ESTIMATING THE EFFECT OF HOUSEHOLD AGE-SEX COMPOSITION ON FOOD EXPENDITURES

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The effects of variation in household age-sex composition on food expenditures are not, conventionally, accounted for when food expenditures are expressed on a per capita basis. Because households differ in physical makeup as well as in their ability to generate income, the specific requirements certain household members place on the family budget raise the problem of determing their relative economic position. The per capita approach fails to reflect the effect of variations in household composition on food expenditures. Therefore, it is desirable to isolate the normal food expenditure relation to the "household-specific" effects.

Two different procedures have been used to derive a measure that can specify these effects. One is developed on the basis of nutritional requirements and the other is empirically estimated. The U. S. Department of Agriculture's family food plans provide scales formulated to meet the Recommended Dietary Allowance for Nutritional Needs for family members [8, pp. 3-12]. These estimates are based on the nutrients a consumer should ingest and not on the foods a consumer actually purchases in the market. Alternatively, approaches to estimating economic behavioral equivalence scales for family members have been studied. Behaviorally determined weights have been computed with British data by Prais and Houthakker [4] and by Brown [1]. Price [5, 6] also has estimated unit equivalent scales, based on urban U. S. data, for total food and for some specific food commodities.

The authors examine the effect of demographic characteristics on food expenditure for a group of households that participated in a survey conducted in 1974-1975 in Griffin, Georgia [7]. In particular, emphasis is placed on the separation of the income effect from household composition in determining food expenditure.

The primary objective of this study is to estimate adult equivalent scales from the relationship of food expenditures to household age-sex composition. Adult equivalent scales are useful in a variety of applications. Comparisons of the household food consumption levels can be made more accurate by use of the scales to isolate the effects of differences in demographic composition. In addition, the scales can be used to adjust for changes in the composition of population over time which normally are not accounted for with the per capita specification. The added information can be of value for policy and forecasting purposes and to empirically minded economists examining the economics of household food consumption behavior.

The Model Formulation

The theoretical model postulated is based on the same expenditure-income relationship formulated and developed by Prais and Houthakker [4]. The model for the Engel relation assumes that food expenditures per adult equivalent are a function of income per adult equivalent. That is,

$$(1)\quad E/\sum_i e_i N_i = f(M/\sum_i m_i N_i), \quad i = 1,2,\ldots, k$$

where

E = household expenditures on a particular commodity
M = disposable income per household
e_i = the adult equivalent scale for the particular commodity of the i^{th} age-sex category
N_i = the number of persons in the i^{th} age-sex category per household
m_i = the adult equivalent scale for income of the i^{th} age-sex category.

The commodity scale, e_i, and the income scale, m_i, in equation 1 are generally unknown and are the parameters to be determined. Prais and Houthakker assumed that the income scales were equal to one for all age-sex cate-

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gories. Furthermore, the functional form of equation 1 needs to be specified if the unknown parameters of N_i are to be estimated empirically. If the double-log form is assumed, the Engel relation can be shown as:

$$(2) \quad E/\sum_i e_iN_i = a(M/\sum_i m_iN_i)^b, \qquad i = 1,2,\ldots, k.$$

Because the scales, e_i, would absorb the effect of variation in household size, the constant term, a, would not vary with household size. Prais and Houthakker, however, assumed the income elasticity, b, to be constant among households of different size and composition.

The hypothesis that income elasticity is constant among households of varying size and composition was tested by Price [5]. Using U.S. data, Price found that there is a significant difference among the income elasticities across household types. To incorporate his findings in computing the expenditure scales, Price refined the basic model by allowing for varying income elasticities for different household types. Upon manipulation, equation 2 for a specific household type j can be written as:

$$(3) \quad E_j = a_j{*}M_j^{b_j}, \text{ and } a_j{*} = a_je_{kj}/(m_{kj})^{b_j}, \quad j = 1,2,\ldots,s$$

where

$e_{kj} = (\sum_i e_iN_i)_j$

$m_{kj} = (\sum_i m_iN_i)_j$

b_j = the income elasticity of the household type j.

Income elasticities can be estimated independently of the scale parameters from equation 3, with household size and composition held constant. Household food expenditures then are adjusted for differences in levels of household income. By allowing for income effects for household types, one can rewrite equation 2 to show that the adjusted food expenditure is a linear function of family composition. Thus,

$$(4) \quad E(1/a_j)(\sum m_iN_i/M)^{b_i} = \sum_i e_iN_i, \quad i = 1,2,\ldots, k, \text{ and } j = 1,2,\ldots, s.$$

The ordinary least squares procedure is used to estimate the income elasticities for different types of household from equation 3. The estimated income elasticities, b_j's, and constant terms, a_j's, than are used to adjust the total food expenditure, E, and form the dependent variable, Y, for equation 5:[1]

$$(5) \quad Y = \beta_1N_1+\beta_2N_2+\ldots+\beta_kN_k.$$

The ordinary least squares procedure is applied to equation 5 to estimate the effects of household age-sex composition on adjusted food expenditures. The regression coefficient of the standard age-sex category, N_1, then is used to compute the desired scales of e_i's in equation 4.

The Data and Procedure

To hold household composition approximately constant, a considerable number of household types are needed for a representative sample of the population. Because of the variability of cross-section data, a relative large sample is required to obtain reliable estimates of the parameters. These data requirements are met with the initial master sample surveys used to establish the Griffin Consumer Panel.[2]

The surveys were random samples of households in Griffin, Georgia stratified by geographic area of the city. Data on the age and sex of each member of each household, total weekly household food expenditures, and household income were collected from the survey.[3] Other information such as level of education of household head, number of household members employed, and household practices of food purchases also was recorded.

Table 1 shows the basic characteristics of the data sample used in the regression analysis of this study. The size of family in the sample data ranged from a one-person household to an 11-person household and averaged 3.32 per-

[1]In practice, $a_j{*}$'s were used in equation 4 instead of a_j's. It is assumed that the ratio, $e_{kj}/(m_{kj})^{b_j}$, is approximate to one within each household type. For e_{kj} and $(m_{kj})^{b_j}$ to remain approximately the same within a specific household type, m_{kj} would have to be much greater than e_{kj} because the b_j's are normally assumed to be less than one. Presumably, m_{kj} should be less than e_{kj} because the differences in expenditure between children and adults are likely to be much greater for many nonfood than for food commodities and likewise for economies of household size. In the study m_{kj} is assumed to be equal to the number of persons in the household and, therefore, can be assumed to be greater than e_{kj}.

[2]For the procedure and summary of survey results, see Raunikar [7].

[3]A total of 1,760 questionnaires were collected in the master sample surveys. However, only 1,116 households provided complete information on food expenditures and household income. Moreover, 126 households were eliminated from the sample. Of these, 14 households had income over $30,000 per year and 112 reported annual income of less than $2,000. The decision to focus the analysis on the households with income greater than $2,000 and less than $30,000 rather than on the entire span of income distribution is based on two considerations. First, the households that failed to provide complete information on food expenditures and income accounted for about 37 percent of the survey sample. Most of these households were believed to be households with income either at extreme high or low levels. Thus, the useable data set is probably not a good representative sample of population in terms of the distribution of income levels. Second, it is theoretically and empirically justified to obtain and analyze information pertinent to given characteristics, such as households consisting only of old age pensioners. In the present analysis, the primary interest is directed toward the determination of the consumption patterns for the households within the given income range. Nevertheless, the limitations of the data sample must be kept in mind.

TABLE 1. MEAN VALUES AND STANDARD DEVIATIONS OF HOUSEHOLD SIZE, COMPOSITION, FOOD EXPENDITURE, AND INCOME, GRIFFIN CONSUMER PANEL, GRIFFIN, GEORGIA 1974-1975

Household characteristics[a]	Mean value	Standard deviation
Male adults (18+)	0.85	0.57
Female adults (18+)	1.14	0.46
Male children (11-18)	0.28	0.67
Female children (11-18)	0.27	0.62
Male children (6-10)	0.18	0.46
Female children (6-10)	0.16	0.46
Children (2-5)	0.31	0.65
Children (<2)	0.14	0.38
No. of persons per household	3.32	1.87
Weekly feed expenditure ($)	35.76	15.18
Annual household income ($)	9,054.51	6,301.46
No. of households in the sample	990	

[a]Ages are given in parentheses.

sons per household. Female adults accounted for about 57.4 percent of total adults in the sample. Average weekly food expenditure and annual income for all households in the sample were $35.76 and $9,054.51, respectively.

The basic procedure used in this study involved estimating the Engel relationships of equation 3 by partitioning the sample with household composition held approximately constant. Six household types were established for the study.[4]

The number of observations within each type ranged from 89 to 332 households for household types that averaged 3.82 and 2.24 persons, respectively (Table 2). The minimum number of persons in each household type ranged from one to four and the average size of each household type ranged from one to six persons.

Various forms of the Engel relationship have been investigated; nevertheless, no single representation has been generally accepted [2, 3]. In this analysis, a double-log function was selected as the hypothesized form for the Engel curve.[5] Of particular interest in testing the results obtained from the Engel relations are the equality of the residual variances and the equality of the income coefficients obtained for the different types of household.

Bartlett's test shows that there are significant differences among the residual variances at the .01 level.[6] Moreover, the residual variances are found to be correlated negatively with family size.

Results of a covariance analysis for equality of the income coefficients show that the difference among the income coefficients is not significant at the .01 level but is significant at the .05 level.[7] The results from the estimated Engel relations show that elasticities are, in general, higher for small and low income households than for large and high income households. The findings of this analysis are in accord with those of Price, who used urban U.S. data [5, 6].

With the estimation of an appropriate Engel curve and income elasticity for each household type (Table 2), total food expenditures can be adjusted accordingly for income effects. Multiple regression analysis was applied to equation 5. The adjusted food expenditures formed the dependent variable and the number of individuals in each family who were in the various age-sex categories constituted the set of independent variables.

The Adult Equivalent Scales

In computation of the scale values, two different models were used. If no significant differences in income elasticities are present among household types, the income effects on food expenditures can be removed by the use of a single income elasticity. If differences are

TABLE 2. MEAN VALUES AND STANDARD DEVIATIONS OF HOUSEHOLD SIZE, AND ESTIMATED INCOME ELASTICITIES BY HOUSEHOLD TYPE, GRIFFIN CONSUMER PANEL, GRIFFIN, GEORGIA 1974-1975

Household type	Household size		Estimated income elasticity	Number of households
	Mean	Standard deviation		
Single Adult (18+)	1.00		0.29	117
All Adults (18+)	2.24	0.53	0.18	332
Adults and Children (6-)	3.52	0.74	0.10	125
Single Adult and Children (18-)	3.82	1.80	0.09	89
Adults and Children (6-18)	4.49	1.36	0.11	209
Adults and Children (18-)	6.03	1.89	0.06	118
All Households	3.32	1.87	0.15	990

[4]The criteria used in the formation of different household types were such that (1) a sufficient degree of homogeneity was present for households included in each type and (2) the number of observations was large enough for reliable statistical results.

[5]Experiments with other functional forms, including semilog and inverse functions, showed that the variability in estimated income coefficients and standard error of estimates among different household types generally was substantially lower for the double-log function than other functional forms. However, there was some indication that the inverse function may yield better results for relatively large households.

[6]The computed χ^2 value was 34.338 compared with a χ^2_5 of 15.086 at the .01 significance level.

[7]The computed F-value was 2.26 compared with the $F_{5,\infty,.01}=3.02$, or $F_{5,\infty,.05}=2.21$.

present, the appropriate way to compute the scales is to use an income elasticity for each type of household. The former is referred to as constant elasticity model and the latter as a variable elasticity model. To obtain more efficient estimates, food expenditures of a particular household type were weighted in inverse proportion to the size of its standard error of estimates. Both weighted and unweighted results were derived for constant and variable elasticity models. The use of different models makes it possible to observe the effects that the various adjustments on the food expenditures have on the scales. The results are presented in Table 3.

TABLE 3. ESTIMATES OF THE EQUIVALENT SCALES SHOWING AGE-SEX DIFFERENCES FOR TOTAL FOOD EXPENDITURES[a]

Age-sex type	No. of persons	Constant elasticity Model I unweighted	Constant elasticity Model IA weighted	Variable elasticity Model II unweighted	Variable elasticity Model IIA weighted
Male adults	838	1.0000 (0.0510)	1.0000 (0.0481)	1.0000 (0.0606)	1.0000 (0.0574)
Female adults	1131	1.2569 (0.0465)	1.1724 (0.0439)	1.3058 (0.0552)	1.1951 (0.0523)
Male, 11-18	280	0.4779 (0.0527)	0.4951 (0.0498)	0.6635 (0.0627)	0.6688 (0.0594)
Female, 11-18	265	0.3258 (0.0585)	0.3478 (0.0552)	0.5573 (0.0695)	0.5686 (0.0658)
Male, 6-10	174	0.4635 (0.0757)	0.4888 (0.0714)	0.7853 (0.0899)	0.7991 (0.0851)
Female, 6-10	157	0.5530 (0.0757)	0.5624 (0.0715)	0.9114 (0.0900)	0.9076 (0.0852)
Child, 2-5	307	0.3538 (0.0542)	0.4031 (0.0512)	0.7684 (0.0645)	0.8109 (0.0611)
Child, under 2	139	0.1835[b] (0.0908)	0.2341 (0.0858)	0.5180 (0.1080)	0.5641 (0.1023)
R^2		0.17	0.28	0.37	0.45

[a]Equation 5 was estimated with ordinary least squares. The regression coefficient of the standard age-sex category, male adults, was then divided into each regression coefficient to obtain the equivalent scales. For each scale value, the respective standard error is shown beneath in the parentheses. All the estimated scales are significantly different from zero at less than the .01 level, unless specified otherwise.

[b]Significantly different from zero at less than the .05 level.

The results obtained from the weighted models indicate higher scale values for each type of person except female adults in Models IA and IIA and female children 6-10 in Model IIA. The standard errors of the weighted models are lower than those of unweighted models. Thus, the weighting procedure generally increased the efficiency of the estimated parameters in each age-sex category. The change from models with constant elasticity to models with variable elasticity also had the effect of increasing scale values. More specifically, the differences in the change of scale values tended to be greater for younger children than for older children. The variation in the value of scales was reduced substantially by using variable income elasticity models.

The results of this analysis lend additional support to the use of variable income elasticity models for estimating equivalent scales. As previously indicated, income elasticities were found to be different among household types and tended to be correlated negatively with the size of household. Failure to account for these different elasticities will lead to biased estimates of the scale values. With respect to the present study, the results are obvious that the constant elasticity model tends to yield much lower scale values for younger children than for other age-sex categories. The outcome is reasonable because one would expect, *a priori*, that children are the type of persons who tend to be present in large households; thus, their scale values would tend to be underestimated if differences in income elasticities were not taken into consideration in the computation of scale values. The degree of underestimate is proportional to the differences in income elasticities among household types.

The results in Table 3 show how an increase of an extra person of a particular type in the household would affect food expenditures in comparison with the addition of a person of the standard type, an adult male. However, it is desirable to go a step further to ascertain the relative importance of the scale values between household members. Statistical tests were performed to determine whether the coefficients were significantly different from each other in addition to the test for statistical significance of the individual coefficient.

The results of the analysis indicate that the scale values of an adult male and an adult female are not significantly different from each other at the .05 significance level.[8] The scale values for children are significantly different from those of adults, except those for adult male and female children 6-10 years old. The scale values for female children 11-18 years old are found to be significantly different from those of children 6-10 and 2-5 years old. No significant differences are found between children 6-10 and children 2-5 years old. However, the scale values do differ significantly between children 6-10 years old and children less than 2 years old.

In general, the results suggest that the age of a particular type of person is a more impor-

[8]Unless otherwise specified, the null hypothesis about the equality of coefficients is tested against a two-sided alternative at the .05 significance level.

tant factor in determining the scale values than sex. Significant differences were consistently detected among different age groups. The finding that the scale value for children generally increases up to the age of eleven indicates that children represent a slightly smaller proportion for the family food budget than adults. Nevertheless, males and females of the same age group generally are found to account for about the same proportion of the household food expenditures. The scale values do not appear to be significantly different between the sexes.

Direct comparisons with earlier investigations would be desirable, but it is only possible to evaluate the results on the basis of their similarity to other findings. Regardless of the method of estimation or the data base, the scales obtained from this analysis appear to be very similar and comparable to those of previous studies.[9] This stability is important. If the magnitude of the scales is somewhat invariant to the estimation method and sample data, such scales will be useful and applicable to other data sets and will be of value for policy decisions.

Conclusion

Food expenditure per adult equivalent is a more precise measurement than food expenditure per capita or per household. Adult equivalent scales were estimated for a group of households that were surveyed in the initial phase of establishing a consumer panel in Griffin, Georgia. The scales were estimated to show the effects of variations in age and sex on food expenditures.

The estimated expenditure scales were acceptable with respect to a few simple criteria. The scale values were all positive and generally increased as the age of the child increased. Moreover, the scales for the youngest children were substantially lower than those of the adults. In general, the results indicate that in the sample investigated the cost of feeding a child is about 70 percent that of feeding an adult. The proportion of food expenditures to be attributed to differences between the sexes is less variable than that attributable to age differences. The scales computed in this study, however, do not account for variations in food expenditures due to age differences among adults.

Many factors and variables that may affect the relationship of the demographic variables of age and sex to food expenditures, such as eating away from home, also are not considered. Apparently the factor of away from home eating may have some effects on the scale values. The finding that female adults have a slightly higher scale value than male adults may indicate that adult males are eating away from home more frequently. A similar situation is found for children aged 2-5 versus children aged 11-18. Adolescents probably eat away from home more often than preschool children. Nevertheless, evidence is not sufficient to judge these effects as statistically significant. The authors believe that in this analysis the effect of away-from-home eating can be expected to be small and does not appear to be a constraint on the usefulness of the resulting scales.

The scales computed in this analysis have proved to be a successful application of the methodology developed by Prais and Houthakker, and Price. An almost direct application of the results of this study to any specific food commodity expenditure should be possible. In terms of their relationship to household composition and income, expenditures for many food commodities should not be substantially different from total food expenditure.

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