FOOD DEMAND ANALYSIS

Implications for Future Consumption

Edited by

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Table of Contents

The Effects of Household Size and Composition on the Demand for Food

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Introduction

Over the past several years there have been changes both in the age-sex composition of U.S. households and in the size of these households. The decline in the birth rate, coupled with increased longevity, has led to smaller proportions of children and larger proportions of elderly in the population. These same factors have led to a decline in household size from 3.3 in 1960 to 2.7 in 1983.

The purpose of this paper is to estimate the effect such changes have had on the demand for food from 1960 through 1983 and to project the effects of future population changes on the demand for food through the year 2000. The analysis deals with the quantity of 28 specific foods and with total food expenditures. The quantity of specific foods was used because of its importance in national policy and in the decision making of private firms. It also eliminates any effect of price changes due to changes or efficiencies of marketing services embodied in the products.

The procedure used was to estimate age-sex equivalent scales and economies of scale coefficients from the 1977-78 United States Department of Agriculture nationwide food consumption survey. This data set includes both household use and individual intake data, but only household use data were used in the study. Also, the USDA survey included only food used at home; thus, our estimates and projections are for only food at home. Estimates for changes in demand for food are made under the assumption that the proportion of meals eaten at home is constant. Since only age-sex composition and household size effects for food eaten at home are taken into account, the projections are not intended to be forecasts, but they simply portray what will happen under certain assumptions. In addition to assuming the proportion of meals at home being constant, all other variables affecting consumption of specific foods such as prices, region and ethnicity are assumed constant. One additional assumption should be given specific attention, that is, that there is no generation effect on consumption. It is assumed that persons who are presently 50-64 years of age will have the same consumption patterns when they reach 65 years of age as the persons who are now 65 years of age.

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Procedures

In order to estimate age-sex equivalent scales and economies of scale coefficients for total food, one should hold per adult equivalent income constant. However, since no accurate income scale is available, expenditure quality of the diet was held constant instead. The demand for food was then assumed to be separable from other goods. Scales for specific products were estimated holding food expenditures per adult equivalent and other relevant variables constant.

Estimation of Scales for Total Food

The basic model for this study was the Prais-Houthakker model which states that expenditures per adult equivalent for a specific good are a function of income per adult equivalent. The model does not account for the effects of price changes which occur with changes in the household composition which in turn lead to substitution effects. However, a recent study by Pollak and Wales, 1981, obtained better results with the Prais-Houthakker model than with others. The problems of adequately specifying prices with the usual cross section data limit the effectiveness of the more complex models.

One of the major problems in estimating scales is the identification problem. An income scale is needed to estimate scales for specific goods but an income scale can be obtained from a weighted average of the scales for specific goods. Additionally there are income measurement problems with the 1977-78 NFCS data. Roughly 30% of the sample failed to report income, and there were a number of households whose weekly value of food used multiplied by 52 exceeded their reported yearly income. Consequently, either yearly income is a poor indicator of permanent income or considerable non-market transactions are taking place. In either case yearly income is not an adequate measure.

In this study, the identification problem was overcome by controlling for "expenditure" quality of the diet instead of income. The basic concept underlying "expenditure" quality is that foods with high income elasticities are of high quality and those with low income elasticities are of low quality. The same concept applies to the elasticity which expresses the percentage change in expenditures of a specific food due to a one percent change in total food expenditures. The relationships between specific and total food expenditures were estimated for 39 food groups.[2] Age-sex composition and household size were held constant by including the numbers in various age-sex categories and the number of meal equivalent persons as regressors. Since there was a considerable number of nonusers of some products, the Tobit procedure was used. These estimates followed prior expectations. Elasticities ranged from a low of -.83 for dried vegetables to a high of 2.74 for shellfish. For further details see Price and Sharma, June, 1983.

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[2]These groups were different from those used elsewhere in this study.

For simplicity of estimation and conformity to the equivalent scale hypothesis, the double log form of the Prais-Houthakker model was used to estimate scales for the value of food for food used at home. The basic expression is:

$$\frac{E}{\Sigma c_j N_j} = a\ (EQ)^{b_1} \left(\frac{NM}{\Sigma N_j}\right)^{b_2} e^u \qquad (1)$$

where E is total food expenditures
c_j is the scale values for the jth age-sex type
N_j is the number of persons in the jth age-sex type
EQ is expenditure quality
NM is the number of meal equivalent persons
a, b_1 and b_2 are the usual coefficients to be estimated
e is the logarithmic constant
U is the error term

The equivalent scale hypothesis means that the only difference in the Engel curves for households of different size and composition are in the intercepts. If one holds household size and composition constant, the equality of the other elasticites can be tested. With equation 1, if $\Sigma c_j N_j$ and N_j are constants, taking logs yields

$$\log E = \log a' + b_1 \log EQ + b_2 \log NM + u \qquad (2)$$

Note that a´ absorbs the effects of N_j and $\Sigma c_j N_j$. Equation 2 was estimated for each of 26 household types. Within these types age-sex composition and household size were relatively constant. The results showed the elasticity for expenditure quality to be nearly constant among the 26 household types. Another analysis with income instead of expenditure quality showed no significant differences among the income elasticities. Some differences in the number of meal equivalent person elasticities did exist. These differences were not large, and for the sake of simplicity the elasticities were assumed to be equal.

Equation 2 provides estimates of b_1 and b_2 with very low standard errors since over 12,000 observations were used. The actual overall estimates were actually obtained from a weighted average of the elasticities for the individual household types. With accurate estimates of b_1 and b_2 equation (1) can be manipulated to isolate $\Sigma c_j N_j$ on the right hand side. That is,

$$E \left(\frac{1}{EQ}\right)^{b_1} \left(\frac{\Sigma N_j}{NM}\right)^{b_2} = (\Sigma c_j N_j) e^u \qquad (3)$$

The error term is multiplicative. The standard deviation of the error term will be proportional to the expected value of the dependent variable. It has been shown that for this case the variance of the dependent variable is proportional to the square of the expected value of the dependent variable (Price 1970). Therefore, each observation was weighted in inverse proportion to the size of the standard deviation of the dependent variable in equation 3 for the relevant household type.

Economies of scale in household food use can be conceptually specified by adding dummy variables to the right hand side of equation 3. This specification, however, fails to account for the fact that the actual size of a household depends on its age-sex composition. To account for this the dummy variables were replaced by a 0 - $\Sigma c_j N_j$ variable instead of the usual 0 - 1 specification. The c_j were obtained by estimating equation 3 without economies of size coefficients. This type of specification has the advantage of not imposing any prior restrictions on the household size-food use relationship. The right hand side of equation 3 thus becomes $\Sigma c_j N_j + D_i(\Sigma \hat{c}_j N_j)$, where D_i are dummy variables for household sizes of 1, 3, 4, 5, and 6 or more persons and the $\hat{c}_j$ are estimates of the food expenditure scale without the economies of scale coefficients. It should be noted that this specification of economies of scale differs from that used by Pollak and Wales, 1981, and by Brown and Johnson, 1984. These approaches add an additional variable for each age-sex type to express economies of scale. With the 15 age-sex types used in this analysis, 30 variables would result. The specification used in this study results in a total of 20 variables to be estimated.

Age-sex equivalent scales and the economies of scale estimates generally had low standard errors and met with prior expectations with respect to both sign and magnitude (Table 1, column 2). The economies of scale estimates enable one to calculate scales for other size households (Table 1, columns 1, 3, 4, 5, 6) using the male age 19-50 years in a two person household as the standard type. This calculation is readily done since the economies of scale coefficients express the change in the value of food used from the value for a two person household while holding age-sex composition constant. For example, the scale value for a female (19-50 years of age) in a one person household is simply (.846)(1.135) or .960.

Estimation of Scales for Specific Food Products

The basic model was modified in several ways to estimate scales for specific food products. By assuming separability, the quantity of a specific food item used per adult equivalent is a function of the total value of food used per adult equivalent. With the adjustment for the proportion of meals eaten at home, the basic model is:

$$\frac{Q_K}{\sum_j c_{Kj} N_j} = a \left(\frac{E}{\sum_j c_j N_j + \sum_i b_i D_i \Sigma c_j N_j} \right)^{b_1} \left(\frac{NM}{\Sigma N_j} \right)^{b_2} e^{u} \qquad (4)$$

where Q_K is the quantity of the Kth food item used, and

C_{Kj} is the scale value for the Kth food item and the jth age-sex type

With specific foods, additional control variables become important and were added to the model. They were region, zone, season, race, origin,

Table 1. Age-Sex Equivalent Scales and Economies of Scale Coefficients for the Total Value of Food Used at Home.

Age-Sex Category	Household Size: 1	2[a]	3	4	5	6+
1. Child (< 1 year)		.547	.495	.447	.409	.370
		(.037)				
2. Child (1-2 years)		.528	.478	.432	.394	.357
		(.028)				
3. Child (3-5 years)		.624	.565	.510	.465	.421
		(.024)				
4. Child (6-8 years)		.717	.648	.586	.534	.484
		(.025)				
5. Child (9-11 years)		.855	.774	.699	.637	.578
		(.027)				
6. Male (12-14 years)		.968	.876	.791	.721	.653
		(.035)				
7. Male (15-18 years)		1.113	1.007	.910	.829	.752
		(.032)				
8. Male (19-50 years)	1.135	1.000	.905	.817	.745	.675
		(.013)				
9. Male (51-64 years)	1.130	.996	.901	.814	.742	.672
		(.019)				
10. Male (65+ years)	.937	.826	.747	.675	.615	.557
		(.017)				
11. Female (12-14 years)		.883	.799	.722	.658	.569
		(.036)				
12. Female (15-18 years)		.854	.773	.698	.636	.576
		(.030)				
13. Female (19-50 years)	.960	.846	.766	.692	.630	.571
		(.018)				
14. Female (51-64 years)	.968	.853	.772	.697	.635	.576
		(.018)				
15. Female (65+ years)	.854	.753	.681	.615	.561	.508
		(.015)				
Household Size Coefficients						
Household Size = 1		.135				
		(.013)				
= 3		-.095				
		(.010)				
= 4		-.183				
		(.012)				
= 5		-.255				
		(.015)				
= 6+		-.325				
		(.016)				

[a] Standard errors are in parentheses.

and education. These are all dummy variables and were added to the right hand side of equation 4 with 1 - e values so that their logs were 0 - 1 variables. First stage estimates for b_1, b_2 and the coefficients for the above dummy variables were obtained by holding household size constant and taking logarithms of equation 4.

$$\log Q_K = a + b_1 \log E + b_2 \log NM + \sum_{K=3}^{14} b_K D_K + u \qquad (5)$$

where D_K are the 0 - 1 dummy variables specifying the effects of the added variables. For the sake of simplicity, household size was kept constant by estimating equation 5 for 7 sizes of households. From previous results, it was felt that this procedure would be sufficient to obtain relatively unbiased estimates of the b_K coefficients. Since the quantity of many specific food items used in a week includes a number of non-users, the Tobit procedure was used to estimate equation 5. Non-users also prevented taking the log of the dependent variable. Therefore, the semi-log form was used, and the resulting estimates were converted to elasticites by dividing them by the mean of the dependent variable.

Age-sex equivalent scales and economies of scale coefficients were estimated by isolating $\Sigma c_{Kj} N_j$ on the right hand side of the equation and adding the expression for economies of scale.

$$Q_K \left(\frac{\sum_j c_j N_j + b_i \sum_i D_i \Sigma \hat{c}_j N_j}{E} \right)^{b_1} \left(\frac{\Sigma N_j}{NM} \right)^{b_2} \prod_{K=3}^{14} \left(\frac{1}{D_K} \right)^{b_K} = \left(\sum_j c_{Kj} N_j + \sum_i b_i D_{Ki} \Sigma \hat{c}_j N_j \right) e^u \qquad (6)$$

where D_{Ki} are 1 - e dummy variables for the Kth specific food for household sizes of 1, 3, 4, 5 and 6 or more persons. The same procedure was used to correct for heteroscedasticity as was used for total food (equation 3).

The truncated variable problem suggests the use of the Tobit procedure to avoid bias. However, the Tobit estimates had much larger standard errors and did not conform to prior expectations with respect to sign and magnitude as well as the OLS estimates did. The regressors of equation 6 have some degree of multicollinearity. The results suggest that the Tobit is more sensitive to multicollinearity than is OLS. Therefore, only the OLS estimates are reported.

One check on the modifications to the estimation procedure for specific foods is to compare a weighted average of these scales to the scales for total food. For this purpose, scales and economies of scale coefficients were estimated for 26 groups using expenditures as the dependent variable. Mean expenditures were used as weights. The results show little difference in the resulting scales and economies of scale coefficients (Table 2).

An additional problem in estimating quantity scales is the unit of measurement for quantity. For homogenous foods pounds is an easily understood yet satisfactory measurement. However, due to varying amounts of

Table 2. Comparison of the Weighted Average Scales from 38 Food Groups With That Estimated from the Total Value of Food.

Age-Sex Category	Weighted Average of 26 Foods	Total Value of Food
1. Child (< 1 year)	.557	.547
2. Child (1-2 years)	.552	.528
3. Child (3-5 years)	.638	.624
4. Child (6-8 years)	.743	.717
5. Child (9-11 years)	.872	.855
6. Male (12-14 years)	.991	.968
7. Male (15-18 years)	1.118	1.113
8. Male (19-50 years)	1.000	1.000
9. Male (51-64 years)	1.018	.996
10. Male (65+ years)	.842	.826
11. Female (12-14 years)	.923	.883
12. Female (15-18 years)	.872	.854
13. Female (19-50 years)	.870	.846
14. Female (51-64 years)	.893	.853
15. Female (65+ years)	.796	.753
Household Size = 1	.093	.135
= 3	-.089	-.095
= 4	-.191	-.183
= 5	-.264	-.255
= 6+	-.339	-.325

concentration and dehydration within some food groups pounds is not always an appropriate unit of measurement. Other units of measurement used in this analysis to overcome this problem are pounds of fresh equivalent, the amount of energy in a food, and the amount of protein in a food (Table 3). The components of each food group were identified so that the most appropriate unit would be used. Fresh equivalent was used only where it was already calculated by the USDA.

The estimates of the scales and economies of scale coefficients are readily interpreted if some aspects of the procedures are kept in mind. First, because the scales were estimated from household data not all food use can be attributed to the specified age-sex category. The scales instead estimate the amount of food used if this particular category is in the household. Although not shown in these results, the classical example is the use of alcoholic beverages. This method of estimating scales will usually show a positive use for the child less than one year of age. This result stems from an increased use by parents with the addition of children to the household. Since almost all food items (Table 3) show a positive use for the child less than one year of age, some of this use could stem from increased intake by the parents resulting from increased physical activity with the advent of children.

Table 3. Quantity Scales for Selected Foods.

	Age-Sex Category	Fluid Milk	Cheese	Frozen Desserts	Table Fat	Fats & Oils	Break-fast Cereal	Flour & Prep. Mixes
1.	Child (< 1 year)	.987	.415	.182	.386	.466	1.274	.760
2.	Child (1-2 years)	1.169	.500	.429	.585	.510	1.136	.731
3.	Child (3-5 years)	.872	.661	.820	.654	.596	1.592	.820
4.	Child (6-8 years)	.856	.768	1.035	.792	.699	1.922	1.050
5.	Child (9-11 years)	1.192	.839	1.235	.885	.844	1.750	.977
6.	Male (12-14 years)	1.535	.904	1.579	1.050	.871	2.567	1.379
7.	Male (15-18 years)	1.763	1.205	1.787	1.117	1.002	1.661	1.509
8.	Male (19-50 years)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9.	Male (51-64 years)	.867	.960	1.108	.989	.781	1.273	1.031
10.	Male (65+ years)	.807	.797	1.326	.918	.601	1.404	1.161
11.	Female (12-14 years)	1.060	.869	1.624	.959	.884	1.654	1.336
12.	Female (15-18 years)	1.116	.968	1.440	.951	.948	1.290	1.506
13.	Female (19-50 years)	.703	1.030	.831	.811	.946	.783	1.254
14.	Female (51-64 years)	.681	.926	1.093	1.021	.910	.840	1.428
15.	Female (65+ years)	.652	.769	1.086	1.062	.701	1.202	1.407
	Household Size = 1	.136	.163	-.145	-.004	-.121	.131	-.621
	= 3	.055	-.153	.015	-.041	-.051	-.060	.035
	= 4	-.016	-.243	-.031	-.126	-.109	-.172	.089
	= 5	-.001	-.322	-.085	-.210	-.163	-.138	.066
	= 6+	-.073	-.488	-.262	-.313	-.244	-.251	.075
	Unit of Measurement	Pounds	Protein Content	Pounds	Pounds	Pounds	Pounds	Pounds

Table 3. Quantity Scales for Selected Foods, Continued.

Age-Sex Category	Bread & Rolls	Crackers Biscuits etc.	Desserts & Snacks	Ground Beef	Beef Steaks & Roasts	Pork (except bacon & sausage)	Luncheon Meats
1. Child (< 1 year)	.192	.401	.524	.353	.157	.217	.371
2. Child (1-2 years)	.456	.583	.845	.516	.356	.361	.655
3. Child (3-5 years)	.589	.832	1.022	.686	.436	.562	.804
4. Child (6-8 years)	.814	.989	1.199	.818	.565	.529	.672
5. Child (9-11 years)	1.070	.947	1.332	.908	.652	.708	.809
6. Male (12-14 years)	1.116	1.145	1.277	1.058	.752	.795	.831
7. Male (15-18 years)	1.335	1.319	1.500	1.103	.959	.997	1.095
8. Male (19-50 years)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9. Male (51-64 years)	.870	1.129	1.023	.723	1.209	1.216	.725
10. Male (65+ years)	.752	1.052	.904	.611	.813	.778	.607
11. Female (12-14 years)	.910	1.134	1.201	.911	.759	.664	.974
12. Female (15-18 years)	.871	1.065	.997	.890	.798	.634	.857
13. Female (19-50 years)	.600	.864	.751	.675	.756	.596	.474
14. Female (51-64 years)	.643	.999	.721	.645	.871	.752	.431
15. Female (65+ years)	.620	1.059	.667	.547	.661	.661	.253
Household Size = 1	.148	.127	.058	.033	-.266	-.158	.167
= 3	-.012	-.109	-.023	-.032	-.054	.054	.002
= 4	-.061	-.216	-.084	-.139	-.126	-.014	-.052
= 5	-.061	-.287	-.167	-.188	-.210	-.035	-.087
= 6+	-.080	-.419	-.396	-.262	-.292	-.164	-.117
Unit of Measurement	Energy Content	Energy Content	Energy Content	Protein Content	Protein Content	Protein Content	Pounds

Table 3. Quantity Scales for Selected Foods, Continued.

Age-Sex Category	Poultry	Eggs	Sugar	Other Sugar Products	Potatoes	Fresh Vege-tables	Canned Vege-tables
1. Child (< 1 year)	.295	.342	.733	.593	.463	.045	.997
2. Child (1-2 years)	.526	.566	.755	1.129	.559	.267	.755
3. Child (3-5 years)	.604	.706	.795	1.337	.603	.489	.885
4. Child (6-8 years)	.629	.647	1.187	1.579	.829	.617	.811
5. Child (9-11 years)	.776	.854	.859	1.523	.910	.796	.887
6. Male (12-14 years)	1.066	.848	1.295	1.674	.879	.946	.900
7. Male (15-18 years)	1.062	1.055	1.273	1.667	1.031	.986	.991
8. Male (19-50 years)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9. Male (51-64 years)	1.076	1.049	.741	1.100	.797	1.240	.822
10. Male (65+ years)	.759	.946	.759	1.102	.672	1.153	.595
11. Female (12-14 years)	1.077	.834	1.135	1.424	.825	.918	.983
12. Female (15-18 years)	.864	.829	1.010	1.322	.887	.762	.751
13. Female (19-50 years)	1.066	.804	.711	.865	.541	1.279	.681
14. Female (51-64 years)	1.171	.788	.851	.977	.620	1.632	.608
15. Female (65+ years)	1.143	.780	.827	1.044	.598	1.430	.601
Household Size = 1	.097	.254	-.224	-.020	-.021	-.029	.112
= 3	-.026	-.085	.035	-.084	.010	-.131	-.074
= 4	-.093	-.144	-.055	-.154	-.054	-.187	-.203
= 5	-.133	-.200	-.129	-.297	-.101	-.271	-.242
= 6+	-.230	-.212	-.121	-.435	-.161	-.333	-.341
Unit of Measurement	Protein Content	Fresh Eq.	Pounds	Energy Content	Fresh Eq.	Pounds	Pounds

Table 3. Quantity Scales for Selected Foods, Continued.

Age-Sex Category	Frozen Vege-tables	Fresh Fruit	Canned Fruit	Fruit & Vege-table Juices	Soft Drinks	Soups, Sauces, Mixt.	Nuts, Peanut Butter
1. Child (< 1 year)	.206	.344	5.850	.390	.614	1.652	-.041
2. Child (1-2 years)	.544	.575	1.761	.744	.596	1.184	.354
3. Child (3-5 years)	.281	.708	1.179	.823	.513	.932	.906
4. Child (6-8 years)	.794	.931	1.007	.711	.646	.898	1.221
5. Child (9-11 years)	.919	1.047	1.085	.863	.931	1.029	.971
6. Male (12-14 years)	.815	1.240	1.078	.886	.791	1.268	1.083
7. Male (15-18 years)	1.118	1.143	1.342	1.210	1.130	1.333	1.373
8. Male (19-50 years)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9. Male (51-64 years)	.744	1.446	1.281	1.029	.653	.695	.921
10. Male (65+ years)	.720	1.273	1.757	.892	.520	.640	.725
11. Female (12-14 years)	1.009	1.117	1.068	.944	.851	1.110	1.179
12. Female (15-18 years)	.948	1.111	.976	1.062	1.067	.807	.871
13. Female (19-50 years)	1.517	1.103	1.085	1.127	.878	.655	.784
14. Female (51-64 years)	1.435	1.421	1.240	1.085	.601	.357	.791
15. Female (65+ years)	1.156	1.472	1.723	1.087	.328	.378	.501
Household Size = 1	.197	.034	.004	.325	.057	.467	.101
= 3	-.150	-.180	-.076	-.147	.033	-.102	-.116
= 4	-.285	-.231	-.185	-.266	-.041	-.274	-.057
= 5	-.365	-.320	-.272	-.340	-.180	-.364	-.145
= 6+	-.640	-.415	-.500	-.452	-.336	-.474	-.223
Unit of Measurement	Pounds	Pounds	Pounds	Fresh Eq.Pounds	Pounds	Energy Content	Energy Content

A second aspect to note is that baby and junior food are distributed among various food items. Any baby or junior food mixtures are in the item titled "soups, sauces, and mixtures." This categorization helps explain the high consumption of this item by the young child.

The third aspect is the interpretation of the economies of scale coefficients. One generally expects more food waste by small households and, thus, generally declining coefficients as household size increases. This was the case for the value of total food (Table 1). There are two important differences between the coefficients for the total value of food and the coefficients for the quantity of specific foods. First, quantity does not include the effect of the higher prices paid by the smaller households. In another part of this study it was estimated (with the use of 213 food items to control for quality) that single person households pay 6 percent more for food than do four person households. Second, with total food it is doubtful that the actual food intake for the smaller households is greater than for the larger households. Therefore, the larger use is primarily due to a higher amount of edible discard. With specific foods it is possible that actual intake varies with household size. The most obvious is flour and prepared mixes (Table 3). The smaller size households apparently find it either less convenient or less economic to do their own baking. Therefore, with the quantity of specific foods, the economies of scale coefficients measure both 1) the decreasing amounts of edible discard with increasing household size, and 2) the differences in actual intake among households of different size.

Changes in the Age-Sex Equivalent Food Population Over Time and Projections to the Year 2000

In order to assess the effects of changes in the age-sex composition and household size on the demand for food, the number of adult equivalents in the U.S. population was estimated from 1960 to 1983 for the quantity of 28 specific foods and for total food expenditures. Using projected population, the number of adult equivalents were projected to the year 2000. Before discussing the results, the assumptions behind these estimates and projections and the data used to make them should be clarified.

First, these estimates and projections are for food used at home. They were made assuming the proportion of meals eaten at home is constant. They can be viewed as estimates and projections of the at home food market. All other variables affecting food use are also assumed to be constant. These include income, relative price, region, education, and tastes and preferences. The estimates are useful in showing the changes in food use which are due only to age-sex composition and household size.

An additional assumption is that the age-sex equivalent scales and the economies of scale coefficients are stable over time. Since persons of different age consume a different mix of foods, age-sex equivalent scales can change with changes in the relative prices of food. With respect to quantity, substitutions take place. Changes in packaging, and in the relative prices of different size packages, can cause changes in the economies of scale coefficients. Finally, changes in product development, availability, and quality can affect both age-sex equivalent scales and economies of scale.

Total food expenditure scales have been estimated for the 1955, the 1965, and the 1977-78 NFCS data by the author using the same method (Table 4). Food expenditure scales can change over time for any of the above reasons. Additionally, they can change with relative price changes even though no substitution among foods takes place.

It is difficult to determine if the changes which occurred are due to sampling error, changes in the survey instrument, or actual structural changes. The 1977-78 survey had more than twice as many observations as the 1955 survey, which produced the least reliable results both in terms

Table 4. Age-Sex Equivalent Scales: Comparisons Over Three Time Periods.

	Scale Values[a]		
Type of Individual	1955	1965	1977-78
Child (< 1 year)	.46 (.067)	.49 (.046)	.32 (.049)
Child (1-5 years)	.46 (.025)	.50 (.028)	.38 (.020)
Child (6-11 years)	.59 (.026)	.58 (.022)	.61 (.019)
Child (12-14 years)	.57 (.046)	.70 (.041)	.73 (.035)
Male (15-19 years)	.77 (.054)	.91 (.047)	.92 (.041)
Female (15-19 years)	.69 (.055)	.73 (.050)	.71 (.043)
First Two Adults (21+ years)	1.00 (.101)	1.00 (.008)	1.00 (.006)
Male (20+ years, other than first)	.70 (.067)	.89 (.061)	.99 (.043)
Female (20+ years other than first)	.60 (.060)	.65 (.060)	.80 (.043)

[a]Standard errors are in parentheses.

of standard errors of the scale and in conformity to prior expectations (the scale value for the child (12-14) was less than that for the child (6-11)). The largest differences between the 1965 and the 1977-78 scales occurred for the child less than 6 years of age and for the additional adults in the household. The latter is a heterogeneous type which consists primarily of either young adults or persons over 65 years of age. Thus, the composition of the additional adult group changes over time. The primary change over time is thus the scale value for the young child. There is no apparent explanation for this change.

The results of this analysis therefore fail to either confirm or disconfirm the argument that scales change substantially over time. The model specification in past studies was not as good as that used in the present study.

The data needed for these estimates and projections are 1) the numbers of persons in each of the 15 age-sex categories from 1960-2000 and 2) the number of households in each of the six household-size categories from 1960-2000. The first data requirement has been met by the Bureau of the Census estimates and projections of the U.S. population by age and sex (Series P-25, No. 952 and No. 917). The second data requirement has been met for the period 1960-1983 by the Bureau of the Census publication "Household and Family Characteristics" (Series P-20). However, no projections have been made for the period 1984-2000. The average size of household has been projected to the year 1995 by the Bureau of the Census (Series P-25, No. 805, May 1979). Series IC has had the most accurate predictions in recent years and was therefore used in this analysis.

With Bureau of the Census projections for household size and the number of persons in each age-sex category for the period 1983-2000 known, the number of households in each size category was projected by first regressing this variable with the appropriate explanatory variables over the 1960-1983 period. The number of persons in each household size category was hypothesized to be a function of household size, the number of males and females age 19-50, the number of children less than 19 years of age, and the number of females 65+ years of age. Including all these variables in a single regression results in severe multicollinearity. Therefore, only the two most relevant measures for the different size households was used in any one regression (Table 5). The results show very high R^2 values for all households but the 5 person household. No explanation for this lower R^2 was apparent. Five of the 7 household sizes had R^2 values of .99. Therefore, with the high degree of relationship between the variables projected by the Bureau of the Census and the number of households in each size category, it was concluded that this method was adequate to make projections of the number of households in each size category.

In order to make comparisons among the different food products, the adult equivalent populations were converted to indices with 1960 as the base year (Table 6). The comparison of greatest interest is the one with the total U.S. population which indicates the degree to which a per capita food use misspecifies the effects of age-sex composition and

Table 5. Regression Results for Predicting the Number of Households by Household Size.

Dependent Variable	Constant Term	House-hold Size	Males & Females (19-64)	No. of Children (<19)	No. of Females (65+)	R^2
	Digressors					
1. Number of Persons in a Single Person Household	4,533	-3,399 (1.78)			1.4747 (7.53)	.995
2. Number of Persons in a 2 Person Household	13,754	-5,315 (2.83)	.1928 (6.07)			.995
3. Number of Persons in a 3 person Household	5,864		.1086 (33.45)	-.09574 (5.52)		.990
4. Number of Persons in a 4 Person Household	7,664		.08501 (31.96)	-.09654 (6.79)		.989
5. Number of Persons in a 5 Person Household	2,896	3,77.6 (3.33)		.06371 (6.21)		.648
6. Number of Persons in a 6 Person Household	-5,521	754.0 (7.22)		.08889 (9.41)		.942
7. Number of Persons in a 7+ Person Household	71,484	1,898.1 (25.94)		.11793 (17.83)		.991

household size. Age-sex composition of the population and household size change slowly over time so that a per capita specification is quite accurate in the short run but the long run differences are substantial. There is little difference between the per capita and the adult equivalent indices over a five year period. However, between 1960 and 1980 the U.S. population increased by 26%, while the adult equivalent population for total food expenditures increased by 35%. The comparable projections to the year 2000 show a 48% increase in the total population but a 61% increase in the adult equivalent population.

The major source of the difference between the total population and the adult equivalent population is the decline in household size with the accompanying increase in food use due to economies of scale. Without the economies of scale, the increase in the total adult equivalent population for total food between 1960 and 2000 is projected to be 52%, a figure which is close to the 48% increase in the total population. There are offsetting changes which minimize the effects of age-sex composition. The proportion of children is declining while the proportion of persons over 65 is increasing. Total food expenditures are lower for both these groups than they are for adults less than 65 years of age.

Table 6. Indices of the Adult Equivalent Size of the U.S. Population 1960-2000.

	1 Fluid Milk	2 Cheese	3 Frozen Desserts	4 Table Fat	5 Other Fats & Oils	6 Breakfast Cereals	7 Flour & Prepared Mixes	8 Bread & Rolls
1960	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1965	108.7	108.7	109.0	108.4	107.9	108.9	107.5	109.2
1970	114.7	117.3	115.2	116.0	115.1	114.3	113.3	116.7
1975	120.8	127.2	123.3	124.3	122.8	119.4	118.4	124.0
1980	126.6	137.1	128.7	132.4	130.4	123.8	122.7	130.7
1985	131.4	144.4	132.8	138.7	136.5	128.4	126.8	135.9
1990	136.9	151.7	137.8	145.0	142.4	134.4	130.8	142.2
1995	142.6	158.3	144.0	151.3	147.9	140.7	135.6	148.7
2000	147.2	164.0	149.9	157.2	152.9	145.2	140.7	154.1

	9 Crackers, Biscuits, etc.	10 Desserts & Snacks	11 Beef Ground Beef	12 Steaks & Roasts	13 Pork(Excl. Bacon & Sausage)	14 Luncheon Meats	15 Poultry	16 Eggs
1960	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1965	108.9	108.5	108.5	107.6	107.6	108.6	108.3	108.8
1970	116.8	114.9	115.7	115.2	114.6	115.1	116.6	116.7
1975	125.5	121.5	123.4	123.4	122.1	122.2	125.5	125.7
1980	133.8	127.9	130.6	131.0	129.0	129.0	134.1	134.8
1985	140.2	133.0	136.5	136.7	134.6	134.9	141.0	141.9
1990	147.0	139.1	142.9	141.9	139.9	141.1	147.5	149.3
1995	153.7	145.0	148.8	147.5	145.5	147.0	154.0	156.0
2000	159.7	149.8	153.6	154.0	151.7	151.5	160.1	161.8

	17 Sugar	18 Sugar Products	19 Potatoes	20 Fresh Vegetables	21 Canned Vegetables	22 Frozen Vegetables	23 Fresh Fruit	24 Canned Fruit
1960	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1965	107.9	108.7	108.3	108.3	108.1	108.6	108.7	106.4
1970	113.6	114.6	114.9	117.4	114.6	118.5	117.0	111.0
1975	119.1	120.7	121.7	127.2	122.2	129.7	125.9	117.2
1980	124.1	126.2	128.4	136.8	130.2	141.4	134.5	125.7
1985	129.0	131.1	133.8	144.1	137.1	149.6	140.9	132.7
1990	134.0	137.0	139.8	151.0	143.9	157.6	147.7	139.1
1995	139.3	142.9	145.5	157.8	149.8	164.4	154.6	144.0
2000	143.8	147.7	150.4	164.8	154.3	170.4	161.4	148.4

	25 Fruit & Vegetable Juice	26 Soft Drinks	27 Soups, Sauces, Mixtures	28 Nuts, P. Butter	Total Food Expends.	Total Food Exp. with HH size Constant	Total Population
1960	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1965	109.0	108.0	108.8	109.0	108.7	108.1	107.7
1970	117.4	115.5	115.4	116.1	116.7	115.1	113.5
1975	127.7	123.8	123.8	123.3	125.8	122.0	119.5
1980	138.1	132.3	133.0	129.7	134.8	128.8	126.0
1985	145.9	138.5	140.5	135.2	141.7	134.5	132.1
1990	153.7	144.8	148.3	141.4	148.6	140.4	138.2
1995	160.6	150.2	154.6	147.7	155.1	146.2	143.7
2000	166.5	154.7	158.5	152.8	160.9	151.6	148.3

Among some food items a per capita food use is even more misleading than for total food (Table 6). The items which show the highest increase over time are generally those used most heavily by the small households. These include cheese, poultry, eggs, fresh vegetables, frozen vegetables, fresh fruit, and fruit and vegetable juice. The two items with the lowest increase, sugar and flour and prepared mixes, are associated with home baking. The results therefore show an increase in the demand for convenience foods which is due only to declines in household size. Food items used heavily by children obviously show a slower increase in demand than others. Three examples of these are fluid milk, frozen desserts, and breakfast cereals. Two offsetting factors are responsible for the fact that increases in the adult equivalent population of these products are similar to the increase in the total population. Demand increases as the number of children declines, but demand increases because of the increase in edible discard as household size declines.

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