Regional Equivalence Scales for Convenience Foods

John R. Tedford, Oral Capps, Jr. and Joseph Havlicek, Jr.

Estimates of regional adult equivalence scales for convenience foods were obtained using the model developed by Buse and Salathe and using data from the 1977–78 Nationwide Food Consumption Survey. Wide disparities exist in scale values among regions, controlling for other factors, suggesting that age-sex composition of households have differential impacts on convenience food expenditures.

Introduction

Over the past few decades an increasing number of convenience food products have appeared in U.S. markets. Little is known about the factors that affect the expenditure patterns of such foods. The purpose of this paper are to present: (1) empirical estimates for adult equivalence scales and test results for composite hypotheses about the effects of age and sex composition on convenience food expenditures, and (2) graphic profiles illustrating the life cycle pattern of adult scales for male and female household members.

Information about commodity specific adult equivalence scales is important because, as Deaton and Muellbauer (1980) show, it is one way of modeling differences in consumer behavior attributable to size, age composition and other household characteristics. As McClements (1977) indicates the relationship between consumption and household composition is central to the emerging literature on the economics of fertility. Differences in household characteristics have been and will continue to be an integral part in the study of such example problem areas as poverty, income distribution, the incidence of taxation, and public assistance programs because differences in household circumstances lead to different expenditure patterns. Since convenience foods have emerged as an important component of the food industry, it is important that empirical estimates be obtained for equivalence scales for expenditures on convenience foods.

The authors are, respectively, Associate Professor of Economics, Clarkson College of Technology; Assistant Professor of Agricultural Economics and Statistics, Virginia Polytechnic Institute; and Professor and Chairman of Agricultural and Resource Economics, University of Maryland.

This work was sponsored by the Consumer Nutrition Division, U.S. Department of Agriculture, under contract No. 53-32U4-1-215.

Definition of Convenience Foods

Traub and Odland (1976) defined convenience foods as "any fully or partially prepared food in which significant preparation time, culinary skills, or energy input have been transferred from the homemaker's kitchen to the food processor and/or distributor." In this study convenience foods consist only of those items falling in the complex convenience food class. That is, as defined elsewhere (Tedford, Capps and Havlicek, 1983), three convenience food classes—namely basic convenience, complex convenience, and manufactured convenience—were established because of the broad range of heterogenous food items encompassed in Traub and Odland's definition. The important characteristic of foods contained in the basic convenience food class is that processing is performed primarily for preservation purposes. The important characteristic of the manufactured convenience food class is that these items do not have home-prepared counterparts. The complex convenience class consists of those food items that the layman normally thinks of as a convenience food. This class consists of items which have high levels of time savings and/or energy inputs, require culinary expertise, and/or consist of multi-ingredient prepared mixtures. Some examples are frozen vegetable mixtures, frozen and canned entrees, frozen desserts, pudding mixes, ready-to-eat cookies, cakes, bread, rolls, and canned soups.

Equivalence Scale Models

Equivalence scales are measures designed to capture the impacts of individual household members on the household's expenditures for food. A number of models and procedures have been used to obtain empirical estimates of equivalence scales (Prais and Houthakker, 1955; Barten, 1964; Cramer, 1969; Price, 1970; Seneca and Taussig, 1971; Meullbauer, 1974, 1975, 1979, 1980; Blokland, 1976; McClements, 1977; Buse and Salathe, 1978). The Prais-Houthakker model in which expenditures per adult equivalent are expressed as a function of income per adult equivalent has been commonly used. This model, however, has a number of limitations (Blokland; Buse and Salathe; Muellbauer, 1980). Two of the limitations are: (1) the age-class specifications yield stepwise discrete scale values which due to lack of regularity and smoothness may show wide leaps and bounds between adjacent classes, and (2) socio-demographic factors that may be important explanatory variables are excluded. The Buse-Salathe model was used in this study since it avoids these limitations.

Similar to Blokland's (1976) arguments, Buse and Salathe use cubic spline functions to specify adult equivalence scales as continuous functions of age for individual male and female household members. Restrictions are imposed to reflect the way a particular member affects the household's expenditures at various ages of their life cycle from birth to death. Highlights of the functional forms and important properties underlying Buse and Salathe's model specifications are presented in Table 1. A male household member between the ages of 20 and 55 is treated as the standard member and assigned a weight of one. The equivalence scale for other members depends upon the values of one or more of the scale parameters ϵ, γ, δ, ζ, μ, or ν. The parameter ϵ indicates the relative contribution of a newborn male or female child. The scale for an adult female (defined to be 20 to 55 years of age) is given by the parameter γ. The parameters μ and ν indicate the impact that an elderly adult male or an elderly adult female (75 years or older) will have on the household's equivalence scale. Finally, δ and ζ are coefficients of the cubic functions associated with the childhood years.

Consumption by individual household members is not measured directly but must be inferred or imputed. While the 1977–78 Nationwide Food Consumption Survey (NFCS), the source of data for this study, provided the age and sex of each household member, expenditures and other data were reported only for the household unit. Therefore, the adult scale parameters have to be obtained indirectly by estimating household equivalence scales.

Household equivalence scales are aggre-

Table 1. Adult Equivalence Scale Parameters and Relationships Underlying Buse and Salathe's Model[a]

Age-Sex Class	Sex (s_j)	Age (a_j)	Adult Equivalence Scale $S(a_j,s_j)$
n_1	$s_j = 1$	$a_j = 0$	$S(0,1) = \epsilon$
	$s_j = 1$	$0 < a_j < 20$	$S(a_j,1) = \epsilon + \delta{*}a_j + [.0075{*}(1 - \epsilon) - .1{*}\delta]{*}a_j^2 - [.00025{*}(1 - \epsilon) - (.0025{*}\delta)]{*}a_j^3$
n_2	$s_j = 1$	$20 \le a_j \le 55$	$S(a_j,1) = 1.$
n_3	$s_j = 1$	$55 < a_j \le 75$	$S(a_j,1) = 1. + [.0075{*}(\mu - 1){*}(a_j - 55)^2] + [.00025{*}(1 - \mu){*}(a_j - 55)^3]$
n_4	$s_j = 1$	$a_j > 75$	$S(a_j,1) = \mu$
n_5	$s_j = 2$	$a_j = 0$	$S(0,2) = \epsilon$
	$s_j = 2$	$0 < a_j < 20$	$S(a_j,2) = \epsilon + \zeta{*}a_j + [.0075{*}(\gamma - \epsilon) - .1{*}\zeta]{*}a_j^2 - [.00025{*}(\gamma - \epsilon) - (.0025{*}\zeta)]{*}a_j^3$
n_6	$s_j = 2$	$20 \le a_j \le 55$	$S(a_j,2) = \gamma$
n_7	$s_j = 2$	$55 < a_j \le 75$	$S(a_j,2) = \gamma + [.0075{*}(\nu - \gamma){*}(a_j - 55)^2] - [.00025{*}(\nu - \gamma){*}(a_j - 55)^3]$
n_8	$s_j = 2$	$a_j > 75$	$S(a_j,2) = \nu$

[a] Buse-Salathe define the standard household member as a male ranging in age from 20 to 55 years who is assigned a scale value of one. Sex of the member is represented by s_j with $s_j = 1$ if a male and $s_j = 2$ if a female. The life cycle, from birth to death (0 to 84 years), for each sex is obtained by splicing together the relevant parameters and relationships. The life cycle pattern for males is obtained from age-sex classes n_1 through n_4 whereas the female pattern is generated from classes n_5 through n_8.

gates of the adult scales and may be expressed as explicit functions of the adult scale parameters for households in the i^{th} region by:

$$(1) \quad KH_i = P + \gamma_i Q + \epsilon_i R + \delta_i S + \zeta_i T + \mu_i U + \nu_i V.$$

The variable KH_i is the equivalence scale for a household in the i^{th} region and γ_i, ϵ_i, δ_i, ζ_i, μ_i, and ν_i are the adult scale parameters defined earlier. P, Q, R, S, T, U, and V are weighted sum variables which depend upon the number and ages of members comprising the household unit and are computed from the NFCS survey data. By including household equivalence scale specifications in the Engel functions, it is possible to obtain statistical estimates and perform tests of hypothesis about adult scale parameters.

Data and Estimation Procedures

Weekly expenditure data (i.e. the money value of foods used at home as recorded for each household) in the 1977–78 Nationwide Food Consumption Survey (NFCS) are used in this study. The data permitted computation of the weighted sum variables P, Q, R, S, T, U and V needed to generate the household equivalence scales. Of the households surveyed, 12,750 were usable, of which 3,066 were located in the Northeast, 3,265 in the North central, 4,399 in the South, and 2,020 in the West. Estimates for the United States were obtained by aggregating over the regional estimates under the assumption that the regional sub-samples are independent.

The household equivalence scale, KH_i, and selected sociodemographic variables are included in the expenditure functions for each region as follows:

$$(2) \quad E_i = f_i(M, D, A, B, C, Y, KH_i, B.KH_i, C.KH_i, Y.KH_i, KH_i^2, B.KH_i^2, C.KH_i^2, Y.KH_i^2)$$

E_i is the i^{th} regional household's weekly expenditure, M represents the employment status of the female household head, D the educational status of the female head, A identifies the preparer of food in the household, B refers to the residential location of the household, C the race of the household respondent and Y, the annual income status of the household. The variables M, D, and A are introduced as intercept shifters and the variables B, C, and Y are included as intercept and slope shifters. The square of the household equivalence scale variable and its interaction with B, C, and Y are introduced to account for the possible existence of economies of size (Price, 1970; Buse-Salathe, 1978). In constructing the adult equivalence scales for convenience foods, the socio-demographic factors are controlled.

Estimates of the parameters of the household equivalence scale are constrained to be equal both for KH_i and KH_i^2, which requires use of a nonlinear estimation procedure. A nonlinear regression algorithm using Marquardt's compromise (Draper and Smith, 1966) was used to estimate the parameters of Engel curves for each region.

Empirical Results

Regional and nationwide estimates of adult scale parameters are presented in Table 2. Estimates for all scale parameters show wide differences in magnitude among regions. For example, the contributions of an adult female to a household's expenditures range from a low of 50 percent of the standard male's contribution in the West to a high of 1.07, seven percent above the standard male's imputed value, in the North central.

As expected, the scale parameter for children at birth (ϵ) was found to be significantly different from one for each region except the North central. In the South and North central the weights estimated for newborn children were subsequently larger than those in the Northeast and the West.

In each region the contributions of both the elderly male (μ) and female (ν) are significantly less than that of the standard male. Except for the Northeast, the weights estimated for elderly females are larger, especially in the West, than for elderly males. The parameters δ and ζ were not significantly different from zero in the expenditure functions, of the northeast, north central or south, suggesting that the scale function for convenience foods could have been specified as a strict monotonic function of age over the childhood years for these regions.

Composite hypotheses about age and sex effects on household expenditures were tested using the Chow-Fisher procedure. Results in Table 3 indicate that age and sex differences of household members significantly influence the expenditures on convenience foods. Sex dif-

Table 2. Estimated Equivalence Scale Parameters and Standard Errors for Convenience Foods for the Northeast, Northcentral, Southern and Western Regions and the United States[1]

Region \ Parameters	γ	ϵ	δ	ζ	μ	ν	R^2
NE	.5743#	.2106#	.0799	.0891	.6117#	.2614#	.3616
	(.0858)	(.1571)	(.0539)	(.0538)	(1.685)	(.1541)	
N. Central	1.0780	.7540	−.0014	−.0393	.4817#	.5981#	.4069
	(.1208)	(.1805)	(.0597)	(.0595)	(.2093)	(.2106)	
South	.6282#	.7081#	−.0961	−.0064	.4252#	.5516#	.3044
	(.0929)	(.1595)	(.0500)	(.054)	(.1303)	(.1344)	
West	.5015#	.1760#	.2695*	.2017*	.1463#	.4085#	.3285
	(.1147)	(.2397)	(.0951)	(.0831)	(.2341)	(.2345)	
U.S.	.7067#	.5099#	.0301	.0425	.4412#	.4676#	.3535
	(.0520)	(.0893)	(.0593)	(.0302)	(.0887)	(.0880)	

Computations by authors
* Indicates that test of null hypothesis δ or $\zeta = 0$ was rejected at the .05 probability level.
\# Indicates that test of null hypothesis γ, ϵ, μ or $\nu = 1$ was rejected at the .10 probability level.

ferences, particularly of adults, are not significant in the North central region; however, the sex differences of elderly adults are significant. Age differences in males are significant in each region. The effects of differences in ages of females are quite dissimilar among the four regions.

Plots of male and female equivalence scales demonstrating the impacts of age-sex composition on convenience food expenditures over the life cycle are presented in Figures 1 and 2. For male children, the value of the adult equivalence scale increases monotonically in the Northeast and the North central regions. In the West, the scale increases from 0.18 at birth to 1.26 at 10 years of age and subsequently decreases monotonically to the standard at age 20. In contrast, in the South the scale decreases from 0.71 to 0.483 at 5 years of age and then increases monotonically to the standard at age 20. From ages 55 to 75, the scales for all regions exhibit similar decreasing patterns. The greatest decline occurs in the West and the smallest in the Northeast due to differences in the respective scales for elderly males in these regions.

The plots in Figure 2 provide information about the relative differences in female equivalence scales among regions and about the differences of female scales relative to the adult

[1] Pairwise test of the scale parameters across regions using a 5 percent probability level and the t distribution, indicated the following significant differences:
(a) the north central region's estimate for γ was significantly different from the value found for each other region.
(b) the northeastern region's estimate of ϵ was significantly different from that for the north central and southern regions but not for the west.
(c) regional estimates for μ and ν were not significantly different.
(d) the western region's estimates of δ and ζ were significantly different from those obtained for the north central and southern regions. The northeastern and southern estimates of δ were also significantly different.

Table 3. Summary Results of Statistical Tests Performed on Regional Equivalence Scale Parameters for Convenience Foods

	Composite Tests of Hypotheses	Regions in Which Test was Rejected[a]
(1)	Age and sex are not important	NE, NC, S, W
(2)	Sex is not important	NE, S, W
(2a)	Sex of adults is not important	NE, S, W
(2b)	Sex of elderly is not important	NC
(3)	Age of males is not important	NE, NC, S, W
(3a)	Male children are not different from adult males	NE, NC, S, W
(3b)	Older adult males and elderly males are not different from adult males	NE, NC, S, W
(4)	Age of females is not important	NE, NC, W
(4a)	Female children are not different from adult females	NC, W
(4b)	Older adult females and elderly females are not different from adult females	NE, NC

[a] The regions are designated as: NE-Northeast, NC-North Central, S-South, and W-West. The .10 level of significance was used in testing the hypotheses.
Source: Computations by the authors.

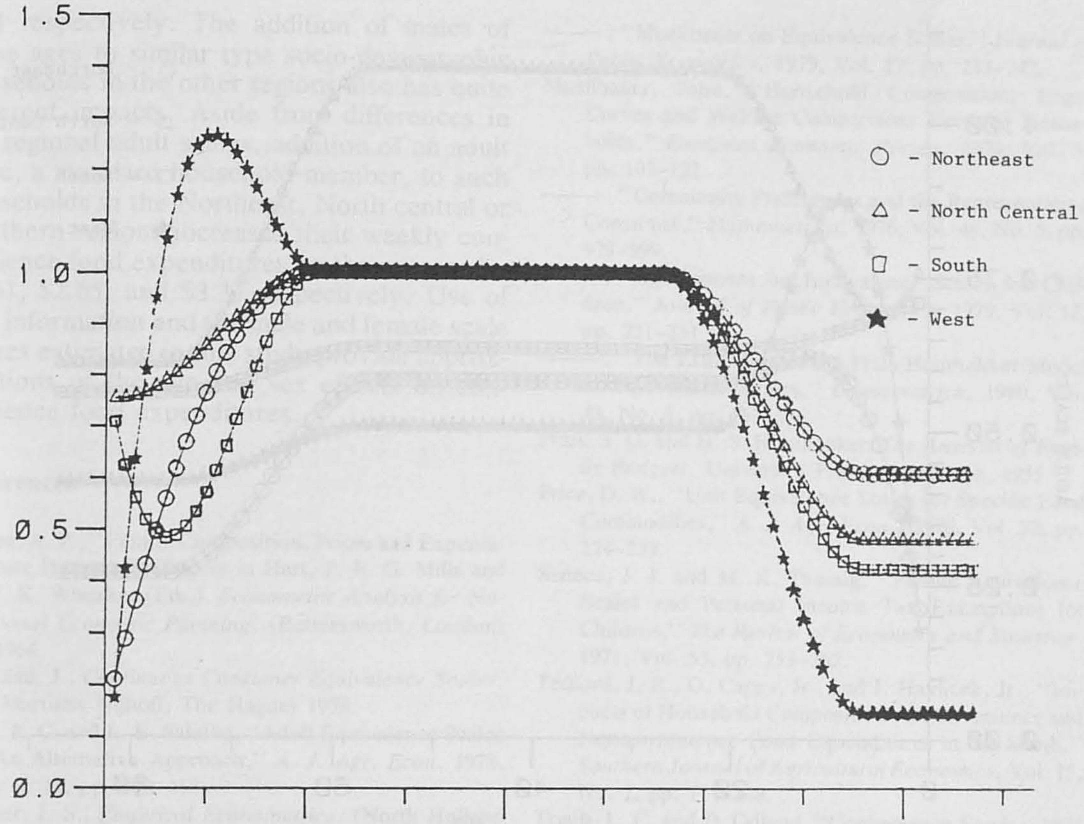

Figure 1. Male Equivalence Scales for Convenience Foods

male standard within regions. The regional patterns of adult equivalence scales for females during the childhood years, except in the West, differ from those for male children. In the West, the scale increases from 0.08 at birth to 0.87 at age 8 and then decreases to a value only 50 percent as great as the standard male's value at age 20. In the South, the scale decreases monotonically from 0.71 at birth to 0.63 at age 20. In the Northeast, the scale increases from 0.21 at birth to 0.62 at age 11 and subsequently declines to 0.57 at age 20. In the North central region, the scale declines from 0.75 at birth to 0.68 at age 4 and then dramatically increases to 1.08, unequivocally above the male standard, at age 20.

The scale value of the adult female in the North central region exceeds those of the adult male by 8 percent and is 71 and 116 percent greater than the corresponding values in the South and West, respectively. Consequently, controlling for the socio-demographic factors in the expenditure functions (equation 2), adult females in the North central region have, at the margin, greater impacts on expenditures for convenience foods than either adult males in all regions or adult females in other regions. From ages 55 to 75, the adult equivalence scales for females decline gradually for the South and the West. From ages 20 to death, the scales for these regions are nearly uniform. On the other hand, from ages 55 to 75, the North central and Northeast regions exhibit sharp declines in the values of the adult equivalence scales (48 percent and 54 percent respectively).

Concluding Comments

Using 1977–78 Nationwide Food Consumption Survey data and the model developed by Buse and Salathe, parameters of equivalence scales were estimated by a nonlinear regression algorithm using Marquardt's compromise for convenience foods for the Northeast, North central, South, and Western regions of the United States. Statistical tests conducted

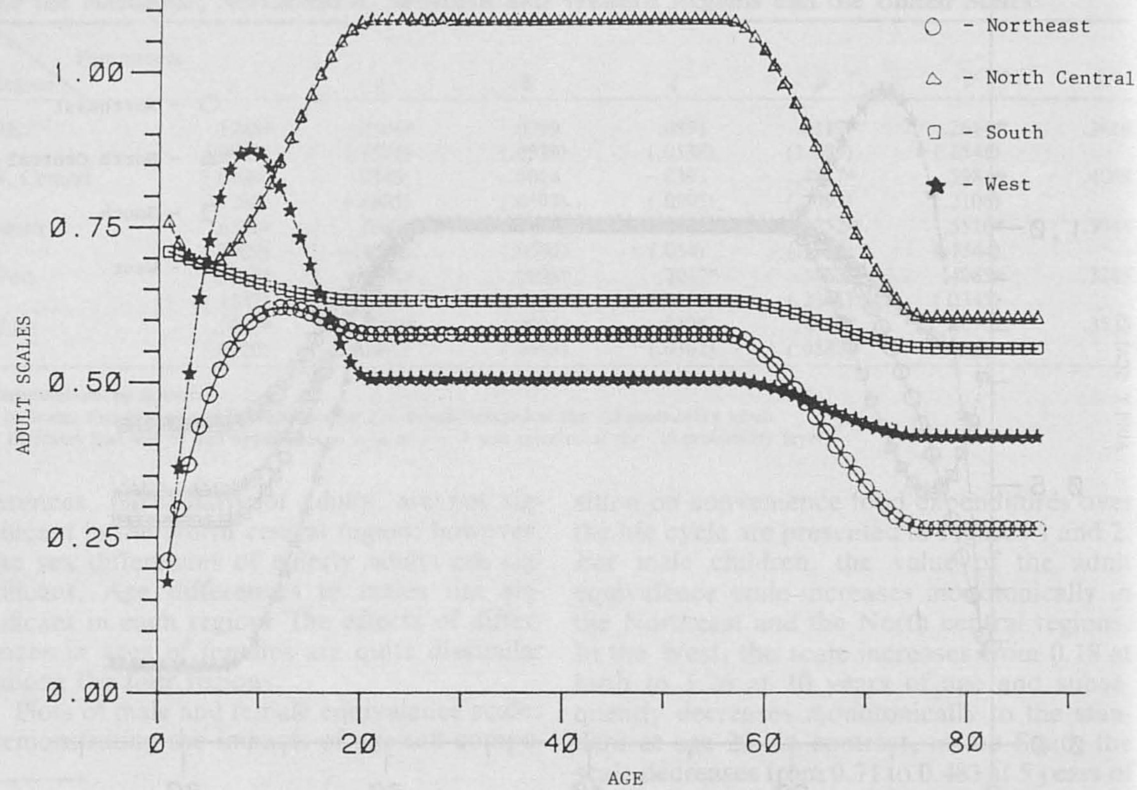

Figure 2. Female Equivalence Scales for Convenience Foods

on the equivalence scales parameters indicated that size and age-sex composition were important in accounting for household expenditure behavior in all regions. Widespread dissimilarities exist in the equivalence scales for the childhood years both among regions and between sexes. For the ages 20–55 years, the adult years, female adults in the North central region had a greater impact on the household's expenditures on convenience foods than did their male counterparts or adult females in other regions. For the ages of 55 to 75 the adult equivalence scales declined monotonically for both sexes and all regions.

Overall, the empirical adult scale parameter estimates and resulting life cycle profiles show surprising variability in the convenience food expenditures imputed to household members of different ages, sex and regional locations in the United States even when other socio-demographic attributes such as income, race, education, employment status, etc., are taken into account.

These findings should be of interest and an aid to management in convenience food processing-distribution companies. As an example, consider the following question: what differential impact will the addition of a male member of age 10, 25 or 76 have upon a household's weekly expenditures on convenience foods in the west? The adult equivalence scales for males of these respective ages are 1.26, 1.0 and .15. Let us also suppose the male is added to a household which has an income between $10,000 and $20,000 per year, the female head is the real preparer, she has a high school education or less, is white, is not employed outside of the household and resides in a central city. Such households located in the west in 1977–78 spent an average of $11.54 weekly on convenience foods (i.e. 22.4 percent of their $51.59 average expenditure on all foods). These households also had, on the average, 3.31 members, but when measured by the household equivalence scale for expenditures on convenience foods only an average size of 2.51. Since the addition of a standard household member (adult male, 20 to 55 years of age) to such households increases their weekly convenience food expenditure by $2.71, the addition of a 10-year-old boy or a 76-year-old man would increase it by $3.41 and

$.41 respectively. The addition of males of these ages to similar type socio-demographic households in the other regions also has quite different impacts. Aside from differences in the regional adult scales, addition of an adult male, a standard household member, to such households in the Northeast, North central or Southern regions increases their weekly convenience food expenditures on the average by $3.61, $2.65, and $3.37 respectively. Use of this information and the male and female scale values estimated in this study provide approximations of the age and sex effects on convenience food expenditures.

References

Barten, A. P., "Family Composition, Prices and Expenditure Patterns," Chapter in Hart, P. E. G. Mills and J. K. Whitaker (Eds.), *Econometric Analysis for National Economic Planning*. (Buttersworth, London) 1964.

Blokland, J., *Continuous Consumer Equivalence Scales*. (Martinas Nijhoff, The Hague) 1976.

Buse, R. C. and L. E. Salathe, "Adult Equivalence Scales An Alternative Approach," *A. J. Agr. Econ*. 1978, Vol. 16, pp. 460–468.

Cramer, J. S., *Empirical Econometrics*. (North Holland Publishing Co., Amsterdam) 1969.

Deaton, A. and J. Muellbauer, *Economics and Consumer Behavior,* Cambridge University Press, 1980.

Draper, N. R. and H. Smith, *Applied Regression Analysis*. (Wiley, N.Y.) 1966.

McClements, L. D., "Equivalence Scales for Children," *Journal of Public Economics,* 1977, Vol. 8, pp. 191–210.

———, "Muellbauer on Equivalence Scales," *Journal of Public Economics,* 1979, Vol. 12, pp. 233–242.

Muellbauer, John, "Household Composition, Engel Curves and Welfare Comparisons Between Households," *European Economic Review,* 1974, Vol. 5, pp. 103–122.

———, "Community Preferences and the Representative Consumer," *Econometrica,* 1976, Vol. 44, No. 5, pp. 979–999.

———, "McClements on Equivalence Scales for Children," *Journal of Public Economics,* 1979, Vol. 12, pp. 221–231.

———, "The Estimation of the Prais-Houthakker Model of Equivalence Scales," *Econometrica,* 1980, Vol. 48, No. 1, pp. 153–176.

Prais, S. G. and H. S. Houthakker, *The Analysis of Family Budgets,* University Press, Cambridge, 1955.

Price, D. W., "Unit Equivalence Scales for Specific Food Commodities," *A. J. Agr. Econ.,* 1970, Vol. 32, pp. 224–233.

Seneca, J. J. and M. K. Taussig, "Family Equivalence Scales and Personal Income Tax Exemptions for Children," *The Review of Economics and Statistics,* 1971, Vol. 53, pp. 253–262.

Tedford, J. R., O. Capps, Jr., and J. Havlicek, Jr., "Impacts of Household Composition on Convenience and Nonconvenience Food Expenditures in the South," *Southern Journal of Agricultural Economics,* Vol. 15, No. 2, pp. 111–118.

Traub, L. C. and D. Odland, "Convenience Foods—1975 Cost Update," *Family Economic Review* (Winter, 1976), pp. 26–33.

———, "Convenience Foods and Home Prepared Foods: Comparative Costs, Yield and Quality," Agricultural Economics Report No. 429, U.S.D.A., Economics Statistics and Cooperative Services, United States Department of Agriculture, Washington, D.C., August 1979.