, the results of this study are of greater significance than they would be in a period in which income and population were changing only slowly. In the absence of the required projections it is difficult to evaluate the full economic significance of the differences in elasticities which have been found in this study. It is felt however, that the results can be seen, from the somewhat intuitive demonstration given, to be of real economic significance. The full determination of this significance requires substantial further study, and cannot be attempted here.

Another aspect of the economic significance of the results is their implications for the estimation of consumption equivalence scales. The techniques used by Brown and Prais and Houthakker to estimate scales require the assumption of a single income elasticity for all household types, as was indicated in Chapter I. While such an assumption may have been warranted for the British data employed in these two studies, the results of this study indicate that such an assumption would not be warranted for the data of the urban portion of the 1955 U.S.D.A. Household Food Consumption Survey. If the assumption of a single income elasticity for all household types was warranted for the 1955 data, the problem of estimating equivalence scales would be eased substantially. The techniques used to estimate scales in the two British studies do not appear to be suitable for use with recent United States data except in so far as we are willing to accept and take account of the errors introduced by the assumption of a single income elasticity for all household types. It may well be, however, that even though they do require this contrary to fact

assumption, the techniques of Brown and of Prais and Houthakker may still provide the best equivalence scale estimates which can be obtained at the present time.

Justification for Acceptance of the Hypothesis

The evidence produced relevant to a general hypothesis never establishes its truth or falsity, but is intended rather to provide justification for its acceptance or rejection. This study has brought forward evidence relevant to the acceptance and rejection of the hypothesis that significant differences exist between the elasticities of households of differing size and composition. Evidence about the significance of these differences in both a statistical and in an economic sense has been presented.

The evidence provided by the confidence intervals of the elasticities appears to warrant fully the acceptance of the hypothesis in its statistical sense. Statistically significant differences were shown to exist between the elasticities of different household types, as estimated by three different equation forms. Differences were found to exist in a number of instances within each of the groups of household type elasticities estimated by a particular equation form. The elasticities estimated for eighteen household types by the linear equation form (5.1) were found to be significantly different from those of one or more other household types. Nineteen household types were found to have elasticities which were significantly different from those of one or more other household types for the elasticities estimated by the double-log equation form (5.2). Twenty-three of the twenty-six household types were found to have elasticities which were significantly different from those of at least one other household type for the elasticities estimated by the semi-log equation form (5.3). In cases where most of the household types differed significantly only from one other household type, it would be easy to explain away these differences

as due solely to a single unrepresentative sample. However, for each of the equation forms there were several household types whose elasticities differed significantly from those of a number of other household types, far too many to make the appearance of unrepresentative samples seem a likely explanation of the differences.

As usual, the evidence of the economic significance of the results is somewhat less clear-cut. The illustrative projections presented did indicate, however, that the naive model usually used in projections of food expenditures and implicit in historical per capita consumption series is least reliable in periods like the present when incomes and population composition are changing rapidly. It is held, therefore, that the results do have an economic significance under present conditions, which they would not have in periods of relatively stable incomes and relatively stable population composition.

The acceptance of the hypothesis is further supported by the similarity of the results of this study to the general pattern which was noted in previous studies. The one general pattern noted in the previous studies discussed in Chapter I was the tendency for income elasticities to increase with household size. This tendency was also noted in the results of this study. The conformance of the results to the pattern noted in previous studies is further evidence of their validity and thus lends additional support to our decision to accept the hypothesis.

Further Studies Needed

The needed research most immediately suggested by this study is an evaluation of the full economic significance of the results which have been presented. Until detailed projections of numbers by households type and income by household type are available or can be estimated roughly, it will be impossible to determine the exact significance of the

differences which have been found to exist between the elasticities of the different household types. It is felt that the results of this study raise serious questions about the validity of using certain projection techniques employed in the past under present conditions. Full evaluation of the current usefulness of these techniques requires a fuller exploration of the economic significance of the results of this study.

The results of this study suggest a partial explanation of the changes which have been noted in historical per capita food consumption series. These changes in consumption over the years have been laid chiefly to "changes in tastes." The results of this study indicate that these changes in consumption may be due, at least in part, to changes in the distribution of household types and in the age-sex composition of the population. Changes in the kinds of individuals making up the population may be as important in explaining changes in per capita food consumption as actual changes in the preferences of these different kinds of individuals. The effects of changes in population composition on per capita consumption are probably less dramatic for all food in the aggregate than they are for many individual food categories. The income elasticity for milk seems likely to differ greatly between household types with children and those without, for example. While the results of this study provide some evidence that changes over time in per capita food consumption can be explained in part by changes in the distribution of household types and in population composition, its evidence cannot be considered conclusive. Further studies are needed to evaluate fully the influence of changes in population characteristics on per capita consumption of all food in the aggregate, and on per capita consumption of particular foods.

The difficulties experienced in handling the income variable in the course of this study indicate that a better definition of income is needed for survey work on household budgets. A definition is required which will clearly separate the business and household accounts of the

self-employed and will not permit the reporting of zero or negative incomes along with a positive level of expenditure.

The variables included in this study generally explained less than half of the variation in food expenditure for a particular household type. Recent changes in tastes and consumption behavior may have made new variables, not employed in previous studies, relevant. Theoretical and empirical work is needed to identify these variables. It may be the case, however, that with increasing discretionary income the forces acting on consumption have become too complex to be described by the functional forms which have been employed in the past. Other methods of describing of the relationship between expenditure and income plus other determining variables should be investigated; elasticities and single-equation models may be becoming altogether inadequate to describe the increasing complexity of the forces influencing household consumption behavior.

In addition to the effects of household composition on expenditure behavior, certain other effects of the economic and family life cycle clearly appear to merit further study. One such study which seems indicated in this area is the effects of changes in the stock of consumer durables and other assets on household expenditure behavior. It may well be that the major inadequacy of the income variable as usually formulated lies in the vastly different asset structure with which any given income may be associated over the family and economic life cycle.

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APPENDIX I

THE 1955 HOUSEHOLD FOOD CONSUMPTION SURVEY SAMPLE[1]

The data which is utilized in this study was drawn from the urban portion of the United States Department of Agriculture's 1955 Household Food Consumption Survey. The purpose of the U.S.D.A. study was to collect current information on patterns of food consumption, expenditures, dietary levels and household food practices. The study includes data from 6,060 households in which at least one member of the household ate 10 or more meals from household food supplies in the preceding week. Of the 6,060 households from which complete interview schedules were taken, 4,556 were in the basic national sample. The basic national sample was supplemented by interviews of 1,504 farm-operator households, which were selected in the same manner as the basic national sample, but were drawn from rural areas only. The interviews were collected in the months of April, May and June, 1955.

Only households in which one member ate 10 or more meals in the preceding week were considered eligible. The 4 percent of the population which lives in non-housekeeping units, such as rooming houses, institutions and prisons, is thus omitted from the study. Of the 5,927 dwelling units selected for the basic sample, 5,625 were found to be occupied and 5,207 were found to have served 10 or more meals to at least one person in the previous week. Complete schedules were collected for 4,605 of these eligible households in the basic sample, the other 732

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[1]This appendix summarizes the description of the survey and the sampling procedures employed given in U. S. Department of Agriculture, Food Consumption of Households in the United States ("Household Food Consumption Survey 1955," Report No. 1; Washington: U. S. Government Printing Office, 1956), pp. 1-3, 186-195.

eligible households had no one at home or refused to supply the desired information. Only 91 percent of the urban households selected for the basic sample were found to be eligible, of these 3,276 eligible households 2,832 households actually participated in the survey by supplying the information requested.

The survey employed the "recall-list" method and used specially trained interviewers to help respondents recall the quantities of food used during the week and the amounts paid for purchased items. The information collected was on food consumed or used up, rather than on purchases. In addition to this information on the quantities used at home for all food items in the previous week, information was collected on the number of meals eaten at home and away by each individual in the household and expenditures on food eaten away from home.

The basic sample was a national, self-weighting, area, probability sample. It was drawn by first separating metropolitan areas with a population of over 50,000 from the non-metropolitan areas. The 168 metropolitan areas were divided into five size classes on the basis of their population in the 1950 Census. Each of the 8 metropolitan areas in the over 2 million population size class was regarded as a separate stratum. The other metropolitan areas were grouped into 3 to 8 geographic areas within each of the remaining four size classes. Each of these groups of metropolitan areas had a population of approximately 2 million and were made up, with few exceptions, of varying combinations of states within the four Census regions, Northeast, North Central, South and West. This grouping produced 32 metropolitan area strata, 8 of which consisted of a single major metropolitan area, with the remaining 24 strata each consisting of a group smaller metropolitan areas of the same approximate size, all located within the same region.

In each of the 8 major metropolitan area strata, cities were classified by size. One city was selected from each size stratum, for a total

of 23 cities. A total of 24 cities was selected from the other 20 metropolitan area strata. The 45 cities selected were chosen with a probability proportional to their 1950 population.

The 605 cities with populations between 10,000 and 50,000 outside the standard metropolitan areas were grouped within Census regions into 15 strata, averaging about 85 thousand people per strata. One city was selected from each of these 15 strata with probability proportional to its 1950 population. These 15 strata for cities outside standard metropolitan areas and the 45 strata for cities within standard metropolitan areas provided a total of 60 cities for the national sample.

In the 32 standard metropolitan areas, the 81 counties (excluding cities of over 10,000) were grouped into 33 strata. The remaining 2,697 counties outside the standard metropolitan areas were grouped into 82 strata of contiguous economic areas, each having about 650,000 persons. One county was selected from each of these 115 county strata. A total of 60 cities and 115 counties were thus selected for the sample.

Within the cities, sample segments were selected by numbering all the segments set up within the city and drawing every n-th one with probability proportional to the number of dwelling units in the segment. Sample segments were selected randomly in each county from a listing of Census enumeration districts which excluded places of 10,000 or more population. One smaller segment was selected with equal probability from each of these enumeration districts. A total of 2,000 segments were selected from the 60 cities and 115 counties in the sample, of these 1,527 were allocated to the basic sample.

The dwelling units to be visited within each segment were selected from lists made up in a specified geographic order. A random number was used to select the first sample dwelling unit to be interviewed, it and every n-th succeeding unit were then designated for interview. The number "n" was determined by dividing the expected number of dwelling units in

the segments by the expected number of units to be visited. Each segment was expected to yield 3 interviews. No substitutes were provided for households which were not eligible to participate, or which were absent or refused to participate. In urban areas, interviewers were required to make as many as four return visits if necessary, in order to make original contact.

The "urban" households whose behavior is considered in this thesis are those in the U.S.D.A. survey which were located in communities of 2,500 or more population, or in fringe areas around cities of 50,000 or more. This includes all the households in the sample in the 60 cities of 10,000 or more, all those in the 33 county strata made up of areas lying within the standard metropolitan areas but outside cities of 10,000 or more population, and all the households within the remaining 82 county strata which were located in cities of 2,500 to 10,000 population.

The survey sample may be appraised by comparing it with Census data. The distribution of households by number of persons, the proportion of non-white households and the proportion owning television sets were found to be much alike. In the urban sample, the chief discrepancy in comparison to Census data was the over representation of persons under 15 years of age at the expense of those between 15 and 29 years. In all other respects the nonfarm households were considered to be well represented.

About 13 percent of the eligible urban households failed to participate in the survey by supplying the requested information. The resulting non-response bias was considered to be small on the basis of comparisons of the answers to certain questions obtained from those classified as non-respondents with those obtained from participating households, and the comparatively small proportion of non-respondents. The proportion of non-participants to participants was smaller than average in the South and larger in the North Central region. The non-participating households had

fewer husband-wife households and fewer household members. The members of the non-participating households included fewer children and more adults over 50. A higher proportion of the housewives in the non-participating households were employed.

Income was not reported by about 9 percent of the households which participated in the survey. Some of these households were not asked for their income in the previous year, 1954, since they were only recently established. Others refused to provide the information on income, but answered all other questions. The resulting bias was not investigated; it was expected that the group of households not asked showed the characteristics of recent establishment and that those who refused to provide the information were, like the eligible non-participants, not different enough or numberous enough to distort the total results.