On Modelling Variety in Consumption Expenditure on Food*

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ABSTRACT

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 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 nutrient intake.

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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]

[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.

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 calorie deficiency. 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 not be as high as is often claimed because of the failure in such estimation to allow for the positive association of nutrient prices with incomes in poor economies. 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 in endogenous to income. Hence an Instrumental Variable (IV) approach to estimation must be pursued.

As the likely contamination of the 55th round of the NSS data 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 HCRs of the undernourished over different rounds of the NSS are not

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

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, implying a moderately strong preference for expensive foods at higher income levels[5]. Although this

[4] In a personal communication, J. V. Meenakshi reports a slight reduction in the head count ration 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.

[5] Denoting food consumption/expenditure elasticity by εf, calorie elasticity by εcal and calorie price elasticity by εpcal, with respect to income, it is easy to show that

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

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 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 nutrient intake.

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

II. Motivation

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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).

Once we have established the existence of a Poverty Nutrition Trap (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 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 (or 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. These results are illustrated in figures 1 and 2)

Figures 1 and 2 here (From Behrman and Deolalikar 1989)

III. Methodology and Data

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

Hence we conduct 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, land. In the second step the per capita demand for any nutrient is regressed on the instruments 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, land. . The data used in this paper comes from the National Council for Applied Economic Research (NCAER). This data were collected through a multi-purpose household survey spread over six months, from January to June 1994. A description of the variables used in the analysis is presented in table 1.

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,	Religion dummies. 1, 2, 3, 4, 5, 6, 7
land_own	Land Owned in Acres

land_own2	Square of Land Owned
Land	Whether land owned
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

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

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

food items is maximized subject to a budget constraint on food expenditures. Invoking the duality theorem they posit the indirect sub-utility function as:

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

where Y = total expenditure, P = food price, 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

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

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.

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 collection methodology involved a multi-purpose household survey spread over six months, from January to June 1994. The data were collected using varied reference periods based on some conventional rules.

IV. Results

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

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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

Protein	0.191506	0.016501	11.61	0
Calcium	0.200333	0.023008	8.71	0
Thiamine	0.025195	0.01572	1.6	0.109
Riboflavin	0.127487	0.018025	7.07	0
Iron	0.151005	0.016014	9.43	0
Carotene	0.19159	0.033655	5.69	0

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 and 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).

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

An implied policy conclusion from this estimation is that increases in income could lead to significant increases in nutrition for the poor. This conclusion is more in agreement with that of Subramaniam and Deaton (1996) than that of Behrman and Deolalikar (1989).

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	

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) is not supported by our analysis.[8] Thus in our data set increases in income could well support the contention that income increases could lead to an increase in nutritional intake. An additional policy conclusion is that if there is reason to believe that consumer choices are

[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.

not well-informed, there is a case for improving information about nutritional implications of food choices.

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Appendix: Detailed Regression results for Macro and Micro Nutrients

Table A1: Calorie (lepc=log energy per capita)

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

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

(sum of wgt is 1.0069e+08)
Instrumental variables (2SLS) regression

Number of obs	=	30794
F(20, 30773)	=	126.85
Prob > F	=	0
R-squared	=	0.1096
Root MSE	=	0.33081

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 A2: Protein (lpropc = log protein per capita)

Source	SS	df	MS	Number	of	obs	=	30794
Model	6231.998	21	296.7618	Prob	>			
Residual	13934.21	30772	0.452821	R-squared	=	0.309		
Total	20166.21	30793	0.654896	Root	MSE	=	0.67292	
F(	21,	30772)	=	655.36				
F	=	0						

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

(sum	Of	wgt	is	1.0069e+08)		
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 A3: Calcium (lcalpc=log calcium per capita)

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

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 A4 Thiamine (Lthiapc=log thiamine per capita)

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

Source	SS	df	MS				
				Number of obs = 30794			
				F(21, 30772) = 655.36			
Model	6231.998	21	296.7618				
Residual	13934.21	30772	0.452821	R-squared	=		0.309
Total	20166.21	30793	0.654896	Root	MSE	=	0.67292

R-squared = 0.3086

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

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 A5: Riboflavin (lribopc=log riboflavin per capita)

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

Source	SS	df	MS		
				Number of obs =	30794
				F(21, 30772)	655.36
Model	6231.998	21	296.7618	Prob > F	0
Residual	13934.21	30772	0.452821	R-squared	0.309
				Adj R-squared	0.3086
Total	20166.21	30793	0.654896	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
(sum	of	wgt	is	1.0069e+08)
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 A6 Iron (lironpc = log iron per capita)

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

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

(sum	of	wgt	is	1.0069e+08)		
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 A7 : Carotene (Lcarotpc = log carotene per capita)

First-stage regressions (sum of wgt is 1.0024e+08)

				Number	of	obs	=	30671
F(	21,	30649)	=	652.07				
Source	SS	df	MS					
Model	6193.687	21	294.9375	Prob	>	F	=	0
Residual	13862.85	30649	0.45231					
R-squared	=	0.3088		Adj	R-squared	=	0.3083	
Total	20056.53	30670	0.653946	Root	MSE	=	0.67254	

lpce	Coef.	robust Std. Err.	t	P>t
land_own	0.005017	8.11E-05	61.86	0
land_own2	-1.12E-06	2.73E-08	-40.95	0
headsex	0.038725	0.021676	1.79	0.074
lheadage	-0.48192	0.266371	-1.81	0.07
lheadage2	0.101743	0.035746	2.85	0.004
lpr_male	0.249496	0.009637	25.89	0
lpr_female	0.078327	0.011201	6.99	0
lhhsize	-0.46528	0.054486	-8.54	0
lhhsize2	0.0007	0.015251	0.05	0.963
hhgrp	-0.15958	0.008777	-18.18	0
_relreligi~1	0.165653	0.056127	2.95	0.003
_relreligi~2	0.16385	0.05771	2.84	0.005
_relreligi~3	0.336952	0.061862	5.45	0
_relreligi~4	0.445333	0.063795	6.98	0
_relreligi~5	-0.09654	0.084579	-1.14	0.254
_relreligi~6	0.077432	0.092472	0.84	0.402
_relreligi~7	0.523043	0.233735	2.24	0.025
bimaru	-0.08267	0.0083	-9.96	0
coastal	0.192493	0.019966	9.64	0
lithead	0.319907	0.008271	38.68	0

land	0.17845	0.00892	20.01	0
_cons	9.17693	0.493526	18.59	0

(sum	of	wgt	is	1.0024e+08)		
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