On Modelling Variety in Consumption Expenditure on Food*

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ABSTRACT

In this paper we compute nutrient-expenditure elasticities for two macro nutrients (calories and protein) and five micro nutrients (calcium, thiamine, riboflavin, calcium and iron) using an all India sample of rural households for 1994. We show that in each case the respective elasticities are positive and significant. This lends support to our hypothesis that an increase in income would increase nutrient intake by varying amounts, contrary to some assertions. We then compute differences in the elasticity of substitution for rich and poor across commodity groups and show that these differences, while significant, are small. This further corroborates our conclusion that increases in income of the poor would lead to greater increases in their nutrient intake as compared to the non-poor, although the magnitudes will be small.

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I. Introduction

In recent years, there has been a growing realisation that poverty is multi-dimensional and money-metric indicators such as minimum income or expenditure cannot adequately capture all these dimensions. Attention has therefore shifted to other indicators such as health status that relate more closely to basic capabilities of individuals. An important point is that the correspondence between basic capabilities (e.g. to live a healthy and productive life) and level of income is often weak (Sen, 1999).[1] It is therefore not surprising that a wide range of indicators including income/expenditure, health and education reflect a diverse pattern in India during the 1990s. In fact, as emphasised in a recent study, while most indicators have continued to improve during the 1990s, social progress has followed diverse patterns, ranging from accelerated progress in some fields to slowdown and even regression in others.[2]

Of particular interest is the debate over changes in the *extent* and *severity* of undernutrition in India during the 1990s- particularly on the prevalence of deficiency in macro and micro nutrient intake. While there is a link between income and nutritional deprivation, there is often a divergence between the two. In an important contribution, Behrman and Deolalikar (1987) demonstrated that calorie elasticities with respect to income may be quite low. The literature prior to this contribution had overestimated these elasticities because it failed to allow for the positive association of nutrient prices with incomes in poor economies. However, other estimates-including our own- point to stronger income effects. Subramaniam and Deaton (1996), for example, report calorie-income elasticities to be in the range 0.3 to 0.5.

The methodology for the estimation of the income elasticity of nutrients recognizes that such nutrient intake is endogenous to income. Hence an Instrumental Variable (IV) approach to estimation must be pursued.

[1] There is a great deal of variability between low capabilities, such as undernourishment, and low incomes, and this relationship is conditional, differing by community, families and individuals. More specifically, the contribution of income or expenditure to explaining health outcomes is limited. Sahn and Stifel (2002), for example, report that the correlation coefficient between a wealth index derived using factor analysis and a health indicator ranges from 0.081 to 0.243 in a sample of 10 countries.

[2] Deaton and Dreze (2002) show that improvements in income poverty went hand in hand with a decline in female-male ratio among children, from 945 girls per 1000 boys (in the 0-6 age group) in 1991 to 927 girls per 1000 boys in 2000. In another but more sceptical review, Cassen (2002) also paints a mixed picture of social progress.

As the likely contamination of the 55th round of the National sample Survey (NSS) data (for 1999–00) due to changes in sample design and recall periods, as compared to the earlier rounds of the NSS, has implications for expenditure on frequently purchased food items, estimates of changes in undernutrition derived from various rounds of the NSS may also lack direct comparability. Hence the findings of recent studies based on NSS data without adjustment to the 55th round estimates (e.g. Meenakshi and Vishwanathan, 2003, Srinivasan, 2003) must be interpreted with some caution. Unfortunately, estimates of undernutrition at the all-India level (including both rural and urban households) are not reported.[3] Specifically, comparisons of the head count ratios (HCRs) of the undernourished over different rounds of the NSS are not carried out in these studies. Srinivasan (2003), however, draws attention to a moderate reduction in calorie intake between 1983 and 1993 and a moderate increase between 1993 and 1999- mainly due to a higher intake in urban areas. Vishwanathan and Meenakshi (2001), and Meenakshi and Vishwanathan (2003), on the other hand, report changes in various indices of undernutrition (specifically, measuring the prevalence, depth and severity of undernutrition) for different clusters of states over the period 1983 and 1993, and at the state level for the period 1983–1999, respectively.[4]

Changes in nutrient intake depend on: (i) the sensitiveness of food expenditure to income; (ii) price-induced substitution between nutrients; and (iii) the preference for attractive packaging, different flavours and/or variety. Some illustrative evidence, based on NSS data for the 1970s and mid-1980s, points to a preference for costlier calories (Gaiha, 1999) - specifically, food expenditure elasticity with respect to household expenditure ranged from 0.70 to 0.89 for rural and from 0.76 to 0.81 for urban areas. Calorie elasticity was 0.47 for rural and 0.58 for urban areas. The difference between food and calorie elasticities (i.e. the elasticity of the price of calories with respect to household expenditure) worked out to be 0.298 for rural and 0.19 for urban areas,

[3] See, for example, Vishwanathan and Meenakshi (2001), Srinivasan (2003), and Meenakshi and Vishwanathan (2003).

[4] In a personal communication, J.V. Meenakshi reports a slight reduction in the head count ratio of calorie deprivation (HCR) at the all-India level over the period 1983-99, based on a calorie cut-off point of 1800. Jha and Gaiha (2004) provide an analysis of the regional variation of calorie deprivation in rural India based on alternative cut-off points consistent with sedentary, moderate and heavy norms for calorie adequacy.

implying a moderately strong preference for expensive foods at higher income levels.[5] Although this weakens the nutritional impact of higher incomes, it does not negate it entirely. This is in striking contrast to the Behrman-Deolalikar (1987) finding that calorie elasticity is (statistically) close to 0. As noted earlier, these estimates corroborate the role of income in improving nutritional status without overlooking the preference for costlier foods/calories.

In the present paper we compute nutrient-expenditure elasticities for two macro nutrients (calories and protein) and five micro nutrients (calcium, thiamine, riboflavin, calcium and iron). We show that in each case the respective elasticities are positive and significant. This lends support to our hypothesis that, in contrast to the results of Behrman and Deolalikar (1987), an increase in income would increase nutrient intake. We then compute the difference in the elasticity of substitution for rich and poor across commodity groups (along the lines of Behrman and Deolalkar (1989)) and show that this difference, while significant, is small. This further corroborates our conclusion that increases in income would lead to higher nutrient intakes for the poor.

The plan of this paper is as follows. In section II we motivate the analysis whereas section III explains the data and methodology. Section IV presents the results of the analysis and section V concludes. .

II. Motivation

Once the existence of a Poverty Nutrition Trap has been established (Jha, Gaiha and Sharma, 2006), the logical next step is to inquire about the extent of subsidy necessary to break the undernutrition-low wage cycle. Behrman and Deolalikar (1987) argue that it is incorrect to assume that existing preference patterns of the poor will persist if transfers to them are increased. In other words, it is incorrect to extrapolate from existing patterns of the poor to predict their preferences (and hence nutrition intake) when they are given

[5] Denoting food consumption/expenditure elasticity by ε_f, calorie elasticity by ε_{cal} and calorie price elasticity by ε_{pcal}, with respect to income, it is easy to show that

$$\varepsilon_f = \varepsilon_{cal} + \varepsilon_{pcal}$$

and thus

$$\varepsilon_{pcal} = \varepsilon_f - \varepsilon_{cal} .$$

Since ε_f and ε_{cal} can be directly estimated from the NSS data, their difference yields an estimate of ε_{pcal}. Behaviourally, the greater the preference for attractive packing, different flavours and variety, the lower will be the nutritional impact of income (Behrman and Deolalikar, 1987).

a further subsidy — either directly in terms of an enhanced minimum wage or indirectly through food subsidies.

Various studies have reported a low calorie-income elasticity (Behrman and Deolalikar, 1987). Assuming that there is a strong preference for variety- a catch all term for flavour, taste, packaging- etc., this finding has important policy implications. In other words, raising income will not necessarily correct calorie deficiency. In this paper, we outline a procedure (due to Behrman and Deolalikar, 1989) that will allow us to test for different calorie-income elasticities at different income levels as well as different elasticities of substitution between different foods (that may vary in terms of cost of calories). Two issues are central to addressing these concerns: one is the curvature of indifference curves at different income levels, and the second is the location of the indifference curve (i.e. whether it is centred nearer the cheaper source of calories at low income levels and away from it at higher income levels). Some elaboration, based on the exposition in Behrman and Deolalikar (1989), would be helpful in interpreting the econometric results.

If concern for low –cost calories characterises food choices at low-incomes, the food indifference curves would be relatively flat (reflecting high substitution between different food items induced by relative price changes) and located nearer the axis for the cheaper source of calories (higher concentration of cheap sources of calories). As incomes rise (or food budgets increase), the food indifference curves may become more sharply curved and shift away from the source of cheap calories. In effect, there will be lesser concentration on cheap sources of calories and greater variety of food consumed for given prices and less change in food composition in response to relative food price changes. So a preference for food variety is reflected in greater curvature and locational centrality of food indifference curves.

III. Methodology and Data

We begin by measuring the nutrient-expenditure elasticities for major macro and micro nutrients. In line with Behrman and Deolalikar (1987) we argue that since nutrients and expenditures are mutually endogenous we should pursue instrument variable estimation of these elasticities.

Hence we pursue an instrument variable approach to estimating the elasticity of various nutrients with respect to income. The instrumented variable is log of per capita income (lpce) and the instruments are land_own,land_own2, headsex, lheadage, lheadage2, lpr_mail, lpr_female, lhhsize, $lhhsize^2$, hhgrp, relreligio_1, relreligio_2, relreligio_3, relreligio_4, relreligio_ 5,relreligio_6, relreligio_7, bimaru, coastal, lithead, whether landless. In the second step the per capita demand for each nutrient is regressed on the instrumented per capita income, land_own, land_own2, headsex, , lheadage, lheadage2, lpr_male, lpr_female, lhhsize, lhhsize2, hhgrp, relreligio_1, relreligio_2, relreligio_3, relreligio_4, relreligio_ 5,relreligio_6, relreligio_7, bimaru, coastal, lithead, whether landless.

A description of the variables used in the analysis is presented in table 1.

To keep the empirical estimation simple and useful, we will restrict income groups to two — poor and non-poor.[6] Four food groups are chosen for the analysis — wheat, rice, pulses and milk.

The Behrman-Deolalikar (1989) methodology postulates the existence of a utility function separable between food and non-food items. The sub-utility function involving food items is maximized subject to a budget constraint on food expenditures. Invoking the duality theorem they posit the indirect sub-utility function as:

$$V = AY^{\alpha}\left(\sum_i \beta_i P_i^{\rho}\right)^{-\alpha/\rho}, \beta_i = b_i e^{vi}, \qquad \rho \le 1, \qquad (1)$$

where Y = total expenditure, P_i = price of ith food, v = an error term that reflects stochastic variation in tastes and i indexes the different foods in the direct sub-utility function. The function V is assumed to be homogenous of degree zero in prices and income. Applying Roy's identity (for details, see Behrman and Deolalikar, 1989) we have

$$F_i = -(\partial V / \partial P_i)(\partial V / \partial Y) = Yb_i e^{vi} P_i^{\rho-1} /(\sum_i \beta_i P_i^{\rho}) \qquad (2)$$

where F_i is the quantity demanded of food i. Relation (2) subsumes a homothetic utility function since food demand functions are unitary elastic in total food expenditure. However, since this relation is estimated separately for different income groups, this assumption is not limiting.

[6] The poor are defined as those with per capita income below Rs. 2486 per annum.

Table 1: Variables used in Analysis

Household Level Variables l refers to the natural log	
Variable Name	Variable Description
headage	Age of Household Head
headage2	Square of Age of Household Head
pr_male	Number of adult males divided by HH size.
pr_female	Number of adult females divided by HH size.
Hhsize	Household size
hhgrp	HH Group Dummy Variable 1 if SC/ST HH and 0 Otherwise
Lithead	Dummy for whether head of household is literate
HINDU, MUSLIM, CHRISTIAN, SIKH, BUDDHIST, TRIBAL, JAIN, OTHERS	Religion dummies. 1, 2, 3, 4, 5, 6, 7, 8
land_own	Land Owned in Acres
land_own2	Square of Land Owned
Land	Whether landless
bimaru	Dummy for Bimaru states (Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh)
coastal	Dummy for Coastal districts
Enepchat	Predicted value of calorie consumption per capita
Enepchat2	Predicted value of square of calorie consumption per capita
Propchat	Predicted value of protein consumption per capita
propchat2	Predicted value of square of protein consumption per capita
Calcpchat	Predicted value of calcium consumption per capita
Calcpchat2	Predicted value of square of calcium consumption per capita
Carothat	Predicted value of carotene consumption per capita
carothat2	Predicted value of square of carotene consumption per capita
Ironpchat	Predicted value of iron consumption per capita
ironpchat2	Predicted value of square of iron consumption per capita
Ribopchat	Predicted value of riboflavin consumption per capita
ribopchat2	Predicted value of square of riboflavin consumption per capita
Thiapchat	Predicted value of thiamine consumption per capita
thiapchat2	Predicted value of square of thiamine consumption per capita

Dividing the demand for food *i* by that for food *j*, we obtain

$$\ln(F_i / F_j) = (b_i / b_j) + (1-\rho)\ln(P_j / P_i) + (v_i - v_j) \qquad (3)$$

Since the elasticity of substitution between foods *i* and *j* is

$\sigma = d\ln(F_i / F_j) / d\ln(P_j / P_i)$,

the degree of curvature of the indifference curve for F_i is given by $(1-\rho)$. The centrality of location of the indifference curve is given by F_i / F_j, holding relative prices of foods *i* and *j* constant. This is obtained from relation (3) as $\exp(b_i / b_j)$.

Equation (3) is estimated for the number of food groups -1 (as these are linearly dependent). Since this is a system of equations with correlated errors, it is jointly estimated by Zellner's seemingly unrelated regression method, imposing equality constraints across equations. Besides, since the ratio b_i / b_j appears in each estimated relation, one normalisation is required for identification of all b_i's. For this purpose, we normalize the $b_1 = 1(\ln b_i = 0)$.

Data

The data used in this paper comes from the National Council for Applied Economic Research (NCAER). The data were collected through a multi-purpose household survey, designed and conducted by the NCAER. This survey was spread over six months, from January to June, 1994. The data were collected using varied reference periods based on some conventional rules. For example, to estimate household income in rural agricultural households, cultivation and output figures used refer to the previous agricultural year. Similarly, to estimate short duration morbidity, occurrence of sickness during the preceding 30 days was recorded, but for major morbidity the reference period was the previous year.

A multi-stage sample design was chosen, in light of cost and time considerations, operational feasibility, and precision of the estimates. In each of the 16 states covered, the districts were cross-classified by income from agriculture and rural female literacy rate to form homogeneous strata in terms of these two variables. From each of these strata a pre-assigned number of districts, depending on the size of the stratum, were selected with probability proportional to the rural population in the district. Given the list of villages in the sample districts in Census records, a pre-assigned number of villages were then selected linear systematically after arranging the villages in a *tehsil* (an administrative block) alternately in ascending and descending order of rural female literacy. The households in the sample villages were listed along with information such as religion, caste, major sources of income, cultivable land, and other social and demographic characteristics as well as the occupation of the head of the household. Sample households from each of the strata so formed were selected linear systematically. Thus a total sample of 35,130 households spread over 1765 villages and 195 districts in 16 states was selected.

IV. Results

Estimates of the income elasticity are reported in Table 2 whereas details of the regressions are relegated to an Appendix.

Table 2: Estimates of Expenditure Elasticity of Nutrient Intake

Nutrient	*Coefficient*	*Robust Standard Error*	*t-value*	*p-value*
Calorie	0.065084	0.013427	4.85	<0.001
Protein	0.191506	0.016501	11.61	<0.001
Calcium	0.200333	0.023008	8.71	<0.001
Thiamine	0.025195	0.01572	1.6	0.109
Riboflavin	0.127487	0.018025	7.07	<0.001
Iron	0.151005	0.016014	9.43	<0.001
Carotene	0.19159	0.033655	5.69	<0.001

All the elasticites are positive. Except for thiamine for which the elasticity is significant at 10 per cent the others are all significant at less than 1 per cent. Thus our estimated elasticities are strong with the exception of calories for which the elasticity is positive and significant but relatively small. These estimates indicate an improvement in nutrient intake with rises in income.

In Table 3 we report results on Zellner estimation of equation (3) for poor and non-poor, respectively.[7] The elasticity of substitution between wheat and all other food items is slightly higher among the poor (0.06 as against 0.05 among the non-poor). Thus while there is a difference between the elasticity of substitution values for the poor and the non-poor these differences are not as stark as in Behrman and Deolalikar (1989). In our case there is little evidence to suggest large-scale substitution of taste for nutritious but inexpensive food as income rises. This is further supported by the fact that the computed ratio of wheat to other commodities under conditions of constant relative prices is not very different for the poor as compared to the non-poor. This is, again, in contrast to the results of Behrman and Deolalikar (1989).

An implied policy conclusion from this estimation is that increases in income could lead to significant increases in nutrition for the poor with the exception of calories. This conclusion is a more comprehensive assessment of nutritional impact of higher incomes than those of Subramaniam and Deaton (1996) and Behrman and Deolalikar (1989). Both these papers confine themselves to calories alone. However, our results on calorie intake are closer to those of Behrman and Deolalikar (1989) with the difference that the effect is significant.

Table 3: Curvature and Centrality of Indifference Curves of Food Commodities

Parameter	*Poor*		*Non Poor*	
	Coefficient	*P value*	*Coefficient*	*P value*
ln b1 (Wheat)	1.00			
ln b2 (Rice)	-0.16	p<0.001	-0.34	p<0.001
ln b3 (Pulses)	1.24	p<0.001	0.99	p<0.001
ln b4 (Milk)	0.07	p<0.001	-0.24	p<0.001
Elasticity of Substitution	0.06	p<0.001	0.05	p<0.001
Implied (relative prices constant) ratio of wheat to:				
Rice	1.00		1.03	
Pulses	2.69		2.41	
Milk	0.37		0.28	

[7] Note that the Breusch-Pagan test rejects the null hypothesis of independence of error terms.

V. Concluding Observations

Our analysis illustrates an important phenomenon associated with rising incomes and changing prices. Attention has been drawn in recent studies to a decline in calorie intake between the 1993 and 1999 NSS rounds and a conclusion has been drawn to a growing calorie deprivation. What the preceding analysis shows is that two sets of relationships are key to this result: one is the relative price effect, depending on the curvature of the food indifference curves for the poor and non-poor, and the second is the location of the indifference curves. The decline in calorie intake is thus a consequence of taste for variety associated with increasing curvature of food indifference curves and their increasing centrality. It must, however, be noted that the curvature is higher among the non-poor but not substantially vis-à-vis the poor, although locational differences are pronounced for some food items.

Our principal conclusion is that**,** to the extent that consumer choices are informed by a taste for variety, a lower calorie intake with rising incomes is not surprising. Strong evidence in support of this would imply that higher income alone may not bring about a substantially higher calorie intake among low income households and that price interventions may be more effective in achieving this objective. However, the strong version of this conclusion as accepted by Behrman and Deolalikar (1989) seems an overstatement.[8] Thus in our data set increases in income are likely to support the contention that income increases result in an increase in nutritional intake but that the increase in calories is likely to be small, though significant. So subsidised food distribution targeted to the poor under the Public Distribution System would improve nutritional status. An additional policy conclusion is that if there is reason to believe that consumer choices are not well-informed, there is a case for improving information about nutritional implications of food choices.

[8] This may partly be a result of the fact that differences between the incomes of the poor and non-poor may be more pronounced in the case of Behrman and Deolalikar (1989) than in our case.

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Appendix:

Detailed Regression results for Macro and Micro Nutrients

Table A1: First Stage Regression

First-stage regressions
(sum of wgt is 1.0069e+08)

Source	SS	df	MS			
Model	6231.99847	21	296.7618	Number of obs	=	30794
				F(21, 30772)	=	655.36
Residual	13934.2083	30772	0.452821	Prob > F	=	0
Total	20166.2068	30793	0.654896	R-squared	=	0.309
				Adj R-squared	=	0.3086
				Root MSE	=	0.67292

Lpce	Coef.	Robust Std. Err.	T	P>t
land_own	0.005027	8.12E-05	61.95	0
land_own2	-1.12E-06	2.73E-08	-41.01	0
headsex	0.040706	0.021664	1.88	0.06
lheadage	-0.51301	0.265878	-1.93	0.054
lheadage2	0.105719	0.035685	2.96	0.003
lpr_male	0.249527	0.009628	25.92	0
lpr_female	0.077799	0.011188	6.95	0
Lhhsize	-0.45245	0.054334	-8.33	0
Lhhsize2	-0.00255	0.015219	-0.17	0.867
Hhgrp	-0.16182	0.008759	-18.47	0
_relreligi~1	0.212539	0.051718	4.11	0
_relreligi~2	0.211766	0.053414	3.96	0
_relreligi~3	0.381652	0.057886	6.59	0
_relreligi~4	0.493963	0.059975	8.24	0
_relreligi~5	-0.04599	0.081771	-0.56	0.574
_relreligi~6	0.12791	0.089913	1.42	0.155
_relreligi~7	0.572162	0.232904	2.46	0.014
Bimaru	-0.08242	0.008291	-9.94	0
Coastal	0.19229	0.019946	9.64	0
Lithead	0.321582	0.008265	38.91	0
Land	0.178636	0.008907	20.06	0
_cons	9.173446	0.492044	18.64	0

Table A2: Calorie (lepc=log energy per capita)

Instrumental Variables (2SLS) regression	Number of obs	=	30794
	F(20, 30773)	=	126.85
	Prob > F	=	0
	R-squared	=	0.1096
			0.3308
	Root MSE	=	1

Lepc	Coef.	Robust Std. Err.	t	P>t
Lpce	0.065084	0.013427	4.85	0
land_own	7.66E-05	8.59E-05	0.89	0.373
land_own2	-2.41E-08	2.10E-08	-1.15	0.25
headsex	-0.06996	0.012952	-5.4	0
lheadage	0.311249	0.154153	2.02	0.043
lheadage2	-0.02893	0.02067	-1.4	0.162
lpr_male	0.089027	0.0066	13.49	0
lpr_female	0.017013	0.006734	2.53	0.012
Lhhsize	-0.38932	0.032753	-11.89	0
Lhhsize2	0.068482	0.009144	7.49	0
Hhgrp	-0.01228	0.005959	-2.06	0.039
_relreligi~1	0.184004	0.030781	5.98	0
_relreligi~2	0.220491	0.031739	6.95	0
_relreligi~3	0.131032	0.034025	3.85	0
_relreligi~4	0.284085	0.034155	8.32	0
_relreligi~5	0.114881	0.049266	2.33	0.02
_relreligi~6	0.104661	0.052402	2	0.046
_relreligi~7	0.111338	0.135088	0.82	0.41
Bimaru	0.101543	0.004991	20.35	0
Coastal	-1.99E-02	1.26E-02	-1.58	0.115
_cons	6.621912	0.307359	21.54	0

Table A3: Protein (lpropc = log protein per capita)

Instrumental variables (2SLS) regression

Number of obs	=	30794
F(20, 30773)	=	139.49
Prob > F	=	0
R-squared	=	0.0918
Root MSE	=	0.39746

Lpropc	Coef.	robust Std. Err.	t	P>t
Lpce	0.191506	0.016501	11.61	0
land_own	-0.00052	0.000103	-5.06	0
land_own2	1.11E-07	2.32E-08	4.79E+00	0.00E+00
headsex	-0.06559	0.016559	-3.96	0
lheadage	0.133156	0.186664	0.71	0.476
lheadage2	-0.00658	0.025032	-0.26	0.793
lpr_male	0.057603	0.007827	7.36	0
lpr_female	-0.0088	0.008061	-1.09	0.275
Lhhsize	-0.38264	0.041061	-9.32	0
Lhhsize2	0.078578	0.011266	6.97	0
Hhgrp	0.013719	0.007244	1.89	0.058
_relreligi~1	0.389797	0.042501	9.17	0
_relreligi~2	0.505488	0.043658	11.58	0
_relreligi~3	0.483261	0.04703	10.28	0
_relreligi~4	0.613764	0.045883	13.38	0
_relreligi~5	0.455481	0.061125	7.45	0
_relreligi~6	0.419448	0.063681	6.59	0
_relreligi~7	0.289124	0.140524	2.06	0.04
Bimaru	0.173737	0.005927	29.31	0
Coastal	-0.16156	0.014122	-11.44	0
_cons	2.005457	0.372266	5.39	0

Table A4: Calcium (lcalpc=log calcium per capita)

Instrumental variables (2SLS) regression

Number of obs	=	30794
F(20, 30773)	=	270.18
Prob > F	=	0
R-squared	=	0.1566
Root MSE	=	0.58084

Lcalcpc	Coef.	robust Std. Err.	t	P>t
Lpce	0.200333	0.023008	8.71	0
land_own	0.001113	0.000158	7.06	0
land_own2	-2.52E-07	5.20E-08	-4.85	0
headsex	-0.06704	0.024613	-2.72	0.006
lheadage	0.00275	0.268927	0.01	0.992
lheadage2	0.014098	0.036128	0.39	0.696
lpr_male	0.044461	0.011292	3.94	0
lpr_female	-0.04654	0.011612	-4.01	0
Lhhsize	-0.4211	0.056792	-7.41	0
Lhhsize2	0.08817	0.015476	5.7	0
Hhgrp	-0.03131	0.010469	-2.99	0.003
_relreligi~1	1.019631	0.069085	14.76	0
_relreligi~2	0.911521	0.07002	13.02	0
_relreligi~3	0.746405	0.073455	10.16	0
_relreligi~4	1.82311	0.072295	25.22	0
_relreligi~5	1.533482	0.089568	17.12	0
_relreligi~6	1.519199	0.094951	16	0
_relreligi~7	1.542956	0.171573	8.99	0
Bimaru	0.266803	0.008518	31.32	0
Coastal	-0.32328	0.020058	-16.12	0
_cons	2.673151	0.535102	5	0

Table A5: Thiamine (Lthiapc=log thiamine per capita)

Instrumental variables (2SLS) regression	Number of obs	=	30794
	F(20, 30773)	=	297.83
	Prob > F	=	0
	R-squared	=	0.2255
	Root MSE	=	0.38733

Lthiapc	Coef.	robust Std. Err.	t	P>t
Lpce	0.025195	0.01572	1.6	0.109
land_own	0.000717	0.000109	6.56	0
land_own2	-1.67E-07	3.93E-08	-4.25	0
headsex	-0.08778	0.015678	-5.6	0
lheadage	0.071786	0.183219	0.39	0.695
lheadage2	0.00397	0.02455	0.16	0.872
lpr_male	0.099995	0.007705	12.98	0
lpr_female	-0.01048	0.007765	-1.35	0.177
Lhhsize	-0.36901	0.038106	-9.68	0
Lhhsize2	0.067085	0.010581	6.34	0
Hhgrp	-0.0383	0.007029	-5.45	0
_relreligi~1	0.553054	0.039962	13.84	0
_relreligi~2	0.511847	0.040838	12.53	0
_relreligi~3	0.406832	0.044342	9.17	0
_relreligi~4	1.01077	0.044534	22.7	0
_relreligi~5	0.661464	0.057143	11.58	0
_relreligi~6	0.654338	0.061539	10.63	0
_relreligi~7	0.720712	0.153689	4.69	0
Bimaru	0.351622	0.005751	61.14	0
Coastal	-0.12638	0.013504	-9.36	0
_cons	-0.29781	0.365972	-0.81	0.416

Table A6: Riboflavin (lribopc=log riboflavin per capita)

Instrumental variables (2SLS) regression

Number of obs
F(20, 30773)
Prob > F
R-squared
Root MSE

Lribopc	Coef.	robust Std. Err.	t	P>t
Lpce	0.127487	0.018025	7.07	0
land_own	0.000444	0.00012	3.71	0
land_own2	-1.04E-07	3.76E-08	-2.77	0.006
headsex	-0.07227	0.018547	-3.9	0
lheadage	0.011076	0.206011	0.05	0.957
lheadage2	0.010475	0.0276	0.38	0.704
lpr_male	0.06876	0.008681	7.92	0
lpr_female	-0.03022	0.008851	-3.41	0.001
Lhhsize	-0.37955	0.0443	-8.57	0
Lhhsize2	0.076023	0.012149	6.26	0
Hhgrp	-0.01899	0.008129	-2.34	0.019
_relreligi~1	0.728452	0.050529	14.42	0
_relreligi~2	0.73926	0.051552	14.34	0
_relreligi~3	0.670312	0.055177	12.15	0
_relreligi~4	1.247269	0.053974	23.11	0
_relreligi~5	1.003917	0.065771	15.26	0
_relreligi~6	0.982094	0.07197	13.65	0
_relreligi~7	0.936	0.164404	5.69	0
Bimaru	0.359264	0.006579	54.61	0
Coastal	-0.23934	0.014701	-16.28	0
_cons	-2.27315	0.410919	-5.53	0

Table A7 Iron (lironpc = log iron per capita)

Instrumental variables (2SLS) regression

Number of obs	=	30794
F(20, 30773)	=	96
Prob > F	=	0
R-squared	=	0.0597
Root MSE	=	0.38554

Lironpc	*Coef.*	*robust Std. Err.*	*t*	*P>t*
Lpce	0.151005	0.016014	9.43	0
land_own	-0.00047	9.97E-05	-4.71	0
land_own2	9.58E-08	2.23E-08	4.3	0
headsex	-0.08661	0.014784	-5.86	0
lheadage	0.382932	0.179751	2.13	0.033
lheadage2	-0.04195	0.024127	-1.74	0.082
lpr_male	0.070811	0.007785	9.1	0
lpr_female	-0.00039	0.007893	-0.05	0.96
Lhhsize	-0.38182	0.040339	-9.47	0
Lhhsize2	0.081023	0.011395	7.11	0
Hhgrp	0.010081	0.006983	1.44	0.149
_relreligi~1	0.272213	0.035664	7.63	0
_relreligi~2	0.388624	0.037002	10.5	0
_relreligi~3	0.261629	0.039195	6.68	0
_relreligi~4	0.390598	0.039158	9.97	0
_relreligi~5	0.191333	0.054495	3.51	0
_relreligi~6	0.168117	0.057333	2.93	0.003
_relreligi~7	0.164334	0.139736	1.18	0.24
Bimaru	0.084456	0.005865	14.4	0
Coastal	-0.14162	0.01388	-10.2	0
_cons	1.35779	0.359452	3.78	0

Table A8 : Carotene (Lcarotpc = log carotene per capita)

Instrumental variables (2SLS) regression			
	Number of obs	=	30671
	F(20, 30650)	=	524.32
	Prob > F	=	0
	R-squared	=	0.2917
	Root MSE	=	0.84465

lcarotpc	Coef.	robust Std. Err.	t	P>t
Lpce	0.19159	0.033655	5.69	0
land_own	0.001474	0.000221	6.67	0
land_own2	-3.23E-07	6.99E-08	-4.63	0
headsex	-0.07315	0.036843	-1.99	0.047
lheadage	-0.36355	0.367974	-0.99	0.323
lheadage2	0.062291	0.049268	1.26	0.206
lpr_male	0.062439	0.016676	3.74	0
lpr_female	-0.07804	0.017013	-4.59	0
Lhhsize	-0.47694	0.078572	-6.07	0
Lhhsize2	0.106636	0.021221	5.03	0
Hhgrp	-0.08858	0.015609	-5.68	0
_relreligi~1	1.751032	0.123657	14.16	0
_relreligi~2	1.564208	0.125018	12.51	0
_relreligi~3	1.250176	0.129782	9.63	0
_relreligi~4	3.074494	0.126436	24.32	0
_relreligi~5	2.649511	0.138911	19.07	0
_relreligi~6	2.501197	0.154065	16.23	0
_relreligi~7	2.599149	0.247474	10.5	0
Bimaru	0.89452	0.012278	72.86	0
Coastal	-0.57423	0.032276	-17.79	0
_cons	2.073084	0.744958	2.78	0.005