Notes

Income and Expenditure for Relatively More versus Relatively Less Nutritious Food over the Life Cycle

Laura Blanciforti, Richard Green, and Sylvia Lane

United States consumers have been accused of being nutritionally inefficient, having a poor quality diet, and often placing themselves at nutritional risk because of their poor choice of foods (U.S. Congress). Unfortunately, the controversy over the consumption of nutritious versus less nutritious or "junk" foods has generated heated discussion but relatively little economic research.

Numerous studies have been made of the income elasticities of food consumption (Burk 1962, Hyman and Shapiro), and Engel curves derived from econometric analysis of family budgets, primarily relating expenditures on food or another consumption good or commodity group to income levels of households, ceteris paribus, abound in the literature (Burk 1968, pp. 84, 215; Aitchison and Brown; Allen; Allen and Bowley; Champernowne; Cramer; Goreux; Hassan and Johnson 1977; Houthakker 1952, 1957; Pras and Houthakker; Philips; and Tornquist). Adrian and Daniel in their 1976 article investigated the consumption of selected food nutrients in the United States using income and the life cycle stage as variables in their analysis, but they did not identify the foods which were the sources of the nutrients. Few researchers have examined the implications of and the differences in food expenditure patterns of households at various points in their lifetimes. And, more important, no research has been done on the expenditures on and income elasticities of the specific groups of food classified as relatively more nutritious and less nutritious components of diets.

The specific purposes of this analysis were to ascertain, using a general functional form, whether or not expenditures on foods classified as relatively more nutritious and less nutritious components of diets vary over the life cycle for U.S. households with different income levels, and to compare income elasticities for the various life cycle stages for all foods, relatively more and relatively less nutritious components of diets.

Description of Data

Cross-sectional data, obtained from the diary component of the second year of the 1972–1973 Consumer Expenditure Survey conducted by the Bureau of Labor Statistics, were used. Results of the 1973 Diary Survey were substantially better than those for the 1972 survey (Walsh). The sample from the 1973–74 portion of the survey totaled 10,514 observations (Carlson). The under $2,000 income group, 7.6% of the total sample and the over $35,000 group, 2% of the entire sample, were removed because their income was not recorded in actual dollar amounts. The exclusion of the over $35,000 group acted to offset partially the bias introduced by the exclusion of the under $2,000 group. Editing the data to remove observations incomplete for key variables results in 9,464 usable observations.

Income data collected was for each household's before-tax income from all sources.1 Expenditure data are recorded food-at-home expenditures for specific items. The data on food expenditures were grouped into three groups: total food at home, relatively more nutritious components of diets, and relatively less nutritious components of diets. The classification of foods into relatively more nutritious and less nutritious components of diets was based upon an analysis of the nutritive composition of the food items. The index of nutritional quality tables developed by Canolty of the Department of Nutrition of the University of California, Davis, were used for this purpose. To be termed "nutritious" (relatively more nutritious), a food had to contain percentages of the requirement for four or more nutrients equal to or greater than the proportion of the energy (calories) provided by that food, or the percentage required of two or more nutrients in twice the proportion to the energy contribution for that food (see table 1). This definition of nutritious is a recommended definition consistent with results from a 1976 study by the Society for Nutri-

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1 It is well known that the income variable as reported in household survey data has several deficiencies as an argument for Engel Curve estimation. For further explanation of this problem, see Brown and Deaton, p. 1172, and Hassan and Johnson 1976, pp. 5–6.
Table 1. Relatively More Nutritious and Less Nutritious Foods

<table>
<thead>
<tr>
<th>Relatively More Nutritious Foods</th>
<th>Relatively Less Nutritious Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals, flour, rice, pasta</td>
<td>Fresh cakes and cupcakes</td>
</tr>
<tr>
<td>Bread, biscuits, rolls, muffins</td>
<td>Crackers</td>
</tr>
<tr>
<td>Meats, poultry, fish and eggs</td>
<td>Cookies</td>
</tr>
<tr>
<td>(except bacon and frankfurters)</td>
<td>Sweet rolls, coffecakes, doughnuts</td>
</tr>
<tr>
<td>Dairy products (except ice</td>
<td>Frozen and refrigerated</td>
</tr>
<tr>
<td>cream and related products)</td>
<td>bakery products, pies, tarts,</td>
</tr>
<tr>
<td>Fruits and vegetables (except</td>
<td>turnovers</td>
</tr>
<tr>
<td>apples)</td>
<td>Bacon</td>
</tr>
<tr>
<td>Margarine(^a)</td>
<td>Frankfurters</td>
</tr>
<tr>
<td>Peanut butter</td>
<td>Ice cream and related products</td>
</tr>
<tr>
<td>Other prepared foods (except</td>
<td>Apples</td>
</tr>
<tr>
<td>other condiments)</td>
<td>Sugar, candy, chewing gum</td>
</tr>
<tr>
<td></td>
<td>and other sweets</td>
</tr>
<tr>
<td></td>
<td>Other fats, oils and salad</td>
</tr>
<tr>
<td></td>
<td>dressings</td>
</tr>
<tr>
<td></td>
<td>Nondairy substitutes</td>
</tr>
<tr>
<td></td>
<td>Nonalcoholic beverages</td>
</tr>
<tr>
<td></td>
<td>Other condiments</td>
</tr>
</tbody>
</table>

\(^a\) Butter is included in dairy products.

The eight key nutrients used in the analysis were folacin, vitamin B-6, pantothenic acid, magnesium, vitamin A, calcium, iron, and vitamin E.

Data for all households and the households stratified according to life cycle stages were used in the analysis. Since cross-sectional data are used the life cycle stages depict different families at each stage rather than a cohort of families moving through different stages. Life cycle stages in this analysis only provide a classification scheme.

The life cycle stages were:
- Life cycle stage 0: all not included in groups one through six, i.e., single men, single women, etc.
- Life cycle stage 1: no children are present and the housewife is over 40 years age.
- Life cycle stage 2: average age of children is less than six years.
- Life cycle stage 3: average age of children is between six and 12 years.
- Life cycle stage 4: average age of children is between 12 and 17 years.
- Life cycle stage 5: average age of children is over 17 years.
- Life cycle stage 6: no children are present and the housewife is over 40 years age.

Because household size and composition account for a significant proportion of variation in food expenditure patterns across similar families, the income and expenditure data were adjusted separately, using an adult-equivalent scale, before estimating the Engel function.\(^4\) The adult-equivalent scale is simply a device for specifying the requirements or expenditures of an individual of a particular age and sex as a proportion of the standard or base individual such as an adult male. The adjustment of the food expenditure and income variables makes the estimation of one Engel function for households of varying sizes, ages, and compositions possible. The procedure prevents attributing to income or food expenditures part of the variation properly attributable to variations in the age, sex of household members, or the effects of family size. Engel curves were estimated for sample households stratified according to their stage in the life cycle.

Methodology

Economic theory provides no a priori rationale for the appropriate functional form for the Engel relationship, although it does indicate that the functional form selected should obey the “adding-up” criterion (Salathe, p. 11). Yet the choice of functional form can influence substantially the estimated income elasticity. The linear and double-logarithmic tend to be the most commonly used functional forms, but empirical studies indicate the income elasticity of food is below unity and falls as income rises. This implies that both the linear functional form with rising elasticity and the double-logarithmic form with constant elasticity are inappropriate for the analysis of Engel relationships (Zarembka).

In this study Engel relationships were estimated using a Box-Cox transformation, for which the linear and logarithmic forms are special cases (Box-Cox, Chang, Zarembka).\(^5\) To begin this anal-

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\(^2\) In that study a sample of SNE members were surveyed concerning the correct definition of a “nutritious” food so that recommendations could be made regarding a proposed Federal Trade Commission Trade Regulation Rule on the use of the term “nutritious” in food advertising.

\(^3\) Pennington in her “Dietary Nutrient Guide” defined the first seven nutrients as key nutrients whose presence in sufficient amounts are indicators of the adequacy of a larger group of essential nutrients. She states that if one obtains the suggested daily intake of the index nutrients from natural foods and follows a few other suggestions, then the diet will be adequate in approximately all essential nutrients. Inclusion of adequate amounts of vitamin A and folacin will contribute to the vitamin E requirement but will not ensure it. The authors, thus, felt justified in including vitamin E as an index nutrient.

\(^4\) Estimates were developed by Price from the USDA 1965 Household Food Consumption Survey. For the analysis, further adjustments were made to reflect economies of size resulting from additional children as discussed in Price, p. 229. Table 2. See Price for additional explanation and discussion. For explanation of derivation of income index values see USDL.

\(^5\) When \(\lambda = 1\), equation (1) is linear and when \(\lambda = 0\), equation (1) is double logarithmic. In the linear case, \(\lambda = 1\), and the income elasticity.
ysis the general functional form of the Engel Curve is written:

\[ C_{t}^{(a)} = a_0 + a_1 Y_{t}^{(a)} + U_{t}, \]

where \( C_t \) is the amount of food expenditure per food-adult equivalent, \( Y_t \) is income per income-adult equivalent, and \( U_t \) is the disturbance term of the cross-sectional group or household. The variables \( C_{t}^{(a)} \) and \( Y_{t}^{(a)} \) are defined as:

\[ C_{t}^{(a)} = (C_{t}^h - 1)/\lambda, \text{ and} \]
\[ Y_{t}^{(a)} = (Y_{t}^h - 1)/\lambda, \]

where \( \lambda \) represents a transformation parameter to be determined. The \( U_t \) term for the given \( \lambda \)'s is assumed to be normally and independently distributed with zero mean, constant variance, and zero covariance. The income elasticity of food demand, \( N_{p} \), can be shown to be

\[ N_{p} = a_1 (Y_{t}/C_{t})^{\lambda}. \]

The sign of the income elasticity depends on the sign of \( a_1 \), since \( Y_t \) and \( C_t \) are nonnegative values but its value depends on the relationship of \( Y_t \) to \( C_t \) and the value of \( \lambda \).

Given the above assumptions for \( U_t \) and using the Box-Cox maximum likelihood approach, the logarithm of the likelihood function for a given \( \lambda \) that is to be maximized is, disregarding the constant,

\[ L_{\max}(\lambda) = - \frac{N}{2} \ln \hat{\sigma}^2(\lambda) + (\lambda - 1) \sum \ln C_i, \]

where \( \hat{\sigma}^2 \) is the estimated error variance of the regression of \( C_{t}^{(a)} \) on \( Y_{t}^{(a)} \). Maximization of (4) over the entire parameter space requires selection of alternative values of \( \lambda \) over a reasonable range, the regression of \( C_{t}^{(a)} \) on \( Y_{t}^{(a)} \) and the determination of the transformation parameter \( \hat{\lambda} \) that maximizes (4). An approximate \((1 - \alpha)\) confidence interval for \( \lambda \) can be defined since \( 2[L_{\max}(\lambda) - L_{\max}(\lambda)] \) is approximately distributed as \( \chi^2 \) with one degree of freedom. That is, the \((1 - \alpha)\) confidence interval for \( \lambda \) is obtained by finding that value on either size of \( \hat{\lambda} \) such that \( L_{\max}(\lambda) - L_{\max}(\lambda) = \frac{1}{2} \chi^2(\alpha) \).

\[ C_t \] was further subdivided into foods that are relatively more nutritious and foods that are relatively less nutritious components of diets, so three general equations were estimated. Households were also separated into life cycle groups. Average income and expenditure on all food and relatively more or less nutritious components of diets appear in Table 2. Average household income, it appears, is higher for each succeeding stage in the life cycle, excepting stage two, until stage five is reached. It then declines. Average expenditure on all food and relatively more and less nutritious food increases until stage four is reached and then declines. Food expenditure, apparently, increases with the addition of children to the household and continues to increase as the children grow older, peaking when they are teenagers.

### Results

Both expenditure and income per adult equivalent were transformed as indicated in equation (2) by \( \lambda \)'s valued at intervals of 0.01 between -1.00 and 1.00. \( C_t^{(a)} \) was then regressed on \( Y_t^{(a)} \) for each set of the transformed data. \( L_{\max}(\lambda) \) was calculated for each regression by using equation (4). Estimated coefficients and related statistics for the various regressions are given in Table 3. \( R^2 \) values are all very low. This is not unusual in cross-sectional studies. The maximum likelihood estimates for \( \lambda, \hat{\lambda} \) ranged from .16 to .47, which is distinctly different from zero or one. The 95\% confidence interval for each \( \lambda \) varied approximately .02 to .08 from the maximum likelihood estimates for \( \lambda, \hat{\lambda} \). Neither \( \lambda = 1 \) nor \( \hat{\lambda} = 0 \) fell within the 95\% confidence interval. The null hypothesis that the functional form was linear \((H_0: \lambda = 1)\) or logarithmic \((H_0: \lambda = 0)\) could be rejected at the 5\% level of significance. Coefficients of \( Y_t^{(a)} \) in all equations excepting life cycle stages 0 and 1 were significant at the 5\% level.

The general functional form was considered to be a more accurate representation of the Engel curve. Income elasticities for the general functional form were represented by \( N_{p} = a_1 (Y_{t}/C_{t})^{\lambda} \) and were also considered to be better estimates of income elasticities. Table 3 contains the estimates of the income elasticity at the means for all six life cycle stages for all food, and relatively more and less

### Table 2. Average Annual Household Income and Expenditure on All Food and Relatively More or Less Nutritious Foods at Each Stage of the Life Cycle

<table>
<thead>
<tr>
<th>Lifecycle Stage</th>
<th>Income</th>
<th>All Food</th>
<th>Relatively More Nutritious Food</th>
<th>Relatively Less Nutritious Food</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6,603.96</td>
<td>1,207.92</td>
<td>1,037.68</td>
<td>170.24</td>
</tr>
<tr>
<td>1</td>
<td>12,610.41</td>
<td>2,025.05</td>
<td>1,740.28</td>
<td>284.77</td>
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<tr>
<td>2</td>
<td>11,369.67</td>
<td>2,885.97</td>
<td>2,478.17</td>
<td>407.80</td>
</tr>
<tr>
<td>3</td>
<td>12,901.33</td>
<td>3,743.19</td>
<td>3,178.67</td>
<td>564.52</td>
</tr>
<tr>
<td>4</td>
<td>14,002.51</td>
<td>4,099.24</td>
<td>3,511.75</td>
<td>587.49</td>
</tr>
<tr>
<td>5</td>
<td>14,716.19</td>
<td>4,361.66</td>
<td>2,958.41</td>
<td>503.25</td>
</tr>
<tr>
<td>6</td>
<td>10,551.08</td>
<td>2,570.11</td>
<td>2,203.64</td>
<td>366.47</td>
</tr>
<tr>
<td>All</td>
<td>11,316.97</td>
<td>2,772.01</td>
<td>2,372.26</td>
<td>399.75</td>
</tr>
</tbody>
</table>

N_t = a_1 \left( \frac{Y_{t}}{C_{t}} \right)^{\lambda} \] and were also considered to be better estimates of income elasticities. Table 3 contains the estimates of the income elasticity at the means for all six life cycle stages for all food, and relatively more and less
Table 3. Regression Results from the General Functional Form for All Food, Relatively More Nutritious, and Less Nutritious Food over Stages of the Life Cycle

<table>
<thead>
<tr>
<th>Stages</th>
<th>λ</th>
<th>(a_0)</th>
<th>(a_1)</th>
<th>(L_{\text{max}}(λ)^{a})</th>
<th>Income Elasticity(^{cde})</th>
<th>λ</th>
<th>(a_1)</th>
<th>(a_1)</th>
<th>(L_{\text{max}}(λ)^{a})</th>
<th>Income Elasticity(^{cde})</th>
<th>λ</th>
<th>(a_1)</th>
<th>(a_1)</th>
<th>(L_{\text{max}}(λ)^{a})</th>
<th>Income Elasticity(^{cde})</th>
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</thead>
<tbody>
<tr>
<td>All</td>
<td>.36</td>
<td>28.58</td>
<td>.041</td>
<td>-59388.33</td>
<td>.050</td>
<td>.32</td>
<td>21.57</td>
<td>.039</td>
<td>-57152.47</td>
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<td>.26</td>
<td>9.90</td>
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<td></td>
<td></td>
<td>(82.30)</td>
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<td>(77.34)</td>
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<td></td>
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<td>(54.71)</td>
<td>(7.03)</td>
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<tr>
<td>0</td>
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<td>28.22</td>
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<td>-.009</td>
<td>.31</td>
<td>22.64</td>
<td>-.009</td>
<td>-11203.29</td>
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<td>.16</td>
<td>8.07</td>
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<td>.005</td>
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<td>(-0.43)</td>
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<td>-9147.38</td>
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<td>(1.77)</td>
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<td>(20.24)</td>
<td>(4.47)</td>
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<td>(37.13)</td>
<td>(5.85)</td>
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<td>(33.88)</td>
<td>(5.74)</td>
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<td></td>
<td>(27.76)</td>
<td>(3.10)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*a The logarithm of the maximized likelihood function, except for constant terms.

*b t-statistics are in parentheses.

*c Income elasticities measured at the mean value of income and consumption for each of the life cycle stages.

*d Chow tests for \(a_i\) for regressions for relatively more and relatively less nutritious foods using linear and logarithmic forms indicated there were significant differences between the \(a_i\)'s in every stage of the life cycle. For the justification of the Chow test for this type of problem see Toyoda. The Chow test is well behaved even under heteroscedasticity as long as at least one of two sample sizes is very large.

*e At the maximized \(\lambda\).
nutritious foods derived at the maximum value, $\hat{\lambda}$, for the general functional form. For all food, the highest income elasticity derived was for Stage 4 ($\hat{\lambda} = .45$) and the lowest for Stage 0 ($\hat{\lambda} = .34$). For foods that are relatively more nutritious components of diets, the income elasticity was highest for Stage 6 (no children present and the housewife was over 40 years of age ($\hat{\lambda} = .27$)) and lowest for Stage 1 ($\hat{\lambda} = .31$). For foods that are relatively less nutritious components of diets, the income elasticity was highest for life cycle Stage 5 ($\hat{\lambda} = .22$), when the average age of the children is over 17 years, and lowest for Stage 0 ($\hat{\lambda} = .16$). As households move from “single persons” to “married with small children” (under six years) their food expenditure response to an increase in income increases for all foods, relatively more nutritious and less nutritious foods. This increased food expenditure response continues for relatively less nutritious foods throughout child-rearing ages and decreases for the highest income elasticity derived was for Stage 4 ($\hat{\lambda} = .45$) and the lowest for Stage 0 ($\hat{\lambda} = .34$). For foods that are relatively more nutritious dietary components, the food expenditure response is more volatile. When children are between six and twelve years, there is a noticeable decline in the income elasticity. This response then rises and reaches a peak when children are in the teenage years, declines again when children are over seventeen and increases for older person households. Thus, the elasticities imply (a) households will spend a greater proportion of a greater income on all food when there are teenagers in the household; (b) older households without children will spend a greater proportion of a greater income on relatively more nutritious foods, and (c) households where the children are older and some, in fact, are young adults, will, on the average, spend the greatest proportion of a greater income for relatively less nutritious food. The further implications are that as the average age of the children in households increases, households will spend a greater proportion of a greater income on foods that are relatively less nutritious components of diets; and that as the proportion of older households without children increases, a greater proportion of greater household incomes will be spent on relatively more nutritious foods.

Summary and Conclusions

Income elasticities for all food, relatively more nutritious and less nutritious components of diets for all stages and seven designated life cycle stages, were estimated using the general functional form utilizing a Box-Cox transformation as proposed by Zarembka. Previous studies have indicated this form of estimation provides a better fit for Engel curves for food than other functional forms (Zarembka, Chang). The maximum likelihood estimate of $\lambda$, $\hat{\lambda}$ in this study, ranged from .16 to .47 which was distinctly different from 0 or 1. The 95% confidence interval for $\lambda$ varied no more than .08 from the value of $\lambda$. The hypothesis that the linear or logarithmic functional forms which were also estimated fit the data was rejected at the 5% level.

Using the mean value in the estimating equations, the highest income elasticity using the flexible functional form was for Stage 4 (average age of children between 12 and 17 years) and the lowest for Stage 0 (single people) for all food. This is logical since food is a higher priority for households, generally, if they have teenage children and a lower priority for single people.

Interestingly, the income elasticity for the relatively more nutritious food components was highest for Stage 6. This implies that older people have a greater appreciation for nutrition. Nutrition education efforts to be most cost-effective should be directed to other household groups. For less nutritious food, the highest income elasticity was for Stage 5 (where the average age of the children was over 17 years). It may well be that relatively less nutritious foods are more appealing to teenagers and young adults. This has serious implications. Greater nutrition education efforts should be directed at those two groups who are just entering the labor force and for whom, over the lifetime, better health and higher productivity will have higher economic and noneconomic payoffs than for older persons.

Thus it would appear estimates of income elasticities based on linear and logarithmic functional forms may require reevaluation. Specific policy-relevant findings from this study indicate single-person households have lower income elasticities than households in any other life cycle stage for all food and for relatively less nutritious foods, while older people in childless households have the highest income elasticity for relatively more nutritious foods. This may not accord with the preferences of those who would prefer households with younger children and younger, more productive, adults to spend high proportions of higher income on more nutritious foods.

[Received December 1979; revision accepted December 1980.]

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