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Nutrition and the Demand for Tastes

Eugene Silberberg

University of Washington

The law of diminishing marginal product, applied to food nutrients, implies that as consumers' incomes increase, a smaller fraction of their food budget will be devoted to pure nutrition. I test this result using data from the Nationwide Food Consumption Survey, 1977–78. The foods consumed by five income groups are observed, and the amounts of 18 nutrients actually consumed are calculated. With those observed nutrient levels as constraints, the linear programming diet problem calculates the diet providing those nutrient levels at least cost. The ratio of actual cost to least-cost expenditure on nutrition is shown to increase with income.

I. Introduction

In 1945 George Stigler formulated and gave an approximate solution to the now famous “diet problem,” which seeks the minimum cost of achieving the recommended daily allowances of nutrients known to be beneficial to humans. That diet, not surprisingly, comprised foods most people find unappetizing: pork liver, spinach, cabbage, dried beans, evaporated milk, and wheat flour. Stigler's menu pointedly demonstrated the difference between “technical efficiency” and economic efficiency, where preferences count. In this paper I develop a hypothesis about the exercise of tastes by humans with regard to food consumption, using the law of diminishing marginal product. This
theory is then tested with data from the Nationwide Food Consumption Survey, 1977–78, published by the U.S. Department of Agriculture (USDA). Specifically, I show that economic postulates predict and the data confirm that as income rises, expenditure on pure “nutrition” falls as a percentage of overall expenditure on food.

II. The Model

The choice of foods consumed has in general been unexplained by economists; these decisions have been relegated to the domain of “tastes,” to make an inevitable pun. If foods are treated as final goods in consumption, then convexity of indifference curves provides no prediction regarding inferiority or normality of foods. Following Becker (1965) and Lancaster (1966), I treat foods purchased in the market as inputs in the production of meals, which provide both pleasing taste and nutrition. Various vitamins and minerals are by now well known to be useful to humans in maintaining health. As Stigler noted, however, these nutrients, like all productive inputs, are subject to the law of diminishing returns. Advocates of megadoses notwithstanding, the prevailing scientific opinion seems to be that these nutrients are highly useful to humans in some (generally small) amounts, that larger amounts provide marginally less in the way of additional benefits, and that in some cases, for example, nonsoluble vitamins, very large intakes are even toxic. Thus we can assume that nutrients are useful to humans in the classical Knightian sense, with three stages of production.

Since the marginal products of nutrient elements fall as consumption of these inputs increases, we should expect a corresponding fall in consumers’ marginal values of vitamins and minerals. More specifically, as nutrient intakes increase, the marginal values of tastiness, aroma, texture, and so forth, that is, the qualities of goods relating to palatability, should rise relative to the marginal values of inputs to pure nutrition. We should therefore expect that, as income rises, consumers will spend a decreasing fraction of their food budget on pure nourishment. As income increases, consumers will defer relatively more toward the pleasurable aspects of eating and relatively less toward the production of nourishment.

III. Empirical Tests

A. General Procedure

The theory outlined above is tested as follows. Letting $x_j =$ amount of food $j$ actually purchased by individuals in a given income group, the

1 An additional subscript for income class is omitted to avoid notational clutter.
total amount $b_i$ of nutrient $i$ consumed by individuals in that income class is $b_i = \sum_j a_{ij}x_j$, where $a_{ij} =$ the amount of nutrient $i$ in one unit of food $j$. The combination of foods providing consumers with at least those levels of the nutrients and at least cost is obtained by solving the linear programming diet problem (LPDP),

$$
\text{minimize } y = p'x \\
\text{subject to } Ax \geq b \\
x \geq 0,
$$

where the column vector $b$ consists of the nutrient levels $b_i$ actually achieved by these consumers. Let $x^*$ denote the food vector that solves the LPDP and let $y^* = p'x^*$, the resulting minimum possible expenditure on those nutrients. If $y =$ actual expenditure on these foods, the model predicts that the ratio $y/y^*$ will increase with increasing income.

B. Data

The USDA's Consumer Nutrition Center surveyed food consumption in approximately 15,000 households in 1977 and 1978. Most important for this study, the data were broken into five income groups, ranging from under $5,000 to over $20,000 per household. Altogether, several hundred separate foods appear to have been tabulated, though many small categories are ultimately aggregated. For example, wheat flour includes white, whole wheat, buckwheat, cake meal, gluten, and low-protein flour. Close to three hundred separate food categories were ultimately reported, listing data on physical quantities (pounds per week) and total expenditure per week for each of five income groups plus a total for all households combined. In the analysis presented below, a total of 271 separate foods were considered. Eliminated were foods with such small entries that rounding error appeared significant. A complete list of the foods analyzed is given in the Appendix.

Five household income categories are delineated: under $5,000, $5,000–$9,999, $10,000–$14,999, $15,000–$19,999, and $20,000 and over. The actual mean incomes for these groups are $3,032, $7,223, $12,023, $16,934, and $29,290, respectively. These incomes, however, do not include in-kind transfers such as food stamps, welfare, social security and medicare payments, and the like. The lowest income group, in particular, has actual income above these reported

\[ \text{Examples were cheese dips, in which certain entries were missing, unsalted nuts other than peanuts, and like categories. Also eliminated by aggregation were, e.g., subcategories of fruit ade, drink punch, and nectar, e.g., powdered, frozen, etc. The aggregated quantities and expenditures were deemed more reliable in these instances.} \]

\[ \text{I am indebted to Mary Hama for these figures.} \]
figures. Unfortunately, the households differ in terms of size. Household size was defined to be the number of meals served to all persons in the same week, divided by 21. Thus meals served to guests and boarders were included. Arbitrary weights were given to snacks; for example, coffee and doughnuts served to a neighbor were counted as one-fourth of a meal. Not surprisingly, household size generally increased with income in the sample. The average household sizes for the five income groups listed above are, respectively, 1.91, 2.53, 2.91, 3.22, and 3.21. Happily, the last two income categories have essentially the same size and therefore permit more direct comparisons with each other than with the other households. Using these incomes and household sizes, the per capita incomes, in 1977 dollars, of these individuals are $1,587 +, $2,855, $4,132, $5,259, and $9,125, respectively. The possible effects of differential family size on the empirical results will be discussed later.

Prices for each food were derived by dividing total expenditure on each food by the quantity (pounds) consumed. A comparison was made of the prices derived for each income group. In general there were insignificant differences, much of it due to rounding error, in the prices paid by each income group. The only possible exceptions were that the highest income group sometimes paid slightly higher prices than the other groups. It is not possible to say how many of these differences, if any, were due to the possibility that higher income groups tend to purchase higher-quality food or to make purchases in supermarkets providing better service. The differences appeared quite small, however, and thus food prices were defined by the ratio of all households' expenditures to the quantity consumed by all households for each good analyzed.

The Food Consumption Survey ultimately provided a $271 \times 5$ matrix of foods actually consumed by American households in 1977–78, one column for each income class. The columns of this matrix were divided by household size, producing a $271 \times 5$ matrix, denoted $x$, representing the actual foods consumed per person for each income group. Also calculated from this data source was the $1 \times 271$ matrix (vector) of observed food prices, $p'$. The actual total weekly expenditures on food per person, $p'x = y$, are $y = (14.859, 14.843, 15.007, 15.613, 17.215)$. Even though household income rises, food spent per person actually declines from the first to the second group (though this does not appear significant) and rises only slightly between the second and third income groups. However, increased household income and higher food expenditures clearly occurred for the two highest groups, both of which had higher per capita incomes than the second and third group.

The next step in the procedure was the construction of the $A$ ma-
Demand for Tastes

A matrix of nutrient coefficients, using the nutrients commonly listed in tables of Recommended Daily Allowances (RDAs). The complete list of nutrients is as follows: (1) protein, (2) vitamin A, (3) vitamin D, (4) vitamin C, (5) folacin, (6) niacin, (7) riboflavin (vitamin B₂), (8) thiamine (vitamin B₁), (9) vitamin B₆, (10) vitamin B₁₂, (11) calcium, (12) phosphorus, (13) iron, (14) magnesium, (15) zinc, (16) food energy, (17) lipids (total), and (18) carbohydrates. Lipids (fats) and carbohydrates are not listed in tables of RDAs but are important nutritional elements analyzed by the USDA and other agencies.

In all, an 18 × 271 matrix A of nutrient coefficients was constructed. Most of the nutritional information came from publications by the USDA; the data on various minerals were obtained from specific articles on those nutrients (see Hardinge and Crooks 1961; Orr 1969; Hankin, Margen, and Goldsmith 1970; Murphy, Watt, and Rizek 1973; Perloff and Butrum 1977; Greger, Marhefka, and Geissler 1978). The principal source was Agricultural Handbook no. 8, Composition of Foods (1981), a series of detailed listings of nutrients of various foods. This series is at present incomplete; when data were missing, the older handbook, published in 1963, was used.

C. Empirical Results

The per capita levels of the 18 nutrients actually consumed by the five household groups are displayed in table 1. Also displayed for comparison are the RDAs of these nutrients, as published by the U.S. Food and Nutrition Board of the National Academy of Sciences (1980).

Certain features of these nutrient levels should be noted. For most nutrients but not all, specifically folacin and magnesium, the RDAs were easily exceeded for each income group. Indeed, the RDAs of vitamins A and D were exceeded by factors of 10 or more. Consumption of protein, vitamin C, niacin, and phosphorus was approximately

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4 Iodine was commonly listed in tables of RDAs, but this nutrient is not contained in the foods studied. It is obtained in sufficient quantities from the use of iodized salt and was therefore left out of this analysis. Vitamin E was not included because its composition in foods has not yet been analyzed. Vitamin K is produced by the body itself, and deficiency is apparently extremely rare.

5 Lipids include all animal fats and vegetable oils. Aside from providing concentrated amounts of food energy, certain lipids are essential parts of the structure of cell membranes. They also provide solvents for certain vitamins, e.g., A and D, which are insoluble in water. Carbohydrates form the other major food group, in addition to proteins. Carbohydrates comprise sugars and starches and other chemically similar nutrients and are used by the body for energy.

6 Note that these are recommended, not minimum daily requirements. The RDAs vary by sex and age; the ones presented here are for males, aged 23–50, weighing 154 pounds and 70 inches in height. There are no RDAs for carbohydrates and lipids.
double their RDAs; consumption of zinc, four to five times the RDA. The remaining nutrients were in general consumed at levels 10–50 percent greater than their respective RDAs. What these data reveal is that even consumers in the lowest income group were, on average, well beyond the danger of undernourishment in any nutrient, although this obviously does not rule out malnourishment for given individuals. Inspection of table 1 reveals that at the intermediate levels of income, there is no apparent pattern for "normality" or inferiority of these nutrients, though all, with the exception of zinc, appear normal at the higher income levels. It therefore seems safe to conclude that, on average, these consumers were well into stage 2 of the production function for nutrition (indeed very close to the boundary of stage 3) and that the marginal products of these nutrients in terms of improvement of health would all be quite small. We would therefore expect the main response to an increase in income to be a change in the mix of foods purchased in the market so as to produce nutrition in a more enjoyable manner.

A puzzling feature of the data is that the consumption of nutrients by the lowest income group is higher, for every nutrient, than the level consumed by the next higher income group. The reason for this anomaly may be that this low-income group consists disproportionately of adults, in particular, elderly people.7 Older people may place...

7 I am indebted to Tom Borcherding for suggesting this explanation and to Mary Hama for confirming it.
higher marginal values on nutrition than younger people, for given incomes. The ability of the human body to overcome poor nutrition is greater in young people, and with positive real interest rates, the value of prolonged life would be greater for older rather than younger people.\textsuperscript{8} As a result of this feature of the data, the linear programming solution yields a lower expenditure for group 2 than group 1. The actual expenditure on food for these two groups is essentially identical—less than 2 cents out of nearly $15 per week, a difference possibly attributable to rounding error.

The linear programming (LP) solutions to the diet problems, where $b_i =$ the levels of nutrient $i$ actually achieved by each income group, are presented in part A of table 2.\textsuperscript{9} Also displayed is the solution to the traditional diet problem, where the $b_i$'s are the RDAs of each nutrient.\textsuperscript{10} Summary statistics are presented below the commodity levels: the actual per capita expenditure on food, $y$, the LP minimum, $y^*$, and the ratio $y/y^*$ for each income group. Part B of table 2 presents the results when nutrients 17 and 18, lipids and carbohydrates, for which no RDAs are specified, are deleted from the LP constraints. As an additional test of the robustness of the theory, the LP problem was solved using as binding constraints only those for the first four nutrients, protein and vitamins A, D, and C. These results are displayed in part C of table 2. The choice of these particular nutrients was arbitrary; the purpose in doing this experiment was only to see if the results held when only a small set of nutrients was used instead of a larger one.

The results in these tables confirm the theory outlined above. In every case, as income increases, the ratio $y/y^*$ increases, indicating that the actual pattern of food consumption deviates further from the technically efficient consumption of nutrients. The effect is most pronounced in the comparison of income groups 4 and 5, for which household sizes were the same.

It is reasonable to conclude that the results would be stronger if household size were constant for each income group. It seems plausible that there are economies of scale in food preparation. Purchasing food for two persons is likely to result in less waste than preparing food for one person, and so forth as a household size increases. Additionally, purchases made in small quantities are frequently higher priced (per unit) than purchases in larger amounts. In these calculations, price was taken as the same for all households. If any bias is

\textsuperscript{8} However, nutrition may also be preventive maintenance, whose value is larger the longer the horizon.

\textsuperscript{9} These and all other solutions to the LP problems utilized the LINDO program written by Linus Schrage for the VAX computer.

\textsuperscript{10} The foods denoted “wheat cereal” and “oat cereal” are in fact market composites of cold cereals best known by the brand names Wheaties and Cheerios, respectively.
## TABLE 2
### FOOD CONSUMPTION PER WEEK (Pounds)

<table>
<thead>
<tr>
<th>Food</th>
<th>RDA</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td><strong>A. Various Income Classes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Low-fat milk</td>
<td>.199</td>
<td>5.084</td>
<td>4.967</td>
<td>5.401</td>
<td>5.548</td>
<td>6.389</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td></td>
<td>1.813</td>
<td>1.819</td>
<td>1.807</td>
<td>1.836</td>
<td>1.903</td>
</tr>
<tr>
<td>Wheat cereal</td>
<td>.143</td>
<td>.587</td>
<td>.525</td>
<td>.628</td>
<td>.383</td>
<td>.412</td>
</tr>
<tr>
<td>Oat cereal</td>
<td>.704</td>
<td>.054</td>
<td>.102</td>
<td></td>
<td>.230</td>
<td>.260</td>
</tr>
<tr>
<td>Pork chops</td>
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<td>.252</td>
<td>.218</td>
<td>.223</td>
<td>.225</td>
<td>.204</td>
</tr>
<tr>
<td>Mustard greens</td>
<td>.792</td>
<td>2.294</td>
<td>2.297</td>
<td>2.133</td>
<td>2.219</td>
<td>2.361</td>
</tr>
<tr>
<td>Baking powder</td>
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<td>.004</td>
<td>.009</td>
<td>.008</td>
<td>.015</td>
</tr>
<tr>
<td>*<em>Computed y</em> ($)**</td>
<td>3.145</td>
<td>4.979</td>
<td>4.846</td>
<td>4.850</td>
<td>4.898</td>
<td>5.257</td>
</tr>
<tr>
<td><strong>Computed y ($/individual)</strong></td>
<td>14.859</td>
<td>14.843</td>
<td>15.007</td>
<td>15.613</td>
<td>17.215</td>
<td></td>
</tr>
<tr>
<td><strong>Nutrients 1–4 Only: Protein, Vitamins A, D, and C</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
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<td>.206</td>
<td>.209</td>
<td>.212</td>
<td>.193</td>
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<tr>
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<td>2.865</td>
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<tr>
<td>*<em>Computed y</em> ($)**</td>
<td>1.495</td>
<td>3.378</td>
<td>3.291</td>
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<td>3.628</td>
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<td></td>
</tr>
<tr>
<td><strong>Nutrients 1–16 (Excludes Lipids, Carbohydrates)</strong></td>
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<td></td>
<td></td>
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</tbody>
</table>
DEMAND FOR TASTES

present, the smaller units, which are the lower-income groups in these data, pay more than reported. Thus on both accounts, the figures for y (actual expenditures) are if anything too high for the low-income groups and too low for the high-income groups. Correcting for such bias would have the effect of increasing the rate of change of $y/y^*$ as income increases. It is also likely that higher-income families are more highly educated and would therefore more likely have better information about nutrition than the lower-income families. This, too, would tend to reduce $y/y^*$ as income increases. In fact this ratio increases with income even in the presence of factors that might cause the ratio to go the other way.

The LP solutions that emerged for the three problems are unusual in that far fewer foods (approximately one-half) appeared in these solution matrices than would be expected. A fundamental theorem of linear programming states that, in an optimal solution, the number of nonzero variables will be no greater than the number of linearly independent constraints. Thus there might have been 18 foods appearing in part A of table 2, 16 in part B, and 4 in part C. In fact, there were only 8, 7, and 3, respectively. The foods utilized in the least-cost solution for the most part were nutritious (and inexpensive) in several nutrients. Interestingly, the same foods were used in the solutions to the three problems, with certain foods dropping out as constraints are deleted.

These solutions are strikingly similar to those presented by Stigler 40 years ago. The matrix of technical coefficients for the foods appearing in the LP solutions is given in table 3, along with the prices of those foods. When we take the households of group 4 as most closely representative of the median U.S. family in terms of size and income, the percentages of each nutrient total accounted for by consuming the goods in the LP solution are displayed in table 4, parts A–C, corresponding to the solutions (for group 4 households) presented in table 2, parts A–C. Also, part D of table 4 gives this same information for the traditional diet problem where the RDAs are used as the constraints.

In table 4, parts A–C, the top entry in each cell represents the actual amount of nutrient i provided by food j in the linear programming solution, $a_j x_j^*$. The lower entry represents the fraction of the constraint level of nutrient i that is provided by food j, that is, $(a_j x_j^*)/b_i$. These constraint levels, the $b_i$'s, are the amounts of nutrient i consumed in the actual diets by families in the $15,000–$19,999 range; these were the levels used in the LPDP for this income class. In the column headed $b_i^*$ are the row sums of the fractions of nutrient i provided by each food, that is, $b_i^* = \Sigma_j (a_j x_j^*)/b_i$. In part A, in which all 18 nutrients are used as constraints, necessarily, $b_i^* \geq 1, i = 1, \ldots, 18,$
<table>
<thead>
<tr>
<th>Nutrients per Pound: Foods in Minimum-Cost Diet</th>
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C. Fraction of Total Nutrients Provided by Each Food, Nutrients 1–4 Only

| Pounds | 5.548 | 9.816 | ... | ... | 2.679 | ... | ... | ... |
| Protein | .838 | 5.919 | ... | ... | .254 | ... | 7.011 | .999 |
| Vitamin A | .516 | .844 | ... | ... | 5.953 | ... | 4.897 | 1.321 |
| Vitamin D | 9.775 | ... | ... | ... | ... | ... | 9.775 | 1.000 |
| Vitamin C | .238 | ... | ... | ... | 8.251 | ... | 8.490 | 1.000 |
| Folacin | 1.276 | ... | 16.883 | ... | ... | ... | 18.500 | .982 |
| Niacin | .216 | 19.337 | ... | ... | ... | 19.931 | 1.017 | .036 |
### TABLE 4 (Continued)

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|                  | **D. Fraction of Total Nutrients Provided by Each Food Using RDAs** |              |               |             |            |             |                |               |       |        |
| Pounds           | .199         | ...           | 11.418       | .143         | .704       | ...        | .792           | .095          |       |        |
| Protein          | .030         | ...           | 6.885        | .078         | .301       | ...        | .075           | 3.920         | 1.880 |        |
| Vitamin A | .018 | ... | ... | .339 | 1.163 | ... | 1.760 | ... | .700 | 4.685 |
| Vitamin D | .351 | ... | ... | ... | ... | ... | ... | ... | ... | 350 | 1.003 |
| Vitamin C | .008 | ... | ... | .359 | 1.394 | ... | 2.439 | ... | 4.200 | 1.000 |
| Folacin   | .046 | ... | 19.639 | 2.216 | 6.104 | ... | ... | ... | 28.000 | 1.000 |
| Niacin    | .196 | ... | 22.493 | 1.622 | 5.935 | ... | .214 | ... | 12.600 | 2.418 |
| Riboflavin| .149 | ... | 6.166 | 1.357 | 4.998 | ... | .554 | ... | 11.200 | 1.180 |
| Thiamine  | .035 | ... | 28.431 | 1.201 | 4.435 | ... | .269 | ... | 9.800 | 3.508 |
| Vitamin B6| .039 | ... | 17.584 | 1.434 | 6.273 | ... | ... | ... | 15.400 | 1.644 |
| Vitamin B12| .328 | ... | 3.214 | 17.466 | ... | ... | ... | ... | 21.000 | 1.000 |
| Calcium   | .110 | ... | 2.124 | .080 | .099 | ... | .460 | ... | 2.723 | 5.600 | .999 |
| Phosphorus| .086 | ... | 19.262 | .219 | .847 | ... | .126 | ... | .672 | 5.600 | 3.787 |
| Iron      | .004 | ... | 17.127 | 1.377 | 5.669 | ... | .752 | ... | 7.000 | 3.562 |
| Magnesium | .123 | ... | 58.574 | .573 | 2.605 | ... | .681 | ... | 24.500 | 2.553 |
| Zinc      | .003 | ... | 1.187 | .024 | .191 | ... | ... | ... | 1.050 | 1.338 |
| Food energy| .045 | ... | 17.241 | .235 | 12.573 | ... | .078 | ... | .045 | 18.900 | 1.597 |
| Lipids    | .017 | ... | 1.039 | .010 | .149 | ... | .013 | ... | 0    | ...   |
| Carbohydrates | .043 | ... | 36.777 | .510 | 2.543 | ... | .141 | ... | .108 | 0    | ...   |
whereas in part B, \( b_i^* \geq 1, i = 1, \ldots, 16 \), and in part C, \( b_i^* \geq 1, i = 1, \ldots, 4 \). (In some cases \( b_i^* = 0.999 \) because of rounding error.)

Tables 2, part C, and 4, part C, are interesting in terms of the nutritional properties of low-fat milk, wheat flour, and mustard greens. These three foods appear to provide quite a healthy diet. Although chosen to satisfy only the protein and vitamins A, D, and C constraints, they approximately satisfy the constraints for most other nutrients; only vitamin \( B_{12} \) is deficient in terms of its RDA.

In all the LP solutions, there were some foods whose inclusion would not substantially alter the minimum expenditure levels. Skim and whole milk were very close substitutes for low-fat milk, and various green vegetables—particularly broccoli, collards, and cabbage—could be substituted for mustard greens without dramatically affecting the cost of the diet. (Stigler's solutions involved cabbage and spinach.) These foods all had indirect costs (imputed values) only slightly in excess of their actual costs.\(^{11}\) Other foods for which this is true are orange juice, grapefruit, and white potatoes. Only a small amount of meat, in the form of pork chops, appeared in the LP solutions, and then only when the two large sets of nutrients (but not when the actual RDAs) were used as constraints. Wheat flour provides the bulk of protein in these diets.\(^{12}\)

\section*{D. Inferior Goods}

Whereas certain final goods in consumption may be inferior, it is difficult to imagine why increased income would reduce the demand for nutrition. With the exception of movement from income class 1 to class 2, which may be a measurement problem, the nutrients studied are in fact virtually all normal, at all income levels, though the income elasticities appear to be very low.\(^{13}\) Although these nutrients are normal, consumers choose to arrange for the consumption of these nutrients differently as income increases. In fact, though inferiority of various foods is apparent in the data, there are surprisingly few instances of dramatic inferiority. The only foods that exhibit marked inferiority are processed milk, hot oat cereals (though oatmeal is inferior at the lower incomes while hot wheat cereal is inferior at higher incomes), cornmeal, stewing beef (but not at the highest income level), liver, bacon, and, among vegetables, collards, mustard greens, and

\(^{11}\) The LINDO LP program provides these indirect costs as part of the output. The foods listed above had indirect costs of less than 10¢ per pound.

\(^{12}\) No distinction of protein by amino acid composition has been made in this paper. Such a consideration might increase the utilization of meat in the LP solutions.

\(^{13}\) One would expect to find larger income elasticities for consumers with incomes lower than that represented by the lowest income group in these data.
dried beans. Strikingly not particularly inferior are such textbook examples as hamburger, margarine, and white potatoes. The per capita weekly consumption of these foods plus bread and butter is displayed in table 5. These data clearly do not support either Alfred Marshall’s (1920) example of bread or textbook examples of potatoes during the Irish potato famine as possible Giffen goods, assuming stability of tastes over time.14

IV. Conjectures and Conclusions

The minimum-cost diets presented in this paper are the kinds of diets that would be provided to slaves, although the calorie level might be elevated. In fact the diet of American slaves in the antebellum South resembled these solutions (see, e.g., Fogel and Engerman 1974; Barzel 1977; Kahn, in press).

It would seem that other aspects of consumers’ behavior should be amenable to the framework utilized in this paper. Consider, for example, the choices consumers make about automobiles. In addition to transportation between two locations, cars also provide varying degrees of style and comfort along the way. One should expect rapidly diminishing returns to the pure transport function of cars. Thus as incomes rise, one would expect a greater fraction of the price of a car to be attributable to style and comfort, and less to pure transportation. The development of modern cars from the early Model T’s certainly confirms this, but technological change is obviously also present. On a cross-sectional basis, it seems that various options (e.g., power steering) tend to become more commonly consumed as income rises. It would probably be difficult to purchase a stripped-down Cadillac or other car purchased mainly for the well-to-do.

A similar analysis would apply to the case of housing. One should

14 See also the recent article by Dwyer and Lindsay (1984).
expect rapidly diminishing returns to the pure shelter component of housing, that is, keeping warm and dry. As income rises, one should therefore expect to see a greater proportion of housing expenses directed toward commodiousness and less toward pure shelter. One would, for example, predict that the price of houses would increase in greater proportion than various hedonic measures of shelter such as square footage, after adjusting for the price of the lot on which the house stands. Applying theory in this manner may reveal new refutable implications about consumer behavior.

Appendix

The following is a list of all foods utilized in this paper.

1. **Milk products**: whole, buttermilk, skim, low-fat, yogurt, chocolate, evaporated, condensed, dry.
2. **Cream**: light, heavy, half-and-half, sour, powdered creamers, semisolid toppings, ice cream, ice milk, sherbet.
3. **Cheese**: American, Swiss, 2 percent cottage, cream, spreads, parmesan.
4. **Fats, oils**: butter, margarine, animal fat, vegetable oil, salad oil, regular mayonnaise, imitation mayonnaise, French dressing, low calorie, other.
5. **Flour, cereal**: wheat, other; mixes: pancake, biscuit, cake, pie, cookie, other; hot oat, hot wheat cereal; cold corn, wheat, rice, oat cereal; cornmeal, grits, macaroni, popcorn, cornstarch.
6. **Bread**: white, whole wheat, other.
7. **Bakery products**: crackers, rolls, muffins, cakes, pies, cookies, sweet buns, doughnuts, pretzels; roll, biscuit, and pancake batters.
8. **Beef**: steaks: round, sirloin, porterhouse, hamburger, other; roasts: chuck, rib, round, rump, corned and chopped beef, canned.
9. **Pork**: chops, ham, loin, sausage, other; cured ham, bacon, salt pork, other cured pork, canned.
10. **Veal**: chops, roast, stewing.
11. **Lamb**: chops, roast, stewing.
12. **Miscellaneous**: liver, miscellaneous lunch meats, franks, bologna.
13. **Fish**: fresh/frozen, smoked, canned tuna, other canned, shellfish.
14. **Eggs**: fresh, processed.
15. **Sugar, sweets**: granulated, powdered, brown; syrups: corn, maple, molasses, honey; jelly, jam, candy/toppings with/without chocolate or nuts, dry gelatin pudding, ready-to-eat pudding; ices/popsicles, icings.
16. **Potatoes**: white, sweet, canned white, canned sweet, french fries, dried, chips.
17. **Fresh vegetables**: spinach, kale, collards, mustard greens, other dark green; broccoli, peppers, carrots, pumpkin/squash, tomatoes, asparagus, lima beans, snap/wax beans, cabbage, lettuce, okra, peas, other green, celery, cucumbers, onions, green onions, beets, cauliflower, corn, turnips, other.
18. **Fresh fruits**: grapefruit, lemons/limes, oranges, other citrus, cantaloupe, strawberries, apples, bananas, cherries, other melons, peaches, pears, apricots, avocados, grapes, pineapple, plums, rhubarb.
19. **Canned vegetables**: dark green, deep yellow, tomatoes, asparagus, baked beans, lima beans, snap beans, beets, corn, green peas, sauerkraut, other.

20. **Canned fruits**: citrus, apples, apricots, cherries, peaches, pears, pineapple, mixed, berries, other.

21. **Frozen vegetables**: leafy, broccoli, deep yellow, asparagus, lima beans, snap beans, green peas, corn, mixed, other, strawberries, other frozen fruit.

22. **Juice**: canned tomato, other vegetable, orange, grapefruit, other citrus, apple, grape, pineapple, other noncitrus; frozen orange, frozen noncitrus (grape), fresh citrus.

23. **Dried vegetables, fruits**: beans, peas/lentils, prunes, raisins, other.

24. **Beverages**: coffee, tea, chocolate, cola, fruit, diet, fruit ade, beer, whisky, wine.

25. **Soups**: ready-to-serve meat; condensed grain, meat, mushroom, tomato; dehydrated grain, meat, vegetable.

26. **Nuts, condiments**: peanuts in shell, shelled; other nuts, peanut butter, cat-sup, barbecue sauce, pickles, olives, relish.

27. **Leavenings**: yeast, baking powder.

28. **Baby food**: meat, egg yolk, vegetable, fruit, juice; mixtures: mostly grain, meat, vegetable, fruit, cereal, teething biscuits.

**References**


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