The Intrahousehold Demand for Nutrients in Rural South India: Individual Estimates, Fixed Effects, and Permanent Income

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ABSTRACT

Good estimates of nutrient intake responses to prices and income are very useful for the evaluation of the numerous efforts to improve nutrition in many developing countries through price-subsidy and income-generation policies. We discuss three problems in standard estimates of these responses and then illustrate their implications for nutrient demand relations for a poor sample from rural south India. (1) Intra-household nutrient allocations usually are ignored. In this case nutrient intakes for females systematically have algebraically lower price elasticities than do those for males, which may leave the females particularly vulnerable at times of food shortages. (2) Unobserved fixed effects may bias the estimates of responses to observed variables. In this case not only the community fixed effects on which the previous literature has focused, but also household and individual fixed effects are important. Failure to control for them results in substantial algebraically upward biases in many estimated price responses. (3) Most previous studies use current instead of permanent income, which a priori may account for the low estimated income elasticities. In this case, however, the use of permanent income does not change the conclusion that the nutrient intakes responses to income are quite small.

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I. Introduction

Standard demand analysis suggests that the direct determinants of nutrient intake are prices, income, and individual, household and community endowments. Good estimates of price and income elasticities would be very useful to evaluate the many food-subsidy and income-generation policies that have been used in efforts to improve nutrition in less-developed countries.[1] But there are a number of problems in obtaining estimates of these elasticities. This paper explores three of these problems: intrahousehold allocations of food, unobserved fixed effects, and the role of permanent income.

First, there is a large literature that suggests that intrahousehold nutrient allocations differ among individuals of different age and sex,[2] but no existing studies of nutrient demand relations allow for differential price and income responses for different individuals. The major reason for the lack of such studies is that most data sets include information on household, but not on individual nutrient intakes.[3] We have data on individual nutrient intakes, and explore the possibility of differential price and income responses for different types of members within households.

Second, to our knowledge, no published demand studies in this fairly large genre control for individual fixed effects.[4] If unobserved fixed effects are associated with prices or income, the failure to control for them may lead to biased estimates of price and income responses. If inherently more healthy individuals live in households with higher income, for example, the income elasticity of nutrient intake estimated without control for innate healthiness is biased upwards. We control for unobserved commu-

1. Pinstrup-Andersen (1985) surveys much of the recent literature on food price subsidies in less-developed countries. The World Bank (1981) emphasizes the critical role of income growth and redistribution in improving nutrition.

2. See Sen and Sengupta (1983) and the recent surveys by Behrman (1990), Harriss (1987), and Waldron (1986, 1987).

3. Garcia and Pinstrup-Andersen (1987) have data on individual nutrient intakes in their sample for the Philippines and allow additive differences by sex in their nutrient demand relations, but not different price and income responses. In Behrman and Deolalikar (1989a) we explore the differential impact of prices and income across the *lean* and the *surplus* agricultural seasons on individual calorie and protein intake, using the same data used here. However, in that study we do not explore any *intrahousehold* differences in adjustment to prices and income, nor fixed effects, nor permanent income.

4. See Behrman and Deolalikar (1988) for a survey of studies in this genre. Concurrent studies control for community fixed effects within sample clusters (which are identified with relative price structures) in the Ivory Coast (Deaton 1987, 1988), Indonesia (Case 1988), and over time in Kerala, India (Alderman 1986). In Behrman and Deolalikar (1987) we control for household fixed effects in Engel curve estimates.

nity, household and individual endowments by using fixed-effects estimation methods with panel data.

Third, most previous studies that have analyzed the nutrient-income relationship have considered the effect of *current* income on nutrient intakes. To the extent that households protect their nutrient intakes from short-term income fluctuations, estimates of the income elasticity of nutrient intakes so obtained are biased downward relative to the true household response to permanent income changes. Such a bias could underlie the relatively low nutrient elasticities with respect to income that we and some others have reported recently (e.g., Behrman and Deolalikar 1987 and 1989a) and which question the strong emphasis of the World Bank (1981) on the critical role of income increases in improving nutrient intakes in less-developed countries. Since we have data on household income for nine years, we are able to consider permanent income effects on nutrient intakes and distinguish them from current income effects.

II. Model and Estimation

Our focus is on reduced-form demand relations for individual nutrient intakes as dependent on prices, income and endowments. Such relations are consistent with constrained maximization of a unified household preference function or with the bargaining framework emphasized by Folbre (1984, 1986), Manser and Brown (1980), and McElroy and Horney (1981).[5] In either case reduced-form individual nutrient intake relations result from the intrahousehold decision process constrained by the underlying full-income constraint and structural relations that include, *inter alia:* (i) biological health production functions for each individual that characterize the "production" of health from his or her nutrient and other health-related inputs and time inputs in health-related activities of that individual and of the health-care providers in the household, conditional on the health endowments of that individual and on various environmental influences and (ii) nutrient production functions for each individual that convert quantities of different foods into nutrients consumed.

The intrahousehold allocation process results in a system of reduced-form individual demand equations for food and nonfood consumption, health status, and leisure, as well as derived demand equations for nutrient consumption for each individual. These reduced-form equations have as arguments consumption prices, wage rates, household full income,

5. Available data do not permit testing a bargaining model with a fixed structure against the maximization of unified preferences (see Rosenzweig 1984 and Rosenzweig and Schultz 1984).

personal characteristics, and health endowments of all household members, and relevant family- and location-specific environmental variables. Wage rates enter in because of the role of time in household production; since the evidence is consistent that men and women devote time for such purposes differentially, with women's allocations much larger than those of men (e.g., Engle 1980, 1984, Khandker 1988, King and Evenson 1983), we include female and male wages separately.

Only the demand equations for nutrient consumption are estimated in this study.[6] A log-linear approximation of the reduced-form submodel for the ith individual's (living in household h) intake of nutrient k in time period t is:

$$(1)\quad \ln N^k_{ihvt} = a^k_i + b^k_h + c^k_v + f^k \ln \boldsymbol{P}_{vt} + g^k \ln Y_{hvt} + m^k \ln \boldsymbol{Z}_{hv} + u^k_{ihvt},$$

where

- k indexes a nutrient (e.g., calories, protein, etc.),
- i indexes an individual within a household,
- h indexes a household within a village,
- v indexes a village,
- t indexes time,
- N is nutrient intake,
- $\boldsymbol{P}$ is a vector of village-level prices (of food and labor) and time-invariant characteristics (such as population),
- Y is current real household income per adult equivalent,[7]
- $\boldsymbol{Z}$ is a vector of observed time-invariant household characteristics (such as age and schooling of the household head, household size,[8] caste affiliation, and permanent real household income per adult equivalent),

6. An alternative strategy might be to estimate a food demand system and to apply food-to-nutrient conversion factors to such a system in order to obtain nutrient price and income elasticities—a procedure followed by Murty and Radhakrishna (1981), Pitt (1983), Strauss (1984), and Sahn and Alderman (1988). The problem with such an approach is that the use of the food-to-nutrient conversion factors at an aggregate level (as has been done in order to keep the food demand system manageable) suppresses substantial intragroup substitution associated with income, and thus results in considerably overestimated income elasticities of nutrient intakes (see Behrman and Deolalikar 1987). Therefore, we apply food-to-nutrient conversion factors at a relatively disaggregated level (about 120 foods) and estimate the nutrient demand relations directly.

7. We explored nonlinearities in the nutrient-income relationship by including a quadratic income term. However, the coefficients on the quadratic terms were consistently insignificant for all nutrients.

8. The estimated nutrient relations may be interpreted as conditional demand functions since we treat household size and composition as predetermined.

a, b, c are unobserved individual-, household-, and village-specific fixed effects, respectively, and

u is a disturbance term.

Implicit in Relation (1) is the assumption that all individuals within a household respond identically to changes in prices, income, or household characteristics. Since an important objective of this paper is to study *intrahousehold differences* in adjustment to prices and income, we allow the price, income and household characteristics coefficients to vary across four age-sex groups (men, women, boys, and girls) within a household:

$$(2)\quad \ln N^k_{ihvt} = a^k_i + b^k_h + c^k_v + f^k_d \ln \boldsymbol{P}_{vt} + g^k_d \ln Y_{hvt} + m^k_d \ln \boldsymbol{Z}_{hv} + u^k_{ihvt},$$

where d indicates a demographic group ($d = 1, 4$).

The individual fixed effects in (2) include genetic endowments that may vary across members within a household, such as varying levels of inherited immunity to diseases, tolerance to infections and metabolic rates, all of which are likely to be correlated with household income. The household fixed effects include the quality of the household's housing and water supply as well as household health and nutrition knowledge. These presumably also might be correlated with household income and the age and schooling of the household head. Finally, the village fixed effects include unobserved soil, climatic, and health service characteristics that may be correlated with village-level crop prices and wage rates. Failure to control for all of these fixed effects may bias the estimated coefficients on the price, income, and other household characteristics.

Our prior is that nutrient intake is a normal good, so the coefficients on current and permanent income are positive. Since it is likely that households protect their nutrient intake from short-term income fluctuations to a greater extent than from changes in their permanent income, the permanent income elasticity of nutrient intake may be greater than the current income elasticity. Our prior also is that the wage effects on nutrient intake are negative, since nutrients are household commodities "produced" with foods and household time. Our prior on the food price coefficients is much less clear for two reasons. *First,* nutrients are derived from several foods. Conventional wisdom is that the food price effects on nutrient intake are negative. However, because of cross-price substitution effects among different foods, an increase in the price of some foods may induce substitution towards other foods that are cheaper sources of nutrients, in which case the effect on nutrient intake of increasing the

former price might be positive.[9] In other words, the effective price per nutrient may decrease if the price of some relatively expensive nutrient source increases and induces sufficient substitution away from that food to cheaper nutrient sources. This "perverse" price effect is less likely with price changes for basic staples, such as sorghum in our sample, which generally are low-cost sources of basic nutrients such as calories.[10]

A *second* reason why our results may differ from conventional household nutrient demand estimates is the *individual*-based nature of our sample. Even if the large majority of food price effects on aggregate household nutrient intake were negative, the impact of these food prices on the nutrient intake of certain household members could be nil or positive, depending upon the response of intrahousehold food allocation patterns to food price changes. For instance, if the burden of reduced household food intake due to increased food prices fell entirely on certain members, such as females, the food price effects on the nutrient intake of females would be very negative while those on the nutrient intake of males would be zero. Such intrahousehold responses to price changes have not been considered in much of the literature.

Because of the possible importance of the community, household, and individual fixed effects, we control for them by estimating Equation (2) in terms of deviations from individual means:

$$(3)\quad \Delta \ln N^k_{ihvt} = f^k_d \Delta \ln \boldsymbol{P}_{vt} + g^k_d \Delta \ln Y_{hvt} + \Delta u^k_{ihvt},$$

where Δ indicates deviation from the individual mean (e.g., $\Delta N_{ihvt} = N_{ihvt} - N_{ihv}$). Equation (3) is purged of all unobserved effects, whether community-, household- or individual-based.[11] Alternatively, one could control only for community fixed effects or for household (but not individual) fixed effects. Note that each level of control is cumulative; hence, the household fixed-effects estimates also control for community effects,

9. Selowsky (1979), Pitt (1983), Strauss (1984), Pitt and Rosenzweig (1985), and Sahn (1988) all are explicit on this point. Nevertheless, there is some ambiguity in the literature. For example, Sahn (p. 328) suggests that it is "expected" that ". . . most calorie elasticities are negative," Timmer and Alderman (1979, p. 987) state that "raising basic food prices . . . clearly has an adverse effect on food intake of consumers, especially those poor consumers already at substantial risk of consuming inadequate protein and calories," and both Strauss (1984) and Timmer and Alderman (1979) report only negative estimated compensated price elasticities.

10. It is common in India to distinguish between *superior* grains (including rice) for which the income elasticities of demand are thought to be relatively high and *inferior* grains (including sorghum) for which the income elasticities are thought to be much lower and possibly negative.

11. It also is purged of all observed time-invariant variables, such as those included in the vector $\boldsymbol{Z}$ and some of the variables in $\boldsymbol{P}$. As a result, the fixed effects estimates cannot be used to estimate the effects of, say, permanent household income on individual nutrition.

while the individual fixed-effects estimates also control for community *and* household fixed effects. We have estimated a total of four models for this paper: levels, community fixed effects, household fixed effects and individual fixed effects. Since the models are nested, each model can be tested against the preceding (more restrictive) model using standard F-tests. In Sections IV and V below we present only the levels and the individual fixed effects estimates, but report F-test statistics for the significance of community, household and individual effects.

One possible problem with our estimates of Relations (2) and (3) is the assumption that household income is predetermined. Insofar as nutrient intakes may influence household income by enhancing labor productivity (Strauss 1986, Deolalikar 1988, Sahn and Alderman 1988, Behrman and Deolalikar 1989b), our estimated income effects in (2) and (3) may be biased. We have chosen not to use instrumental variable methods,[12] since we are particularly interested in making the distinction between current and permanent income effects on nutrient intakes. The use of predicted current income (predicted from household wealth and assets) would have obliterated the distinction between current and permanent incomes. If income indeed is endogenous because of a link between nutrient intake and productivity, the income effects we estimate will be upwardly biased. This bias, however, is likely to be much less important or even absent in the individual fixed effects-estimates. This is the case since the most common source of simultaneity bias in a nutrient demand equation is an unobserved fixed effect (such as innate healthiness) that influences both nutrient intake and household income, but which is controlled in the individual fixed-effects estimates.

III. Data

We use the ICRISAT VLS (International Crops Research Institute for the Semi-Arid Tropics Village Level Studies) data set for rural south India to estimate Relations (2) and (3), as well as alternatives with control for only household and community fixed effects and for only community fixed effects. The ICRISAT VLS data are panel data that were collected at regular intervals from 1975–76 to 1984–85 on production, expenditure, time allocation, prices, wages, and socioeconomic characteristics for 240 households in six carefully-selected "typical" vil-

12. Instrumental variables estimation would have addressed another potential problem with the income variable, viz., random measurement error. While *current* household income may be measured with random errors, such errors are likely to be averaged out in the *permanent* income variable that we use.

lages in three different agro-climatic zones in SAT India. The villages are sufficiently isolated from one another to have different relative prices (as well as different community endowments) given the fragmented nature of markets in SAT India. Within each village, ten households were randomly selected representatives of agricultural labor and nonland holding households and another 30 were a stratified (by size of land holding) random sample of cultivating households. For the 1976–77 and 1977–78 agricultural years, four rounds of a nutrition survey were undertaken in which were recorded individual nutrient intakes in the past 24 hours.[13] For further details concerning the ICRISAT VLS data, see Binswanger and Jodha (1978), Ryan et al. (1984), and Ryan and Walker (1989).

We use data for the two years of the nutrition survey (averaging the multiple nutrient observations within each) for only three of the six villages surveyed, since no income data were collected for the other three villages. This gives us a total of 1,264 individual/year observations. Table 1 gives the means and standard deviations for the variables used in the analysis. We include the intakes of seven nutrients (calories, protein, calcium, iron, thiamine, niacin and riboflavin) in the vector N, each of which is defined relative to Indian standards (see Ryan et al. 1984).[14] The statistics in Table 1 indicate that the sample on average consumes less calcium, riboflavin and calories and more of the other nutrients than recommended Indian minimum standards. Calorie consumption is slightly less than 90 percent of recommended Indian standards.

Table 1 suggests fairly large variation across individuals in their intakes of nutrients. For all of the nutrients, the intrahousehold variances are considerable, ranging from a minimum of 15 percent of the total variance for riboflavin to 48 percent of the total variance for calcium (last column in Table 1). The substantial importance of intrahousehold variance in these age and sex-standardized nutrient intakes points to the possible importance of considering *individual* nutrient intakes, not *household averages* as usually is done.

A casual look at the average nutrient intakes for the four demographic

13. To obtain data on individual food intakes, the food preparer in each household was issued standard-sized bowls and spoons, and asked to serve food to each member in these bowls. The investigators then obtained information on the number of servings of each type of food to individual members from the food preparer on the basis of 24-hour recall. See Ryan et al. (1984) for further details.

14. These nutrients are among the nine that Ryan et al. (1984) claim were most critical for the sample population. We dropped carotene and vitamin C from our analysis, since the sample averages suggest systematic underestimation of the intakes of these nutrients. (For instance, the data indicate that the sample individuals on average consumed only 24 and 29 percent of the Indian standards for carotene and vitamin C, respectively. For all other nutrients, average sample intakes were at least 67 percent of Indian standards.)

groups reveals no systematic pattern of intrahousehold discrimination, with the possible exceptions of calcium and iron. Children appear to consume a much smaller proportion of their recommended allowance for calcium than do adults, and men consume a much higher proportion of their recommended allowance for iron than do others (though, for iron, the means for all four groups are above the Indian standards).

We include in the vector $\boldsymbol{P}$ the prices of four foods (gram, sorghum, rice and milk—which are the four most important food items in terms of both expenditure and calorie intake),[15] male and female village-level daily agricultural wage rates, and village population. Sorghum is the basic staple, rice and milk are relative luxury goods, and gram is in between. Village population is used as a proxy for the availability of community health and other services and infrastructure,[16] as data on the latter are not available.

The vector $\boldsymbol{Z}$ includes the age and schooling of the household head, the number of adult equivalents[17] in the household, its caste affiliation (with low caste the excluded category) and its average real income per adult equivalent over the 1975–76 to 1983–84 period.[18] The latter serves as a proxy for household permanent income, which may be quite distinct from current annual income. Both the current and permanent income variables, as well as all food prices and wage rates, are deflated by the state-level Agricultural Laborers' Consumer Price Index.

IV. Levels Estimates

Although the individual fixed-effects estimates are our preferred estimates, we first discuss the levels estimates, since these are

15. These are *not* unit values paid by households but independently collected village prices, so they are relatively uncontaminated by the endogenous food quality choice on which Deaton (1987, 1988) has focused recently.

16. Although population does vary across the two sample years, we treat it as a time-invariant characteristic of a village. Village population is the best available variable for representing the scale economies needed for infrastructural investments, such as primary health care centers or hospitals, as well as for the variety of private health services that are available.

17. In calculating adult equivalent consumption units, we used the weights defined by the Indian National Sample Survey Organization. These weights are .485 for persons aged 0–3 years, .795 for ages 4–9, 1.0 for males 10–15 years old, .865 for females 10–15 years old, 1.02 for males 16–19, .75 for females 16–19, 1.0 for males 20–39, .71 for females 20–39, .95 for males 40–49, .68 for females 40–49, .90 for males 50–59, .64 for females 50–59, .75 for males above 60 and .505 for females above 60.

18. In the ICRISAT data household income is calculated as the sum of net crop returns (net of all purchased input costs), net returns from other production activities (such as animal husbandry, pottery, etc.), wage labor income from all sources, and net transfer receipts.

Table 1
Variable Dictionary: Rural South Indian Individuals, 1976 and 1977

Variable	Men		Women		Boys		Girls		All Persons		Proportion of Variance that is Intrahousehold
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	
Nutrient intake as % of Indian Standards											
Calories	88.2	25.0	95.7	29.5	84.4	26.9	82.8	27.3	88.6	27.6	0.34
Protein	126.1	42.1	127.8	45.9	137.3	53.0	132.0	52.3	130.0	47.7	0.34
Calcium	88.3	66.6	70.4	59.9	47.4	27.5	49.9	35.8	67.4	55.8	0.48
Iron	192.8	81.5	117.6	52.4	115.6	54.3	101.7	49.5	137.7	73.2	0.42
Thiamine	159.6	65.7	171.8	73.1	143.9	63.7	144.2	65.5	157.1	68.4	0.22
Riboflavin	78.1	57.8	80.8	64.9	68.4	64.2	69.2	71.0	75.2	63.9	0.15
Niacin	103.9	39.2	115.2	46.2	99.3	40.3	99.7	45.2	105.5	43.2	0.30
Percent share in total sample size	31.2		29.5		20.9		18.4		100.0		

Price of sorghum (Rs/kg)	1.06	0.15
Price of rice (Rs/kg)	1.88	0.36
Price of milk (Rs/litre)	1.69	0.29
Price of gram (Rs/kg)	2.09	0.30
Male wage rate (Rs/day)	3.23	0.76
Female wage rate (Rs/day)	1.79	0.42
Schooling of household head (years)	2.5	3.3
Age of household head (years)	46.4	12.3
No. of adult equivalents in the household	6.1	2.7
Current real income per adult equivalent (Rs/year)	778	700
Average household real income per adult equivalent over 1975–76 to 1983–84 (Rs/year)	684	524
Dummy for medium-low caste*	0.19	0.39
Dummy for medium-high caste*	0.20	0.40
Dummy for high caste*	0.22	0.41
Population of village (numbers)	1,751	712

Notes: All prices, including male and female wages, vary only across villages, and are deflated by the Agricultural Laborers' Consumer Price Index for the state of residence.
Total number of observations is 1,264.
* Excluded category is low caste.

typically what are reported in the literature. Also, the effects of the time-invariant household and village characteristics on nutrient intakes are not estimated in the fixed-effects procedure. Table 2 reports the levels estimates of nutrient demand. The top panel presents elasticity estimates for men, while the lower three panels indicate how the elasticities for women, boys and girls differ from those for men. The elasticities for the four demographic groups are shown in Table 3. We first discuss the estimates for the base group (men) and then note the deviations, if any, for the other three groups.

What is immediately striking about Table 2 is the large number of statistically significant and numerically large food price elasticities. For instance, of the 28 food price coefficients (four for each of seven nutrients) estimated for men, 17 are significant at the 10 percent or lower level. Of these, 15 are larger than one in absolute value. *Thus, there are pervasive and large food price effects on individual nutrient intakes.*

The pattern of the estimates suggests that *the nutrient elasticities with respect to the prices of sorghum and gram tend to be smaller algebraically than the nutrient elasticities with respect to rice and milk prices.* This supports our expectation that "perverse" food price effects are least likely for staple foods, which tend to be low-cost sources of nutrients, and most likely for foods such as milk that are high-cost sources of nutrients.

Contrary to our expectations, both *male and female wage rates generally have positive effects on average household nutrient intakes,* with the former having larger effects than the latter. If wages were only representing the opportunity cost of time, we would expect negative wage effects on nutrient intakes. However, since the wages that we use are village-specific, it is possible that they are representing in part village endowments, and not merely the opportunity cost of time of individuals. We come back to this point in our discussion of the individual fixed-effects estimates in Section V.

Current household income per adult equivalent does not appear to be a significant determinant of individual nutrient intakes.[19] In Section II we discuss the possibility that our estimated income effects might be *upward* biased because of the potential endogeneity of household income (arising from a nutrition-productivity link). Thus, the weak estimated relationship between nutrient intake and income is likely to be even weaker if such a bias indeed exists in our estimates. The low income effects on nutrient intakes are consistent with our earlier findings in Behrman and Deolalikar (1987) where we argue (as have Shah 1983, Behrman and Wolfe 1984, and others) that nonnutritive attributes of food, such as taste, aroma, appearance, and status, dominate nutrition considerations in the

19. The only significant estimate is for calcium for girls.

food decisions of even poor and allegedly malnourished people such as those in our sample.[20] However, one might argue that the low-income elasticities of nutrient intakes in the literature are biased estimates of the true household response to long-run changes in income, since they are typically estimated with data on current household income.[21] Insofar as households are likely to protect nutrient intakes from short-run income fluctuations, but not from permanent income changes, the current income effects on nutrient intakes would be underestimates of the true income effect.

However, *we find even the estimated permanent income effects on nutrient demand generally to be not significantly different from zero.*[22] This suggests that the generally low observed income elasticities of nutrient intakes are attributable not to the failure (on the part of researchers) to make a distinction between current and permanent income changes, but to a real and strong household demand for the nonnutritive attributes of food.

Among the other household characteristics, *the age and schooling of the household head and the household's caste affiliation generally do not influence the nutrient intakes of household members.*[23] *Household size* (measured by the number of adult equivalents residing in the household), *however, has persistent negative effects on individual nutrient intakes.*

Finally, for five of the seven nutrients, the population of the village of residence has large positive (and significant) effects on individual nutrient intakes. To the extent that the availability of health (and other) services and infrastructure is generally positively correlated with village size due to the existence of scale economies, *our results underscore the importance of village infrastructure for nutritional improvements.* In fact, the

20. This argument is based on our finding that, although the income elasticities of nutrient intakes are small, the income elasticities of expenditures on food are quite large for the same sample considered in this paper (Behrman and Deolalikar 1987).

21. Of course, to the extent that some studies have used predicted household income (predicted from household assets and characteristics) as the relevant income variable, the permanent income effect is captured in part in such estimates. However, as is well known, such estimates often are sensitive to the choice of instruments.

22. Only for calcium for women and for iron for boys are the permanent income effects significant.

23. For men only 2 out of 7 schooling coefficients and only 2 out of 21 caste coefficients are significant. For all four groups the corresponding numbers are 6 out of 28 and 13 out of 84, respectively. When schooling of the household head is significant, it indicates a positive effect on men's protein and niacin intakes and a negative impact on child (usually, male child) nutrient intakes. For men medium-high caste has a significant positive effect on calcium and high caste has a significant negative effect on riboflavin. Ten of the other 11 significant estimates for caste indicate lower nutrient intakes for medium or high castes (mostly for females) than for low castes.

Table 2

OLS Levels Reduced-Form Ln Nutrient (as percentage of Indian Standards) Demand Equations: Rural South India, 1976 and 1977

	Calories		Proteins		Calcium		Iron		Thiamine		Riboflavin		Niacin	
Independent Variable	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio
Intercept	**−45.407**	−4.0	**−50.735**	−4.1	**34.253**	1.7	−19.075	−1.2	**−66.422**	−4.3	**−65.755**	−3.4	**−46.135**	−3.1
Gram price	−0.043	−0.1	−0.295	−0.6	**1.761**	2.1	0.269	0.4	−0.964	−1.4	**−1.724**	−2.0	−0.086	−0.1
Sorghum price	**0.465**	1.7	**0.642**	2.1	−0.236	−0.5	−0.267	−0.7	**1.088**	2.8	−0.151	−0.3	0.394	1.1
Milk price	**8.328**	3.9	**9.142**	4.0	−2.697	−0.7	**5.362**	1.8	**12.532**	4.3	**11.761**	3.2	**8.977**	3.2
Rice price	**3.512**	5.4	**4.060**	5.7	−0.857	−0.7	**1.843**	2.0	**4.546**	5.1	**3.581**	3.2	**3.393**	3.9
Male wage	**1.474**	2.5	**2.144**	3.4	**−3.406**	−3.3	0.626	0.8	**2.929**	3.6	0.675	0.7	**2.012**	2.6
Female wage	**1.215**	3.8	**0.954**	2.7	0.246	0.4	0.395	0.9	**1.181**	2.7	**3.178**	5.7	**0.813**	1.9
Current income per adult	−0.043	−1.0	−0.045	−1.0	0.070	0.9	−0.067	−1.1	−0.010	−0.2	0.098	1.3	−0.063	−1.1
Permanent income per adult	0.040	0.8	0.066	1.2	−0.134	−1.5	0.034	0.5	0.049	0.7	0.086	1.0	0.030	0.4
Age of household head	**−0.035**	−1.7	−0.036	−1.6	−0.059	−1.6	−0.038	−1.3	−0.032	−1.1	−0.048	−1.3	−0.030	−1.1
Schooling of head	0.008	1.3	**0.012**	1.7	−0.001	−0.1	0.010	1.1	0.007	0.8	0.011	1.0	**0.018**	2.1
Population of village	**5.591**	4.3	**6.180**	4.4	−3.338	−1.5	2.673	1.5	**7.955**	4.5	**8.082**	3.6	**5.652**	3.3
No. of adult equivalents	**−0.068**	−1.7	**−0.088**	−2.0	**−0.147**	−2.1	**−0.091**	−1.7	−0.063	−1.2	−0.107	−1.6	−0.085	−1.6
Dummy for medium-low caste	0.070	1.3	0.084	1.5	−0.135	−1.5	0.033	0.5	0.041	0.6	−0.129	−1.4	0.090	1.3
Dummy for medium-high caste	0.069	1.3	0.094	1.6	**0.206**	2.2	0.089	1.2	0.100	1.4	0.012	0.1	**0.127**	1.8
Dummy for high caste	0.008	0.1	0.048	0.8	−0.146	−1.5	0.025	0.3	0.053	0.7	**−0.184**	−1.9	0.056	0.7
Dummy for women interacted with														
Intercept	**35.263**	2.3	**38.932**	2.3	31.570	1.2	34.583	1.6	**53.270**	2.5	**58.378**	2.2	**43.056**	2.1
Gram price	0.376	0.6	0.958	1.5	0.414	0.4	0.355	0.4	**2.225**	2.7	**1.866**	1.8	0.671	0.8
Sorghum price	−0.118	−0.3	−0.062	−0.1	0.218	0.3	−0.392	−0.7	−0.219	−0.4	0.052	0.1	−0.273	−0.5
Milk price	**−7.376**	−2.4	**−7.412**	−2.3	−8.253	−1.6	−6.488	−1.5	**−8.799**	−2.1	**−11.949**	−2.3	**−8.430**	−2.1
Rice price	**−1.594**	−1.7	−1.543	−1.5	−1.397	−0.9	−1.775	−1.4	−1.799	−1.4	−1.506	−0.9	**−2.092**	−1.7
Male wage	−0.204	−0.3	−0.865	−1.0	1.065	0.8	−1.013	−0.9	**−2.210**	−2.0	−0.715	−0.5	−0.564	−0.5
Female wage	**−1.053**	−2.4	**−1.191**	−2.5	**−1.747**	−2.3	−0.643	−1.1	**−1.626**	−2.7	**−2.084**	−2.7	**−1.270**	−2.2

Current income per adult	−0.015	−0.3	0.031	0.5	−0.049	−0.5	0.007	0.1	−0.030	−0.4	−0.087	−0.8	−0.032	−0.4
Permanent income per adult	0.019	0.3	−0.029	−0.4	**0.253**	2.1	0.034	0.4	0.006	0.1	0.038	0.3	0.027	0.3
Age of household head	0.025	0.9	0.024	0.8	0.032	0.6	0.032	0.8	0.028	0.7	0.043	0.9	0.028	0.8
Schooling of head	−0.004	−0.4	−0.004	−0.4	0.007	0.4	−0.007	−0.5	−0.003	−0.3	0.004	0.2	−0.004	−0.3
Population of village	**−4.045**	−2.3	**−4.503**	−2.3	−3.868	−1.2	−4.025	−1.6	**−6.184**	−2.5	**−6.844**	−2.2	**−4.934**	−2.1
No. of adult equivalents	−0.019	−0.3	0.011	0.2	−0.065	−0.7	0.017	0.2	0.023	0.3	0.054	0.6	−0.010	−0.1
Dummy for medium-low caste	−0.105	−1.3	−0.119	−1.4	0.077	0.6	−0.177	−1.6	−0.138	−1.3	−0.110	−0.8	−0.130	−1.3
Dummy for medium-high caste	**−0.130**	−1.7	**−0.145**	−1.8	−0.099	−0.7	−0.113	−1.1	−0.143	−1.4	−0.147	−1.1	**−0.178**	−1.8
Dummy for high caste	**−0.177**	−2.1	**−0.190**	−2.1	−0.156	−1.1	−0.171	−1.5	**−0.218**	−1.9	−0.205	−1.4	−0.182	−1.6
Dummy for boys interacted with														
Intercept	5.320	0.3	10.025	0.5	−45.697	−1.5	−2.502	−0.1	15.970	0.6	9.843	0.3	−3.831	−0.2
Gram price	0.933	1.4	**1.430**	2.0	−0.330	−0.3	1.306	1.4	**2.067**	2.3	**2.127**	1.9	**1.473**	1.7
Sorghum price	−0.049	−0.1	−0.054	−0.1	0.589	0.8	0.102	0.2	−0.110	−0.2	0.390	0.5	0.346	0.6
Milk price	0.571	−0.2	−0.910	−0.2	8.518	1.4	−0.241	−0.1	−2.477	−0.5	−1.002	−0.2	0.586	0.1
Rice price	0.166	0.2	0.080	0.1	2.014	1.1	1.005	0.7	0.340	0.2	0.789	0.4	1.174	0.8
Male wage	−0.743	−0.9	−1.299	−1.4	1.866	1.3	−0.155	−0.1	−1.537	−1.3	−0.973	−0.7	−0.465	−0.4
Female wage	−0.374	−0.8	−0.444	0.8	−0.031	0.0	−0.700	−1.0	−0.843	−1.3	−1.169	−1.4	−0.456	−0.7
Current income per adult	0.020	0.3	0.051	0.7	0.095	0.8	−0.034	−0.4	−0.007	−0.1	0.095	0.8	0.024	0.3
Permanent income per adult	0.066	0.8	−0.012	−0.1	0.205	1.5	**0.225**	2.1	0.136	1.3	−0.004	0.0	0.122	1.2
Age of household head	0.026	0.8	0.029	0.8	0.041	0.7	0.025	0.5	0.017	0.4	0.047	0.8	0.008	0.2
Schooling of head	−0.015	−1.3	−0.006	−0.5	0.004	0.2	**−0.045**	−2.8	**−0.034**	−2.2	−0.004	−0.2	**−0.028**	−1.9
Population of village	−0.750	−0.4	−1.246	−0.6	4.805	1.3	−0.088	0.0	−2.086	−0.7	−1.419	−0.4	0.166	0.1
No. of adult equivalents	0.075	1.1	0.031	0.4	0.135	1.1	**0.202**	2.1	0.109	1.1	0.015	0.1	0.101	1.1
Dummy for medium-low caste	−0.077	−0.9	−0.097	−1.0	−0.138	−0.9	0.048	0.4	−0.033	−0.3	−0.130	−0.8	0.080	0.7
Dummy for medium-high caste	−0.117	−1.3	−0.053	−0.6	**−0.418**	−2.7	−0.071	−0.6	−0.044	−0.4	−0.136	−0.9	−0.007	−0.1
Dummy for high caste	−0.086	−0.9	−0.075	−0.7	−0.175	−1.1	−0.007	−0.1	−0.050	−0.4	−0.036	−0.2	0.033	0.3
Dummy for girls interacted with														
Intercept	27.510	1.5	30.268	1.6	−5.490	−0.2	**60.176**	2.4	**59.343**	2.4	34.103	1.1	**55.050**	2.3
Gram price	−0.471	−0.7	−0.095	−0.1	−0.233	−0.2	−1.122	−1.1	−0.653	−0.7	1.178	1.0	−0.810	−0.9
Sorghum price	−0.299	−0.7	−0.439	−0.9	0.224	0.3	−0.495	−0.8	−0.496	−0.8	0.183	0.2	−0.765	−1.3
Milk price	−5.428	−1.6	−4.730	−1.3	2.088	0.4	**−12.859**	−2.8	**−12.330**	−2.7	−6.468	−1.1	**−11.318**	−2.5
Rice price	**−2.463**	−2.2	**−2.603**	−2.2	−0.825	−0.4	**−4.615**	−3.0	**−4.288**	−2.8	−1.280	−0.7	**−4.420**	−3.0
Male wage	−0.147	−0.2	−1.171	−1.2	0.084	0.1	−0.057	0.0	−0.343	−0.3	−0.601	−0.4	−0.251	−0.2
Female wage	−0.436	−0.9	−0.384	−0.8	−0.667	−0.8	−0.770	−1.2	−0.978	−1.5	**−1.397**	−1.8	−0.922	−1.5

Table 2 (*continued*)

Independent Variable	Calories		Proteins		Calcium		Iron		Thiamine		Riboflavin		Niacin	
	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio
Current income per adult	0.022	0.3	0.123	1.6	**0.300**	2.4	−0.064	−0.6	−0.011	−0.1	−0.026	−0.2	−0.005	−0.1
Permanent income per adult	0.066	0.8	−0.094	−1.0	0.133	0.9	0.133	1.1	0.101	0.9	0.099	0.7	0.100	0.9
Age of household head	0.015	0.5	−0.016	−0.4	0.021	0.3	0.011	0.2	0.018	0.4	−0.007	−0.1	0.004	0.1
Schooling of head	−0.041	−1.3	−0.012	−1.1	0.017	0.9	**−0.027**	−1.8	−0.020	−1.4	−0.013	−0.7	−0.020	−1.4
Population of village	−3.137	−1.5	−3.333	−1.5	0.301	0.1	**−6.873**	−2.4	**−6.754**	−2.4	−4.031	−1.1	**−6.239**	−2.3
No. of adult equivalents	0.070	1.0	0.010	0.1	−0.057	−0.5	0.102	1.0	0.094	1.0	−0.084	−0.7	**0.156**	1.7
Dummy for medium-low caste	−0.096	−1.1	−0.052	−0.5	−0.032	−0.2	0.026	0.2	0.013	0.1	−0.107	−0.7	0.033	0.3
Dummy for medium-high caste	−0.119	−1.4	**−0.162**	−1.7	**−0.342**	−2.3	0.034	0.3	0.041	0.4	−0.067	−0.5	0.019	0.2
Dummy for high caste	**−0.222**	−2.3	**−0.263**	−2.6	−0.186	−1.1	−0.105	−0.8	−0.073	−0.6	−0.171	−1.0	−0.086	−0.7
F Ratio	5.080		7.390		9.970		17.520		10.780		7.420		7.600	
R-Square	0.217		0.288		0.353		0.489		0.371		0.289		0.294	

Notes: All variables, with the exception of dichotomous variables, are in natural logs. Number of observations is 1,216. All prices, including male and female wages, vary only across villages, and are deflated with a consumer price index. The latter is used to deflate current and permanent income as well. Two annual observations per individual are used in the estimation. Bold type indicates significance at the 10% level.

dominance of village characteristics over household income in determining individual nutrient intakes may suggest that infrastructure creation policies and public provision of health care and other services may be far more important in raising nutrient intakes than are household income-generation policies.[24]

Interestingly, most of the significant deviations from the above results occur for women and girls, with very few occurring for boys. The pattern of these deviations is such that the food price elasticities for females are generally more negative (or less positive) than those discussed above for men. For instance, for women there are nine food price coefficients (out of a total of 28) that are significantly different than those for men, and seven of these are negative deviations. For girls, there are eight food price coefficients that are significantly different, and all eight are negative. Thus, our *results suggest assymetric treatment of women and girls within the household such that, when food prices rise, the nutrient intakes of these members are adjusted downward by more than the household average.*[25]

The same type of results obtain with respect to village size and female wages. While the effect of village size on the nutrient intakes of household members is generally positive, it is much smaller (in fact, nil or even negative in many cases) for women and children. Similarly, while female wages are associated with an improvement in the nutrient intakes of most household members, this impact is substantially reduced for women themselves. Thus, *women and girls appear to be excluded from the general nutritional rewards reaped from living in a large village or from higher village wages for female labor.*

In Table 3 we present the implied household average elasticities as the weighted sum of the elasticities for the different demographic groups. A look at these elasticities indicates how much of the intrahousehold disparity in nutrient intake responses to prices is lost by looking only at average household responses. For instance, an average household elasticity of calories with respect to the price of rice of 2.6 masks elasticities of around one for girls, 1.9 for women and around 3.5 for men and boys. The elasticity of calories with respect to milk prices is even more dispersed. Another striking dimension of the price elasticities in Table 3 is the frequency of positive estimates. Even for the basic staple, sorghum, over

24. We do not wish to overstate these results, however, since village size may be associated with characteristics other than infrastructure, including village wealth.

25. Note that the different adjustments in nutrient intakes for females does not imply significantly less nutrient intakes for females than for males on average. Behrman (1988), however, reports household preference weights that favor boys over girls in the lean season when local food supplies are relatively limited.

Table 3
Levels Elasticities of Nutrient Intake for Different Household Members: Rural South India, 1976–77

Independent Variable	Calories	Proteins	Calcium	Iron	Thiamine	Riboflavin	Niacin
Implied Household Average Elasticities							
Gram price	0.182	0.280	1.809	0.435	0.039	−0.529	0.279
Sorghum price	0.367	0.530	−0.052	−0.415	0.912	−0.030	0.241
Milk price	4.933	5.909	−3.702	1.937	7.135	6.691	4.408
Rice price	2.614	3.145	−1.103	0.945	3.306	3.038	2.181
Male wage	1.236	1.388	−2.792	0.336	1.864	0.161	1.695
Female wage	0.730	0.438	−0.387	0.005	0.329	2.059	0.154
Current income per adult	−0.040	−0.002	0.110	−0.080	−0.023	0.084	−0.069
Permanent income per adult	0.070	0.037	−0.008	0.100	0.094	0.114	0.080
Age of household head	−0.020	−0.025	−0.041	−0.024	−0.017	−0.027	−0.018
Schooling of head	0.002	0.007	0.004	−0.004	−0.004	0.010	0.008
Population of village	3.615	3.977	−3.782	0.709	4.419	4.963	3.010
No. of adult equivalents	−0.047	−0.076	−0.155	−0.037	−0.019	−0.102	−0.041
Dummy for medium-low caste	0.005	0.018	−0.136	0.001	−0.008	−0.207	0.070
Dummy for medium-high caste	−0.016	0.010	0.067	0.052	0.053	−0.072	0.071
Dummy for high caste	−0.104	−0.073	−0.245	−0.033	−0.039	−0.285	−0.010
Elasticities for Men							
Gram price	−0.043	−0.295	1.761	0.269	−0.964	−1.724	−0.086
Sorghum price	0.465	0.642	−0.236	−0.267	1.088	−0.151	0.394
Milk price	8.328	9.142	−2.697	5.362	12.532	11.761	8.977

Rice price	3.512	4.060	−0.857	1.843	4.546	3.581	3.393
Male wage	1.474	2.144	−3.406	0.626	2.929	0.675	2.012
Female wage	1.215	0.954	0.246	0.395	1.181	3.178	0.813
Current income per adult	−0.043	−0.045	0.070	−0.067	−0.010	0.098	−0.063
Permanent income per adult	0.040	0.066	−0.134	0.034	0.049	0.086	0.030
Age of household head	−0.035	−0.036	−0.059	−0.038	−0.032	−0.048	−0.030
Schooling of head	0.008	0.012	−0.001	0.010	0.007	0.011	0.018
Population of village	5.591	6.180	−3.338	2.673	7.955	8.082	5.652
No. of adult equivalents	−0.068	−0.088	−0.147	−0.091	−0.063	−0.107	−0.085
Dummy for medium-low caste	0.070	0.084	−0.135	0.033	0.041	−0.129	0.090
Dummy for medium-high caste	0.069	0.094	0.206	0.089	0.100	0.012	0.127
Dummy for high caste	0.008	0.048	−0.146	0.025	0.053	−0.184	0.056
Elasticities for Women							
Gram price	0.334	0.663	2.175	0.624	1.261	0.143	0.585
Sorghum price	0.347	0.580	−0.018	−0.659	0.868	−0.100	0.121
Milk price	0.953	1.730	−10.950	−1.126	3.732	−0.189	0.546
Rice price	1.918	2.517	−2.254	0.068	2.747	2.075	1.301
Male wage	1.269	1.279	−2.340	−0.388	0.719	−0.041	1.448
Female wage	0.162	−0.238	−1.501	−0.249	−0.446	1.094	−0.457
Current income per adult	−0.058	−0.015	0.021	−0.060	−0.040	0.011	−0.095
Permanent income per adult	0.059	0.037	0.119	0.068	0.054	0.124	0.056
Age of household head	−0.011	−0.012	−0.027	−0.006	−0.004	−0.005	−0.001
Schooling of head	0.005	0.008	0.006	0.003	0.003	0.015	0.015
Population of village	1.546	1.676	−7.206	−1.352	1.771	1.238	0.718
No. of adult equivalents	−0.086	−0.077	−0.212	−0.074	−0.040	−0.054	−0.095
Dummy for medium-low caste	−0.034	−0.035	−0.058	−0.143	−0.098	−0.240	−0.040

Table 3 (*continued*)

Independent Variable	Calories	Proteins	Calcium	Iron	Thiamine	Riboflavin	Niacin
Dummy for medium-high caste	−0.061	−0.052	0.107	−0.024	−0.042	−0.135	−0.051
Dummy for high caste	−0.169	−0.142	−0.302	−0.146	−0.165	−0.389	−0.125
Elasticities for Boys							
Gram price	0.891	1.134	1.432	1.575	1.103	0.404	1.387
Sorghum price	0.416	0.587	0.354	−0.165	0.978	0.239	0.740
Milk price	7.757	8.232	5.821	5.121	10.054	10.758	9.563
Rice price	3.677	4.140	1.158	2.848	4.886	4.370	4.566
Male wage	0.730	0.845	−1.540	0.471	1.392	−0.298	1.547
Female wage	0.841	0.509	0.215	−0.306	0.338	2.009	0.357
Current income per adult	−0.023	0.006	0.165	−0.101	−0.017	0.192	−0.039
Permanent income per adult	0.106	0.054	0.072	0.258	0.185	0.082	0.152
Age of household head	−0.009	−0.006	−0.018	−0.013	−0.015	−0.001	−0.022
Schooling of head	−0.007	0.006	0.003	−0.035	−0.027	0.008	−0.009
Population of village	4.841	4.933	1.467	2.584	5.869	6.663	5.818
No. of adult equivalents	0.007	−0.057	−0.013	0.111	0.046	−0.092	0.016
Dummy for medium-low caste	−0.007	−0.013	−0.273	0.081	0.007	−0.260	0.170

Dummy for medium-high caste	−0.047	0.041	−0.213	0.018	0.056	−0.124	0.120
Dummy for high caste	−0.078	−0.027	−0.321	0.018	0.003	−0.220	0.090
Elasticities for Girls							
Gram price	−0.514	−0.390	1.528	−0.853	−1.616	−0.546	−0.896
Sorghum price	0.167	0.202	−0.012	−0.762	0.592	0.032	−0.371
Milk price	2.900	4.412	−0.609	−7.497	0.201	5.293	−2.342
Rice price	1.049	1.458	−1.681	−2.772	0.258	2.301	−1.027
Male wage	1.327	0.973	−3.321	0.569	2.586	0.073	1.761
Female wage	0.779	0.569	−0.421	−0.375	0.203	1.781	−0.110
Current income per adult	−0.021	0.078	0.370	−0.132	−0.021	0.072	−0.068
Permanent income per adult	0.106	−0.028	−0.001	0.167	0.149	0.185	0.129
Age of household head	−0.020	−0.052	−0.038	−0.027	−0.014	−0.055	−0.026
Schooling of head	−0.006	0.000	0.016	−0.017	−0.013	−0.002	−0.002
Population of village	2.454	2.846	−3.037	−4.200	1.202	4.051	−0.587
No. of adult equivalents	0.003	−0.078	−0.205	0.011	0.031	−0.192	0.071
Dummy for medium-low caste	−0.026	0.032	−0.167	0.059	0.054	−0.236	0.123
Dummy for medium-high caste	−0.050	−0.068	−0.136	0.123	0.142	−0.055	0.146
Dummy for high caste	−0.214	−0.215	−0.332	−0.079	−0.020	−0.355	−0.029

Notes: All elasticities are calculated from the estimates in Table 2. "Implied household average" elasticities are calculated as the weighted average of the elasticities for the different member types.

half of the price elasticities are positive. Perhaps there are systematic upward biases in these elasticities due to unobserved community characteristics. The estimates in the next section provide further insight into such a possibility.

V. Individual Fixed-Effects Estimates

Table 4 reports the individual fixed-effects estimates of the nutrient demand equations, while Table 5 presents the average household elasticities and the elasticity estimates for the four demographic groups. The last three rows in Table 4 report the F-test statistics for the significance of the community fixed effects, the household versus community fixed effects, and the individual versus household fixed effects. Only for one nutrient (viz., calcium) are the village fixed effects not significant at the 5 percent level. For all seven nutrients, the household fixed effects are significantly different from zero (at the 5 percent level) *beyond the village fixed effects*. Finally, for four of the seven nutrients, the individual fixed effects are significant *over and above the household fixed effects*.[26] Thus, there is strong evidence that unobserved household and, to a somewhat smaller extent, individual fixed effects are important in the determination of individual nutrient intakes. Therefore, estimates that control only for community fixed effects, such as those in Deaton (1987, 1988) and Case (1988), still may be subject to biases because of household and individual fixed effects.

The effects of all time-invariant variables are controlled, but not estimated, in the individual fixed-effects procedure. The only variables for which nutrient demand individual fixed-effects estimates are available are the four food prices, male and female wage rates, and current household income per adult equivalent. To the extent that unobserved household and community endowments are correlated with these variables, the levels estimates of the coefficients of these variables may be biased. The results with respect to the food price elasticities confirm this; the *individual fixed-effects estimates of the food price elasticities are generally much smaller than the levels estimates,* suggesting a positive correlation between unobserved community endowments and food prices. However, in absolute magnitudes, even the individual fixed-effects price elasticities often are quite large. *The elasticities with respect to the sorghum price are almost all negative,* as we conjecture above is likely for the basic staple, but in sharp contrast to the preponderance of positive estimates

26. The three nutrients for which the individual fixed effects are not significant (beyond the household fixed effects) are calories, thiamine and riboflavin.

in Table 3. The elasticities with respect to the other three prices are more mixed in sign, with some large positive ones, particularly for males for the rice and milk prices (that carry over to the household estimates for these two commodities), suggesting the *robustness of strong substitution and "perverse" price effects even with control for individual, household, and community fixed effects.*

For male wages, the fixed-effects estimates generally are negative, which is consistent with the opportunity cost of time hypothesis in Section II, but in contrast to the levels estimates. The only case where the fixed-effects estimates are larger (in absolute magnitude) than the levels estimates is the nutrient intake elasticities with respect to female wages. While the levels estimates of the female wage elasticities are typically around one, the fixed effects estimates are typically two or larger. These results suggest a *puzzling inverse correlation between unobserved village characteristics and agricultural wage rates for women* (but a positive correlation between such characteristics and male wages). The implication of this pattern of correlations is that better community endowments actually may increase the inter-gender wage differential.

Most of the results with respect to the more negative food price effects on the nutrient intakes of females (relative to the intakes of males) hold in the individual fixed-effects estimates.

VI. Conclusion

We first summarize the implications of our estimates for the three estimation problems related to the determination of price and income responses in nutrient intakes of a poor population on which we focus in the introduction.

First, intrahousehold allocations of nutrients may mean that the implications of price and income changes for particular types of individuals may differ substantially from those for household averages. Our estimates suggest that indeed this is the case in the rural south Indian sample that we study. Most noteworthy in this regard is that estimated price and wage elasticities of nutrient intakes in many cases are substantially and significantly less algebraically for females than for males. Household average nutrient intake responses, thus, may disguise substantial gender differences in adjustments to price and wage changes.

Second, individual, household and community fixed effects may cause standard level estimates to be biased. Our comparison of level estimates with fixed-effects estimates suggests that indeed this is the case for the sample that we examine. Statistical tests indicate that all three types of

Table 4

Fixed Effects ("Within Estimator") Reduced-Form Ln Nutrient (as percentage of Indian Standards) Demand Equations: Rural South India, 1976–77

	Calories		Proteins		Calcium		Iron		Thiamine		Riboflavin		Niacin	
Independent Variable	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio	Coefficient	*t* Ratio
Gram price	0.096	0.2	0.254	0.6	−0.414	−0.6	0.510	1.0	−0.156	−0.3	**−1.685**	−2.4	0.517	1.1
Sorghum price	−0.418	−0.9	−0.198	−0.4	−0.223	−0.3	−0.892	−1.5	−0.050	−0.1	−0.007	0.0	−0.366	−0.6
Milk price	**5.684**	3.1	**7.336**	3.6	1.765	0.6	1.763	0.8	**9.237**	3.6	**8.309**	2.6	**8.942**	4.1
Rice price	**2.028**	2.5	**2.836**	3.2	0.216	0.2	0.244	0.2	**3.009**	2.7	**3.371**	2.4	**2.617**	2.8
Male wage	−1.470	−1.2	−1.386	−1.0	0.018	0.0	−1.828	−1.2	−1.325	−0.8	1.590	0.7	−1.192	−0.8
Female wage	**2.551**	3.7	**2.528**	3.3	0.497	0.4	1.242	1.5	**3.026**	3.1	**2.557**	2.1	**2.300**	2.8
Income per adult equivalent	0.000	0.3	0.000	0.5	**0.003**	2.3	0.000	0.2	0.001	1.0	0.002	1.5	0.000	0.3
Dummy for women interacted with														
Gram price	−0.233	−0.4	−0.376	−0.6	**1.966**	2.1	−0.094	−0.1	0.609	0.8	0.431	0.5	−0.146	−0.2
Sorghum price	−0.868	−1.2	−1.285	−1.6	1.098	0.9	−1.405	−1.6	−1.051	−1.0	−0.939	−0.7	−0.228	−0.3
Milk price	**−5.906**	−2.1	**−7.836**	−2.5	−7.019	−1.4	−4.708	−1.4	**−8.543**	−2.2	**−11.712**	−2.4	**−6.959**	−2.1
Rice price	**−2.281**	−1.8	**−3.178**	−2.3	−0.056	0.0	−2.483	−1.6	**−2.993**	−1.7	−2.989	−1.4	−1.894	−1.3
Male wage	−1.706	−0.9	−2.614	−1.2	1.512	0.5	−3.086	−1.3	−3.074	−1.2	−2.316	−0.7	0.307	0.1
Female wage	0.667	0.7	1.040	0.9	**−2.971**	−1.7	1.392	1.1	0.346	0.2	0.054	0.0	−0.887	−0.7
Income per adult equivalent	0.000	−0.4	−0.001	−0.5	−0.001	−0.8	0.000	0.0	−0.001	−0.4	−0.002	−1.2	0.000	−0.4

Dummy for boys interacted with														
Gram price	0.588	1.0	0.562	0.8	**3.998**	3.8	0.914	1.2	**1.803**	2.1	**2.243**	2.1	0.006	0.0
Sorghum price	−0.165	−0.2	−0.408	−0.4	2.298	1.6	0.087	0.1	−0.666	−0.6	−0.266	−0.2	−1.042	−1.1
Milk price	0.880	0.3	−0.849	−0.2	3.486	0.6	−0.090	0.0	−2.729	−0.6	3.082	0.5	−1.620	−0.4
Rice price	0.393	0.3	−0.159	−0.1	3.582	1.5	0.836	0.5	−0.661	−0.3	1.280	0.5	−1.170	−0.7
Male wage	0.121	0.1	−0.479	−0.2	1.392	0.4	0.951	0.4	−2.034	−0.7	−1.775	−0.5	−1.183	−0.5
Female wage	−0.370	−0.3	−0.218	−0.2	−3.204	−1.6	−0.999	−0.7	−0.514	−0.3	−0.220	−0.1	0.562	0.4
Income per adult equivalent	0.000	−0.4	0.000	−0.3	−0.003	−1.4	−0.002	−1.0	−0.001	−0.7	0.001	0.5	0.000	−0.1
Dummy for girls interacted with														
Gram price	**−0.997**	−1.7	**−1.349**	−2.1	0.733	0.7	**−1.532**	−2.2	**−1.723**	−2.1	0.689	0.7	**−1.501**	−2.2
Sorghum price	−0.153	−0.2	−0.682	−0.7	−3.440	−2.2	−1.225	−1.1	0.852	0.7	−0.407	−0.3	0.667	0.6
Milk price	**−8.501**	−2.6	**−11.890**	−3.2	−6.421	−1.1	**−10.903**	−2.7	**−14.129**	−3.1	**−11.057**	−1.9	**−8.933**	−2.3
Rice price	**−2.572**	−1.7	**−4.230**	−2.4	**−5.800**	−2.2	**−4.495**	−2.4	−3.510	−1.6	−3.737	−1.4	−2.182	−1.2
Male wage	0.927	0.4	−0.480	−0.2	**−9.584**	−2.4	−1.899	−0.7	3.188	1.0	−2.710	−0.7	3.853	1.4
Female wage	−0.732	−0.6	−0.316	−0.2	**3.709**	1.7	1.155	0.8	−2.376	−1.4	−0.696	−0.3	−2.267	−1.5
Income per adult equivalent	0.000	−0.1	0.000	0.1	0.000	−0.1	0.000	−0.1	0.000	0.0	−0.001	−0.2	0.000	0.0
F Ratio	**16.14**		**13.76**		**2.59**		**7.83**		**8.79**		**9.32**		**11.94**	
R-Square	0.268		0.238		0.056		0.151		0.166		0.174		0.213	
F(2,1233)-test for village (vs. no) fixed effects	**28.14**		**31.37**		3.59		**7.12**		**31.30**		**7.70**		**18.51**	
F(113,1120)-test for household (vs. village) fixed effects	**5.57**		**5.04**		**6.95**		**3.72**		**7.03**		**12.23**		**5.12**	
F(516,604)-test for individual (vs. household) fixed effects	0.96		**1.10**		**1.52**		**1.31**		0.77		0.60		**1.10**	

Notes: All variables, with the exception of dichotomous variables, are in natural logs. Number of observations is 1,264, while degrees of freedom are 614. All prices, including male and female wages, vary only across villages, and are deflated with a consumer price index. Two annual observations per individual used for fixed effects estimation. Bold type for coefficients indicates significance at the 10% level and for F-statistics, at the 5% level.

Table 5
Fixed Effects Price and Income Elasticities of Nutrient Intake for Different Household Members: Rural South India, 1976–77

Independent Variable	Calories	Protein	Calcium	Iron	Thiamine	Riboflavin	Niacin
Implied Household Average Elasticities							
Gram price	−0.033	0.017	0.879	0.438	0.094	−1.005	0.210
Sorghum price	−0.753	−0.788	−0.016	−1.397	−0.372	−0.424	−0.528
Milk price	2.518	2.656	−0.760	−0.922	3.571	3.314	4.828
Rice price	0.938	1.090	−0.066	−0.847	1.323	2.035	1.397
Male wage	−1.831	−2.339	−0.619	−2.696	−2.166	0.060	−0.656
Female wage	2.565	2.722	−0.383	1.575	2.638	2.415	1.731
Income per adult equivalent	0.000	0.000	0.002	0.000	0.000	0.001	0.000
Elasticities for Men							
Gram price	0.096	0.254	−0.414	0.510	−0.156	−1.685	0.517
Sorghum price	−0.418	−0.198	−0.223	−0.892	−0.050	−0.007	−0.366
Milk price	5.684	7.336	1.765	1.763	9.237	8.309	8.942
Rice price	2.028	2.836	0.216	0.244	3.009	3.371	2.617
Male wage	−1.470	−1.386	0.018	−1.828	−1.325	1.590	−1.192
Female wage	2.551	2.528	0.497	1.242	3.026	2.557	2.300
Income per adult equivalent	0.000	0.000	0.003	0.000	0.001	0.002	0.000
Elasticities for Women							
Gram price	−0.138	−0.122	1.552	0.416	0.453	−1.254	0.371
Sorghum price	−1.286	−1.483	0.875	−2.297	−1.101	−0.946	−0.594

Milk price	−0.222	−0.500	−5.254	−2.945	0.693	−3.403	1.982
Rice price	−0.253	−0.342	0.160	−2.239	0.015	0.382	0.723
Male wage	−3.176	−4.000	1.530	−4.913	−4.399	−0.727	−0.885
Female wage	3.218	3.568	−2.474	2.634	3.373	2.612	1.413
Income per adult equivalent	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Elasticities for Boys							
Gram price	0.684	0.816	3.584	1.424	1.647	0.558	0.523
Sorghum price	−0.582	−0.606	2.075	−0.805	−0.716	−0.273	−1.408
Milk price	6.564	6.487	5.251	1.673	6.507	11.391	7.322
Rice price	2.422	2.677	3.798	1.079	2.347	4.651	1.447
Male wage	−1.350	−1.865	1.410	−0.877	−3.359	−0.185	−2.375
Female wage	2.181	2.309	−2.707	0.243	2.512	2.337	2.862
Income per adult equivalent	0.000	0.000	−0.001	−0.001	0.000	0.003	0.000
Elasticities for Girls							
Gram price	−0.901	−1.095	0.318	−1.022	−1.880	−0.995	−0.984
Sorghum price	−0.571	−0.880	−3.663	−2.117	0.802	−0.414	0.301
Milk price	−2.817	−4.554	−4.656	−9.141	−4.893	−2.748	0.009
Rice price	−0.544	−1.394	−5.584	−4.251	−0.501	−0.366	0.435
Male wage	−0.543	−1.865	−9.566	−3.726	1.864	−1.121	2.661
Female wage	1.819	2.211	4.206	2.398	0.650	1.861	0.033
Income per adult equivalent	0.000	0.001	0.002	0.000	0.001	0.001	0.000

Notes: All elasticities are calculated from the estimates shown in Table 4. "Implied household average" elasticities are calculated as the weighted average of the elasticities for different member types.

fixed effects are important. This means that previous studies that have emphasized the importance of controlling for community effects (e.g., Deaton 1987, 1988, Case 1988) themselves may suffer from biases due to the failure to control for unobserved household and individual effects in addition to community fixed effects. In the present case the failure to control for fixed effects causes substantial algebraic upward biases in the estimated coefficients for most prices and wages (though apparently the opposite for women's wages). As a result, for example, in the levels estimates the majority of the estimated nutrient responses to the price of the basic staple, sorghum, are positive, but in the fixed-effect estimates almost all of them are negative. Thus, estimates that fail to control for such fixed effects may provide a quite misleading base for policy formulation.

Third, estimates of nutrient intake responses to income that are based on current income may be quite misleading about the responses to permanent income since basic nutrient intakes may be insulated from transitory income fluctuations. Our estimates in this case, however, do not indicate much larger responses to permanent than to current income. Thus, we feel reconfirmed in our earlier conclusion in Behrman and Deolalikar (1987) that in this poor rural south Indian sample the nutrient responses to income are quite small and do not support the assertion of the World Bank (1981) and others that income changes are the most critical element in increasing nutrient intakes in poor populations.

We now turn to three substantive implications of our estimates for the rural south Indian sample under examination.

First, our estimates suggest that individual nutrient intakes in the rural south Indian sample under study respond strongly to food prices, even after control for community, household and individual fixed effects. The price of sorghum, which is the most important staple in the diets of the sample households, generally has negative effects on nutrient intakes in our preferred, fixed-effects estimates. The other food prices, particularly for rice and milk, often have strong positive impacts on nutrient consumption even with controls for income. This implies strong substitution among various foods with changing prices. The positive price elasticities moreover suggest that the sample households do not consume the minimum cost diet, but instead also consider nonnutritive attributes of food, such as aroma, quality, taste, variety and status, in their food choices. This latter point is further supported by the observation that neither current nor permanent household income generally has significant effects on nutrient intakes. The food price results have important implications for the food-subsidy policies that many less-developed countries pursue in order to improve the nutrient intake of the poor. Our results suggest that

subsidies on foods other than inferior ones (e.g., sorghum or cassava) actually can reduce individual nutrient intakes on the average in households and particularly for males!

Second, the general significance of various village characteristics and the lack of significance of household income (whether current or permanent) in the estimated nutrient relations suggests that community effects dominate individual and household effects in the determination of individual nutrient intakes. Thus, policies that affect community variables, such as an improvement in community health infrastructure and the public provision of health and other services, may have a much greater impact on nutrient intakes than household income-generation programs alone.[27]

Third, is there evidence of gender discrimination in the intrahousehold allocation of nutrients among our sample households? The answer to this question depends on what one considers to be gender discrimination in nutrient allocation. Intrahousehold gender discrimination can take various forms. It may occur in the form of lower *average* nutrient intake for female members relative to male members. It also can take the form of a larger variance in female versus male nutrient intake. There is little or no support for these forms of discrimination in our data.[28] What we *do* find is evidence of differential adjustment of male and female nutrient intakes to changes in food prices. Can this form of household behavior be considered discrimination? The more negative food price elasticities that we observe for females imply that the nutritional burden of a *rise* in food prices, which typically occurs in the lean agricultural season or during a drought year, falls disproportionately on female members within households. By the same token, however, women and girls enjoy a disproportionate share of the nutritional reward or bonus from *falling* food prices (say, in the post-harvest season or in years of favorable monsoons). Of course, to the extent that the general risk of malnutrition or starvation is greatest during times of food shortage (when food prices are likely to increase), the relatively great vulnerability of female members at these times could be characterized as gender discrimination.

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27. This conclusion is subject to the qualification in note 24 above.
28. The little support is for medium-high and high caste households. See note 23 above.

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