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# Will Developing Country Nutrition Improve with Income? A Case Study for Rural South India

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The World Bank and others maintain that the major mechanism for improving nutrition in poor communities is increases in income. Aggregate estimates of food expenditure are consistent with such a possibility, implying income/expenditure elasticities close to one. However, the high degree of aggregation at which such estimates are made means that the considerable increase in price per nutrient as income increases is ignored, and the nutrient elasticities are therefore overstated. Estimates for a rural south Indian sample indicate that this bias is considerable and that the true nutrient elasticities with respect to income may be close to zero.

Malnutrition is thought by many analysts and policymakers to be a great and widespread problem in the developing world. One widely held view is that such malnutrition will disappear only with the improvements in income that accompany the development process. The World Bank (1981, p. 59) articulates this view forcefully: "There is now a wide measure of agreement on several broad propositions. . . . Malnutrition is largely a reflection of poverty: people do not have income for food. Given the slow income growth that is likely for the

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poorest people in the foreseeable future, large numbers will remain malnourished for decades to come. . . . The most efficient long-term policies are those that raise the income of the poor."

However, recent reviews of existing studies of nutrient determinants in developing countries lead to a less confident appraisal of the prospects for substantial nutrient improvements as income increases in the process of economic development (e.g., Poleman 1981; Behrman and Deolalikar 1987). True, some studies are interpreted to reflect high elasticities of nutrient intakes with respect to income or expenditure. Prima facie, such studies seem to provide strong support for the World Bank claim noted above. But other studies suggest that nutrient elasticities with respect to expenditure or income are fairly low. If such studies are to be believed, substantial nutrient improvements do *not* automatically accompany increases in income in the process of development.

How might these various results be reconciled? We believe that a possible problem with many of the studies that suggest high elasticities is a confusion between food expenditure and nutrient elasticities. The more sophisticated of these studies from the point of view of economists—for example, Murty and Radhakrishna (1981), Strauss (1982), and Pitt (1983)—estimate food expenditure systems for a relatively small number of food aggregates and then assume that nutrient elasticities equal food elasticities at that level of aggregation by using constant nutrient-to-food conversion factors to translate from the food elasticities to the nutrient elasticities.

But, as many have emphasized, food serves many purposes in addition to the provision of nutrients. Equally nutritious foods may vary in attractiveness, for example, because of differences in taste, appearance, odor, status value, and degree of processing. Even within the categories that are used for estimation of food elasticities, whether they be as broad as "grains" or as narrow as "rice," substantial heterogeneity with respect to these nonnutritive attributes is the rule. Shah (1983) has argued that, even at low levels of income, considerable weight is given by households and individuals to such attributes as taste in making marginal food demand decisions, at least in comparison with the weight placed on nutrition.[1] If this is indeed the case, it is possible, as Behrman and Wolfe (1984) have conjectured, that high *food* income elasticities may be consistent with low *nutrient* in-

[1] Silberberg (1985) recently has presented results consistent with this conjecture for the much higher per capita income population of the United States. He calculated least-cost diets for given nutrient intakes by using linear programming. He notes that the ratio of actual to least-cost expenditure on nutrients increases with income and interprets this result as Shah (1983), Behrman and Wolfe (1984), and Greer and Thorbecke (1984) do.

come elasticities. Greer and Thorbecke (1984, p. 71) speculate that significantly higher food expenditure elasticities than calorie elasticities may prevail in poor Kenyan populations because "a strong demand for tasty and palatable foodstuffs as opposed to calories per se [may display] itself at low household income."

In the present paper our contribution is to explore this possibility for a relatively poor, malnourished sample from rural south India. Our procedure is to compare directly reduced-form elasticity estimates for major food expenditures with those for major nutrients. For the determinations of each food and each nutrient intake we compare the expenditure elasticities obtained from two specifications: a simple linear relation with geographical and time-dichotomous variables to control for differing prices and other characteristics in different markets and with household demographic characteristics in addition to expenditures, and a differenced version to control for fixed effects. These fairly simple estimated relations give important insights into the assertion by the World Bank (1981) and others that economic development will lead to substantial improvements in nutrient intake among members of currently poor populations.

## I. Theoretical Underpinning for Reduced-Form Food and Nutrient Expenditure Relations

Our estimated reduced-form food and nutrient relations are consistent with a household model of constrained maximization. For the purpose of this study, among the arguments in the household preference function is a vector of foods, each element of which has distinctive attributes concerning characteristics such as taste, odor, appearance, and status value. Among the other arguments are included some, in particular health status, that depend in part on food consumption. The preference function is assumed to be separable between arguments directly and indirectly affected by current consumption and other arguments so that we can ignore questions related to savings.

The relevant constraints include the budget constraint for total current expenditures given such expenditures and market prices; a health production function given nutrient intakes, other health-related choice variables, and predetermined endowments; and production functions for each of the relevant nutrients as related to the vector of food intake.

Solution of the first-order conditions under the standard assumption that the relevant functions have desirable properties so that there are interior solutions gives, among other relations, reduced-form demand equations for per capita expenditures on different foods[2] and per capita quantities of different nutrients. Linear approximations[3] to these reduced forms are

$$\mathbf{F} = \mathbf{AP} + \mathbf{b}E + \mathbf{c}H + \mathbf{d}C + \mathbf{u}, \quad (1)$$

$$\mathbf{N} = \mathbf{EP} + \mathbf{f}E + \mathbf{g}H + \mathbf{h}C + \mathbf{v}, \quad (2)$$

where **F** is a vector each element of which is the expenditure on a specific food group, **P** is a vector each element of which is a relevant product price, $E$ is total expenditure,[4] $H$ is household endowments, $C$ is village endowments other than relative price structures, **A** and **E** are coefficient matrices, **b, c, d, f, g,** and **h** are row vectors of coefficients, and **u** and **v** are vectors of stochastic terms.

Our basic interest in this study is to obtain and to compare estimates of **b** and **f** to see whether nutrient intake responses to expenditure are substantial and whether they differ significantly from food expenditure responses. A further question to which relations (1) and (2) point is whether or not the expenditure elasticities are sensitive to a priori zero restrictions on coefficients. That is, do the expenditure elasticities differ between the standard demand equation without household fixed-effects estimates (with **c** and **g** implicitly constrained to zero) and the demand equation with fixed effects? A priori, differences might occur because of omitted variable biases, but the importance of such differences is a matter for empirical exploration.

[2] As alternatives we have estimated relations with per capita quantities of food groups as the dependent variables. We also have estimated relations with measures of food expenditure and nutrients per adult equivalent and with no deflation by an indicator of household size. We further have estimated logarithmic relations. The basic implications of these alternative estimates for the elasticities are the same as those we present below.

[3] Behrman and Wolfe (1984) conjecture that the income or expenditure elasticities for food may be inversely associated with income levels, which may help to explain the patterns of reported elasticities across societies. They present estimates for Nicaragua that indicate a significant, though not very large, inverse association between income elasticities and income levels. Pinstrup-Andersen and Caicedo (1978), Timmer and Alderman (1979), and Murty and Radhakrishna (1981) report more substantial declines in income elasticities as income increases for other developing countries. We have explored the conjecture about an inverse association between income elasticities and income by estimating alternative relations with a quadratic in expenditure added but have not found evidence of a significant effect of this term at the 10 percent level. For simplicity, therefore, we present only the linear estimates. More sophisticated expenditure systems have been presented recently, such as the "almost ideal demand system" of Deaton and Muellbauer (1980*a*, 1980*b*). However, we focus on the linear system here because that is the form utilized in the recent prominent studies that have obtained relatively high nutrient elasticities with respect to expenditure by first estimating expenditure relations and then converting the results to nutrient elasticities.

[4] Total expenditure includes expenditures on durables and semidurables, but these are such a small part of total expenditure in the sample used in this study that excluding them does not materially change the estimates from those that are given below.

## II. Direct Estimates of Nutrient Elasticities versus Indirect Estimation from Expenditure Systems and Aggregation

Two approaches are common for the estimation of nutrient elasticities with respect to total expenditure (or income, profits, or wealth, but hereafter referred to as expenditure): (i) estimating food demand/expenditure systems as in relation (1) for a relatively small number of food groups and then converting the elasticities obtained from these to nutrient elasticities with respect to expenditure at the same level of aggregation (e.g., Murty and Radhakrishna 1981; Strauss 1982; Pitt 1983), or (ii) estimating directly the reduced-form demand for nutrients as in relation (2) (e.g., Levinson 1974; Timmer and Alderman 1979; Ward and Sanders 1980; Wolfe and Behrman 1983; Behrman and Wolfe 1984; Pitt and Rosenzweig 1985). The nutrient expenditure elasticities obtained vary widely: for calories, from lows of 0.0–0.1 for Managua, Nicaragua (Wolfe and Behrman), and Indonesia (Pitt and Rosenzweig) to a high of 0.9 for rural Sierra Leone (Strauss); for proteins, from 0.0–0.1 for small children in rural India (Levinson) and households in Indonesia (Pitt and Rosenzweig) to 0.6–0.8 for rural Bangladesh (Pitt). The nutrient expenditure elasticities estimated by the former (indirect expenditure system) approach tend to be larger than those obtained by the latter direct estimation approach.

Some of the authors have been explicitly aware of the alternative approaches. But most authors have proceeded with one or the other approach without explanation for their choice or any explicit awareness that the choice might make a difference. Pitt, however, adopted the expenditure system approach because he claims it is superior. After describing it, he states: "Calculating nutrient elasticities in this manner seems clearly preferable to the procedure adopted by Alderman and Timmer . . . . They estimated a separate regression having calories as a dependent variable with prices, income and other exogenous variables as regressors. Such an approach is uncalled for since all the parameters of the true calorie-price relationships are completely identified from the individual demand equations" (1983, p. 110).

We now demonstrate that operationally the choice may make a difference, that the expenditure system approach at the level of aggregation at which it is typically applied tends to result in higher estimates of nutrient elasticities with respect to expenditure than the direct estimates, and that the direct estimates probably lead to better, though still possibly upwardly biased, estimates.

Define total nutrients consumed of a particular type (e.g., calories) as

$$n = \sum_i k_i f_i, \qquad (3)$$

where $n$ is the quantity of this nutrient consumed, $k_i$ is the average nutrient content of a unit of food $i$, and $f_i$ is the number of units consumed of food $i$. The total expenditure elasticity for this nutrient is

$$\eta_{nE} = \sum_i \theta_i \eta_{f_i E} + \sum_i \theta_i \eta_{k_i E}, \qquad (4)$$

where $\eta_{XY}$ is the elasticity of $X$ with respect to $Y$, and $\theta_i$ is the share of the total nutrient consumed obtained from food group $i$. Since expenditure on the $i$th food group is $E_i = p_i f_i$, the expenditure elasticity of food demand for the $i$th food group is

$$\eta_{f_i E} = \eta_{E_i E} - \eta_{p_i E}, \qquad (5)$$

where $E_i$ is the expenditure on the $i$th food group, and $p_i$ is the unit price of the $i$th food group. Substitution of equation (5) into equation (4) yields

$$\eta_{nE} = \sum_i \theta_i \eta_{E_i E} - \sum_i \theta_i \eta_{p_i E} + \sum_i \theta_i \eta_{k_i E}. \qquad (6)$$

But $p_i/k_i$ (say, equal to $q_i$) is simply the average cost of the nutrient obtained from food group $i$, so equation (6) can be rewritten as

$$\eta_{nE} = \sum_i \theta_i \eta_{E_i E} - \sum_i \theta_i \eta_{q_i E}, \qquad (7)$$

where $q_i$ is the average cost of the nutrient when obtained from food group $i$.

Indirect expenditure-system-based estimates of the nutrient elasticities with respect to expenditure effectively assume that the second right-side term in relation (7) is zero. There is evidence, however, to suggest that this is not the case. Radhakrishna (1984), for example, reports that the average cost of calories obtained from each of six broadly defined food groups increases monotonically with total expenditure for both rural and urban households in the 1970–71 Indian National Sample Survey. For instance, while the average cost of a calorie from milk and milk products is 0.078 paise (100 paise equal 1 rupee) for the lowest rural expenditure group (0–18 rupees per month), it is 0.133 paise for the highest rural expenditure group (at least 75 rupees per month). Pitt (1983) also observes the same tendency in his sample for rural Bangladesh. The twenty-fifth percentile household (from the top) spent 22 percent more per gram of protein, 15 percent more per calorie, and 44 percent more per milligram of iron than did the ninetieth percentile household. Such systematic changes in the unit cost of nutrients from food groups as total expenditure increases are consistent with people considering nonnutritive qualities—taste, appearance, status, convenience, processing—in their marginal food choices within food groups.

If the elasticities of the average costs of a nutrient within food groups with respect to total expenditure ($\eta_{q_t E}$) indeed are positive, relation (7) implies that the weighted sum of elasticities of food expenditures with respect to total expenditure overstates the elasticity of the nutrient with respect to total expenditure (i.e., $\eta_{nE} < \Sigma_i \theta_i \eta_{E_t E}$). This result applies to both indirect expenditure-system-based estimates and direct nutrient elasticity estimates. However, in practice most expenditure-based studies utilize a relatively high level of aggregation of foods. For instance, Murty and Radhakrishna (1981) and Pitt (1983) use nine food groups and Strauss (1982) uses only five. In contrast, studies that directly estimate nutrient demand typically use nutrient data that are calculated from the consumption of a much larger number of detailed foods, sometimes including different varieties of the same food.[5] Therefore, the fixed food-nutrient conversion factors used by the expenditure-system-based studies are much less sensitive to intra-food-group substitution of higher-nutrient-cost foods for lower-nutrient-cost foods with increased total expenditure. Thus indirect nutrient elasticities with respect to total expenditure from expenditure-system-based studies with typical levels of aggregation result in overestimates of the true elasticities and larger estimates than the direct estimates based on more detailed food data.[6] Whether the extent of the difference is large enough to be important, of course, is an empirical question, on which we focus in this study. If there are possibilities of intrafood substitution within the more detailed food groups typically used in direct nutrient estimates, as certainly appears to be the case (e.g., the substitution among a number of

[5] Not all direct estimates use a relatively large number of foods. For example, Timmer and Alderman (1979) present estimates based on nutrients obtained from just three foods (i.e., rice, corn, and fresh cassava) and indeed report relatively high income elasticities (i.e., 0.7–0.8 for low-income classes, though they decline for higher-income classes).

[6] As a referee has pointed out, another way of characterizing our point is that aggregate nutrient price indices are endogenous and should be treated as such in empirical estimates. An illustration is provided by the two-stage budget literature (e.g., Deaton and Muellbauer 1980*b*), in which, given the conditions for a group price index to exist for the allocation of expenditures among commodity groups, that index in general depends on the reference real income (or utility) level. In empirical work, however, these prices are not properly treated as endogenous. Instead, in some cases household-level weights are used, thus ignoring the endogeneity (e.g., Lau, Lin, and Yotopoulos 1978). In other cases, the endogeneity of the household weights is recognized by using market-level weights but at a high level of food group aggregation (e.g., Strauss 1982; Pitt 1983).

rice varieties in most societies in which rice is the basic staple), moreover, even the direct nutrient elasticities tend to be biased upward.

## III. Data

We use a subsample from the International Crops Research Institute for the Semi-Arid Tropics Village Level Studies (ICRISAT VLS) panel data set for rural south India to explore these issues. These data have been collected from 240 households in six carefully selected "typical" villages in three different agroclimatic zones in two states in semiarid tropical India. Within each village 10 households are randomly selected representatives of agricultural labor and nonlandholding households and another 30 are a stratified (by size of landholding) random sample of cultivating households. For the 1976–77 and 1977–78 crop years, special nutrition surveys were undertaken, from which individual nutrient intakes during the previous 24 hours were recorded.[7] For three of the ICRISAT villages (one from each agroclimatic zone), expenditure data are also available for these two crop years. These expenditure data were constructed by evaluating own farm produced and consumed food at average village prices for that food and adding such values to market expenditures on that food to obtain total expenditures on that food. We use data for these three villages for these two crop years for our sample.

The special nutrition surveys provide information on nine nutrient intake measures: calories, protein, calcium, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid. These nutrients were calculated by applying Indian nutrient/food conversion factors from Gopalan, Sastri, and Balasubramanian (1971) to 120 foods for which direct observations on consumption were made in the nutrient surveys. While this number of foods is not large in comparison to the number consumed in higher-income and more urban societies, it is large in comparison to the number of foods typically used at the estimation stage of indirect expenditure-system-based estimates of nutrient elasticities (see Sec. II).[8]

Table 1 gives the means, standard deviations, and the coefficients of variation for all the data we use. Examination of this table suggests that our sample is generally malnourished in comparison with Indian

[7] For further details concerning the ICRISAT VLS data, see Binswanger and Jodha (1978) and Ryan et al. (1984).

[8] We focus in this paper on average household nutrient and food intakes to avoid unnecessary complexities and to facilitate comparisons with studies by others. In others of our studies we have explored various dimensions of intrahousehold allocation of nutrients for this sample (see Behrman 1986, 1987; Behrman and Deolalikar 1986, 1987).

TABLE 1

MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION FOR BASIC FOOD EXPENDITURES AND NUTRIENTS IN THREE RURAL SOUTH INDIAN VILLAGES, 1976–77 AND 1977–78

| | Mean | Standard Deviation | Coefficient of Variation |
|---|---|---|---|
| Foods expenditures (per capita):* | | | |
| Grains | 177 | 79 | .53 |
| Sugar | 26 | 23 | .85 |
| Pulses | 17 | 24 | 1.20 |
| Vegetables | 31 | 19 | 1.08 |
| Milk | 26 | 34 | 1.06 |
| Meat | 10 | 12 | .66 |
| Total expenditures | 455 | 232 | .54 |
| Nutrients (quantities per capita):† | | | |
| Calories | 90 | 22 | .25 |
| Protein | 116 | 34 | .30 |
| Calcium | 71 | 56 | .79 |
| Iron | 111 | 42 | .38 |
| Carotene | 19 | 21 | 1.11 |
| Thiamine | 113 | 60 | .53 |
| Riboflavin | 72 | 66 | .92 |
| Niacin | 91 | 28 | .31 |
| Ascorbic acid | 32 | 21 | .64 |

NOTE.—The statistics in this table are based on 210 observations for which the necessary data are complete. For details concerning the data, see Binswanger and Jodha (1978) and Ryan et al. (1984).
* In rupees per person per year.
† We present the nutrient quantities as percentages of recommended daily allowances from Gopalan et al. (1971) so the reader can easily have a perspective about the level of nutrition in this population, even though we use the raw numbers for the estimates.

standards, particularly for carotene and ascorbic acid, in which cases less than half of the Indian standards are met at the sample means. Also, less than three-quarters of the Indian standards are met at the sample means for calcium and riboflavin. Only for proteins, iron, and thiamine among these nine nutrients are the sample averages above Indian standards. The coefficients of variation for these nutrient intakes are relatively large for carotene and riboflavin, both with values greater than 0.90, indicating substantial fluctuations in consumption across households. At the other end of the spectrum, the variations across households are relatively small (below 0.40) for calories, protein, niacin, and iron.

For comparability we use food and total expenditure data over the same two crop years from the same households for which nutrition data are complete as the basis for food intake quantities of six basic foods: sugar, pulses, vegetables, milk, meat, and grains. This number of food aggregates is of the same order of magnitude as those typically used at the estimation stage of indirect expenditure-system-based estimates of nutrient elasticities (see Sec. II) and reflects substantially greater aggregation than used to calculate the nutrient intakes for this sample. Together these six foods average 61 percent of total expenditures, reflecting the dominance of food in expenditures for these poor households. By far the most important are the grains, which account for 65 percent of total food expenditures. Relative variations in expenditures are least for grains and only half as large for grains as for milk, pulses, and meat.

Because of the fragmented nature of markets for these products in rural south India, there is price variation among the villages as well as over time. But there are also other relevant systematic variations among the villages beyond those in the price structure. For example, there are compositional differences in the varieties of agricultural products grown and consumed because of the agroclimatic differences across the three zones. In relations (1) and (2) we indicate such possibilities by including the community endowment variable ($C$). However, for our data set we would not be able to obtain separate estimates of the effects of such nonprice community endowments and of the price effects even if the former were observed since for such variables we effectively have only six observations (i.e., three villages for two years). Therefore, we control for the combination of community price structures and other relevant nonprice community endowments by using a dichotomous variable for each village (with one village as the reference point) and for each crop year (with 1977–78 as the reference point). That is, in relations (1) and (2) we effectively are combining the community price structure in $\mathbf{P}$ and the community nonprice endowments in $C$ into one community variable, with an added control for systematic differences across the crop years. This procedure does not allow us to estimate elasticities for prices and for community endowments, but it does permit control for systematic differences across the villages in our estimates of the food expenditure and nutrient elasticities, which are what we are interested in for this study.

## IV. Estimates

### *Food Expenditure Elasticities: Relation (1)*

We have estimated two variants of this relation:

$$\mathbf{F} = \mathbf{b}E + \mathbf{MD} + \mathbf{u}_1, \quad \text{(F1)}$$

$$\Delta\mathbf{F} = \mathbf{b}\Delta E + \mathbf{u}_2, \quad \text{(F2)}$$

where $\mathbf{D}$ is a nine-element vector of control variables, including dichotomous variables with values of one for specific villages and for observations from the 1976–77 crop year, household size, household size squared, the proportion of the household that is adult males, the proportion of the household that is adult females, and the age and years of schooling of the household head; **M** is a coefficient matrix; $\Delta$ refers to the difference between crop years; and the subscripts on the $\mathbf{u}_i$ reflect that the stochastic terms differ between these two variants. The second variant controls for all village and household fixed endowments through differencing between the crop years.[9]

Both variants were estimated using instrumental variable methods to purge the estimate of potential simultaneous equations bias arising out of the possible endogeneity of total expenditure. There is a large literature on farm household models (e.g., Lau et al. 1978; Barnum and Squire 1979; Strauss 1982; Pitt and Rosenzweig 1985; Behrman and Deolalikar 1986, 1987; Singh, Squire, and Strauss 1986) that argues that if markets are incomplete or if labor productivity depends on consumption, the production and consumption decisions of farm households are not separable and recursive. Hence, household income or expenditure cannot be treated as predetermined or exogenous in the food or nutrient demand relations.[10]

The top part of table 2 presents the estimates of the two variants of the food expenditure relations for the six food groups.[11] For all the foods, the expenditure elasticities of interest are significantly[12] positive in the first variant, with values at the points of sample means ranging from 0.54 for grains to 3.27 for milk. Controlling for household fixed effects in the second variant causes a significant increase in the estimated expenditure elasticity for grains and a significant decline in that for milk. These comparisons suggest that standard estimates that do not control for fixed household effects overstate the

[9] In addition, for both of the variants, estimates were made with the addition of a quadratic term in expenditures (or the difference in such a term for the second variant). These test whether the expenditure elasticities vary with expenditure levels. For none of these alternatives, however, is the coefficient estimate of the quadratic term significantly zero even at the 10 percent level. Therefore, we focus exclusively in what follows on the linear expenditure variants. See also n. 3.

[10] The instruments are indicated in the note to table 2. The instrumental variable estimates do not differ in their basic implications from ordinary least squares estimates.

[11] We do not present the coefficient estimates for the control variables in table 2 in order to keep the presentation concise. Briefly, the significant coefficients include household size (with a negative coefficient for the linear term and a positive one for the quadratic term, consistent with economies of scale also reported by Wolfe and Behrman [1983] and Behrman and Wolfe [1984]) and, in about half of the cases, the proportion of the household that is adult males (with a positive sign). The coefficient estimates of interest for total expenditures do not change significantly if these control variables are excluded.

[12] We use the standard 5 percent level of significance here and below unless we otherwise qualify "significant."

TABLE 2

ORDINARY LEAST SQUARES AND INSTRUMENTAL VARIABLE ESTIMATES OF LINEAR PER CAPITA FOOD EXPENDITURE AND NUTRIENT DEMAND EQUATIONS: RURAL SOUTH INDIA, 1976–77 AND 1977–78

| DEPENDENT VARIABLE | RELATION | TOTAL EXPENDITURE VARIABLE | | | $R^2$ | F-RATIO |
|---|---|---|---|---|---|---|
| | | Coefficient | T-Ratio | Elasticity* | | |
| Food type: | | | | | | |
| Grains | Levels | .210 | 5.6 | .54 | .52 | 21.95 |
| | First-difference | .588 | 6.9 | 1.52 | .34 | 46.96 |
| Sugar | Levels | .055 | 7.5 | .95 | .81 | 84.10 |
| | First-difference | .033 | 2.2 | .57 | .05 | 4.68 |
| Pulses | Levels | .036 | 2.4 | .95 | .34 | 10.42 |
| | First-difference | .038 | 1.3 | 1.00 | .02 | 1.66 |
| Vegetables | Levels | .041 | 5.6 | .61 | .70 | 45.95 |
| | First-difference | .034 | 2.3 | .51 | .06 | 5.37 |
| Milk | Levels | .183 | 7.7 | 3.27 | .35 | 10.68 |
| | First-difference | −.007 | .2 | −.13 | .00 | .06 |
| Meat | Levels | .022 | 2.5 | 1.00 | .11 | 2.50 |
| | First-difference | .023 | 2.0 | 1.05 | .04 | 4.16 |
| Nutrient: | | | | | | |
| Calories | Levels | .614 | 1.0 | .17 | .19 | 4.51 |
| | First-difference | 1.378 | 1.0 | .37 | .01 | .98 |
| Protein | Levels | .006 | .4 | .06 | .20 | 5.01 |
| | First-difference | .018 | .4 | .19 | .00 | .19 |
| Calcium | Levels | .000 | .9 | .30 | .28 | 7.79 |
| | First-difference | −.000 | .2 | −.22 | .00 | .03 |
| Iron | Levels | −.006 | .6 | −.11 | .29 | 8.18 |
| | First-difference | .016 | .6 | .30 | .00 | .40 |
| Carotene | Levels | .184 | .5 | .19 | .24 | 6.15 |
| | First-difference | 1.906 | 2.0 | 2.01 | .04 | 3.98 |
| Thiamine | Levels | −.000 | .4 | −.08 | .27 | 7.18 |
| | First-difference | .001 | .4 | .18 | .00 | .13 |
| Riboflavin | Levels | .001 | 1.7 | .69 | .17 | 3.96 |
| | First-difference | .000 | .0 | .01 | .00 | .03 |
| Niacin | Levels | −.004 | .7 | −.15 | .21 | 5.37 |
| | First-difference | .006 | .4 | .21 | .00 | .19 |
| Ascorbic acid | Levels | .003 | .4 | .15 | .19 | 4.80 |
| | First-difference | .029 | 1.2 | 1.25 | .15 | 1.45 |

NOTE.—The number of observations was 210 for the levels equations and 94 for the differenced equations. For the levels equations, the other (control) variables included were household size, household size squared, the proportion of the household that is adult males, the proportion of the household that is adult females, the age and schooling years of the household head, and the various village and year dummies. None of the other coefficients are reported here for the sake of brevity. Instruments used for total expenditure were farm size (operated area in hectares), percentage of farm area under deep (high-fertility) soil, family size, proportions of the household that are adult males and females, age and schooling years of the household head, total annual rainfall in the village of residence, and various village and year dummies. For the differenced equations, only the first difference of total expenditure was included as a right-side variable. The same instruments used in the levels equations were used for the differenced equations.

* Evaluated at the sample means.

extent to which milk is a luxury and understate the extent to which grain demand is expenditure responsive.[13]

For the purpose of the present paper, the most important question is, What is the order of magnitude of the food expenditure elasticities for these rural south Indian households? The answer is close to one: 0.77 for the weighted average of the level estimates in the first alternative and 1.18 for the weighted average of the differenced estimates in the second alternative. Such estimates are of the same order of magnitude as are those reported in other recent expenditure-system-based studies of samples from poor populations (e.g., Murty and Radhakrishna 1981; Strauss 1982; Pitt 1983). If fixed nutrient/food conversion factors are applied at the level of aggregation of these food groups, the implied nutrient expenditure elasticities are of the same order of magnitude since they are weighted averages of the food expenditure elasticities. Therefore, such results would suggest that nutrient intakes increase roughly in line with total expenditure or income.

*Nutrient Expenditure Elasticities: Relation (2)*

We have estimated two variants of relation (2) for nutrients by instrumental variable procedures, exactly parallel to those for relation (1) for food (bottom part of table 2). These nutrient expenditure elasticities are easily summarized. For carotene the differenced relation implies a significant elasticity of 2.01 at the points of sample means. For all other nutrients for both variants (and for carotene for the first variant), there are no significant positive expenditure elasticities.

## V. Concluding Remarks

These estimates are for fairly poor communities by world standards or even by Indian subcontinental standards. They point to the possible importance of appropriate controls for fixed effects in obtaining refined estimates of expenditure elasticities for food and nutrients.

But the really important result is not altered by such refinements: while food expenditure elasticities and therefore indirect nutrient

[13] The comparison between the two variants for milk is consistent with random measurement error in the total expenditure variable being relatively large so that the coefficient is biased toward zero relatively in the differenced estimates. However, for no other food group is the differenced estimate significantly less than the level estimate. Moreover, for grains there is a significant increase, which is consistent with a large serially correlated measurement error so that the level estimate is biased toward zero more than the differenced estimate (see Behrman 1984). Therefore, the comparison of the two variants does not suggest a consistent measurement error interpretation.

expenditure elasticities based on typical food aggregates are on the order of magnitude of one, direct nutrient expenditure elasticities are not significantly positive.[14] The level of aggregation at which fixed nutrient/food conversion factors are applied is critical, and that typically used in expenditure-system-based estimates leads to substantial overestimates of nutrient elasticities with respect to total expenditure.[15] Therefore, in sharp contrast to the strong position of the World Bank (1981) and others summarized in the Introduction and to the implication of indirect expenditure-system-based estimates with aggregate food categories, for communities like the one under study, increases in income in the present context will *not* result in substantial improvements in nutrient intakes. Food expenditures will increase substantially—more or less proportionally to income—but the marginal increments in food expenditures will not be devoted primarily to obtaining more nutrients.[16] Perhaps with more education about the relation between nutrients and other food characteristics or with development of food varieties in which the nutritional benefits are more highly associated with the food attributes that consumers value highly at the margin, stronger associations between nutrient intakes and increases in income could be developed. But in present contexts, the World Bank (1981)–type optimism about the nutrient improvements to be expected with income gains in communities such as the ones under examination seems fundamentally misleading.

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[14] Moreover, to the extent that there are quality differences among the foods used for the calculation of the nutrients that reflect a positive association between nutrient unit costs within such food groups and total expenditure, these are upwardly biased estimates of the true nutrient elasticities (see Sec. II).

[15] Of course, one option to improve expenditure-system-based estimates is to disaggregate the food categories. To date, this option generally has not been followed apparently because practitioners did not consider aggregation to be a critical concern and because of the difficulties in estimating large expenditure systems.

[16] Some readers may be puzzled as to why more weight is not placed on nutrients in marginal expenditure decisions given the substantial shortfalls from recommended daily requirements that are indicated for most nutrients in table 1. The answer may be that such daily requirements underestimate the capacity for the body to adjust and thus overstate nutrient shortfalls, as argued by Seckler (1980), Srinivasan (1981), and Sukhatme (1982). Chaudhri and Timmer (1986, p. vii) seem to make a similar suggestion when they state that "perceived undernutrition [must not be] felt—otherwise . . . expenditure elasticities would be higher."

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