A Panel Data Study of the Determinants of Micronutrient Intake in China

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1. Introduction

The world has witnessed China's unprecedented success in the last two decades, with annual GDP growth rates averaging 9-10% in the course of 1980-2003 and household incomes rising steadily. The proportion of the absolutely poor in China came down from 80% in 1978 to less than 12% in 1998, while the proportion of the extremely poor was reduced from 20% to 6% during the same period (Du, *et. al.*, 2004).

Concomitantly with economic growth, Chinese households have also enjoyed significant nutritional improvements. At the same time, some worrying trends have been detected. China is now often held up as a classic illustration of the 'double burden of malnutrition' wherein undernutrition in some segments of the population co-exists with obesity and disease related to overnutrition in other segments (Popkin, *et. al.*, 1995). Dietary patterns are increasingly based on significant consumption of animal fats, edible oils and processed foods, while traditional foods have started to disappear from diets. Therefore, much attention has been paid to the economic analysis of the demand for specific groups of food products in China and/or the analysis of macronutrients in the form of energy, fat and carbohydrates (*e.g.* Du, *et. al.*, 2004; Guo, *et. al.*, 1999; Yen, *et. al.*, 2004; Fang and Beghin, 2004).

However, little attention appears to have been focused on the socioeconomic determinants of micronutrients such as vitamins, iron and calcium in the Chinese population. Micronutrients are often only needed in relatively small amounts by the human body, and yet deficiencies are associated with debilitating and productivity-reducing health conditions such as birth defects, lower IQs, weakened bones and anaemia. Nutritionists have been studying micronutrient deficiencies in China and have commented particularly on the large-scale deficiency of vitamin A and calcium and associated health effects (*e.g.* Shi-an, 2004; MI & UNICEF, 2004). Yet, there is a lack of literature systematically examining the economic determinants of these key micronutrient intakes. This research explores the determinants of micronutrient demand using a panel dataset of Chinese households observed in 1997 and 2000.

2. Micronutrient Intakes and Their Determinants

The amount of micronutrient intake that is actually used by the body depends on a number of factors, including 'bioavailability' from the specific source, the personal metabolism of the individual and the interaction effects with other micronutrients.

Despite this, inadequate dietary intake is still considered as the major cause of micronutrient malnutrition (FAO, 1997). Thus food-based strategies are consistently suggested by international organisations to prevent micronutrient malnutrition.

2.1 Nutrient Intake Modelling

A vibrant literature exists on econometric modelling of the determinants of nutrient intakes. Calorie intake, being closely related to hunger satiation, is the most frequently modelled variable. One strand of the literature subsumes this within traditional demand modelling approaches, and estimates systems of demand equations using broad groupings of food categories, and indirectly derives calorie demand elasticities using appropriate conversion factors. While estimation of demand systems enables full appreciation of cross and own price and other effects in determining nutrient outcomes, nutrient values of food products within broad categories can vary tremendously, and the use of aggregated groups can result in substantial bias in estimation due to the fact that intra-group substitutions are ignored (Behrman and Deolalikar, 1987). Therefore the other strand undertakes direct estimation, expressing nutrient value as a function of income, prices and other socioeconomic variables (*e.g.* Behrman and Deolalikar, 1987; Abdulai and Aubert, 2004).

If poverty reduction readily takes care of malnutrition as well, policy and aid can be focused primarily on raising household incomes, without requiring substantial separate focus on nutrition. Therefore, the income elasticity of calories is the key scalar of interest in this literature. Estimates range from 0.01 to 1.18 (Gibson and Rozelle, 2004), varying by geographical setting, methodology and measurement techniques.

2.2 Micronutrient Intake Modelling

Much less attention has been paid to the modelling of micronutrients. Behrman (1995) notes that micronutrients enter the utility functions of consumers in an indirect fashion, through food choices made on the basis of health, taste and other attributes of different foods, rather than for their own sakes. In this sense, the nature of micronutrient demand is conceptually slightly different from calorie demand, since the latter is more perceptible and has a direct influence on utility, manifested as the satiation of hunger. Thus, Behrman suggests that reduced form explanatory variables for micronutrients should include a full set of prices and human, physical and financial assets that play a role in household demand relations.

Micronutrient demand relationships are also different from calorie demand in other ways. Firstly, they are less generalizable across time and space than calorie relationships, since food choice patterns vary substantially. One can even envisage negative income elasticity for some micronutrients, for instance due to the increased substitution of micronutrient-poor processed foods like milled rice or colas for relatively micronutrient-rich staples. Secondly, there are multiple micronutrients of importance derived to varying degrees from various foods, and so changes in a particular variable can result in very different effects on various micronutrients. Consistent with these two points, previous studies have found very different income elasticities and income elasticity ranges in different settings. Behrman and Wolfe (1984) estimated income elasticities for micronutrients in Nicaragua to be positive but small, ranging from 0.04 to 0.10, while Bouis and Novenario-Reese (1997) have reported a much larger range, from 0 to 0.81 in Bangladesh. Bouis (1991) found income elasticities in the Philippines to range from 0 for vitamins to 0.4 for iron.

3. Data

The data used in this study derive from the China Health and Nutrition Survey (CHNS), a large Sino-American collaborative longitudinal data collection exercise with numerous research outputs (http://www.cpc.unc.edu/projects/china/publication provides a listing). This, however, is the first use of the data in modelling micronutrient demand. The dietary portion of the CHNS recorded food consumption in great detail over a 3-day period in each wave. Extensive household-specific information was collected, and CHNS also makes available a carefully constructed income variable for each household. Supplementary community-level food price information is also available and is used here in conjunction with the household-specific information. These data were intersected with nutrient conversion information from China Food Composition (FCT) Tables 2002 produced by the

Institute for Nutrition and Food Safety, China CDC (Chinese Centre for Disease Control and Prevention). The FCT provides conversion values for over 1500 food items consumed in China, enabling a good degree of precision in calculating micronutrient values. The household data used here are from the latest two waves for which data are available, 1997 and 2000. All households with data available for both years were originally included, and following deletion of observations with significant missing information, a balanced panel of 2673 households was retained for analysis.

4. Methods

Initial analysis of the data showed that calcium and vitamin A were the two micronutrients for which intakes were substantially and consistently below recommended values. Therefore, a decision was made to focus on these two micronutrients. The household data were then processed to provide summary statistics tables showing the extents of deficiencies and the food sources of these nutrients, with the household nutrient intake data expressed on a per-capita basis, and broken down by income tertiles.

4.1 Nonparametric Estimation:

Continuing the emphasis on the micronutrient-income relationship, we applied nonparametric smoothing techniques to investigate the shape of this relationship. The shape of nutrient-income relationships is difficult to generalize across studies. In the calorie modelling case, log-linear, quadratic in log-linear and quadratic in levels forms have all been used. There is even less guidance available on what the micronutrient-income relationship might look like. Nonparametric methods have the advantage of not imposing functional forms on the data (see DiNardo and Tobias, 2001; Fan, 2001, for details). They are useful in providing an initial idea of nutrient-income relationship, and are also thus able to provide guidance for the specification of parametric models. Gaussian kernels were used in estimation with a 0.8 bandwidth (alternative specifications of bandwidths did not result in substantially different relationships).

4.2 Parametric Panel Data Estimation

Separate panel data regressions were carried out for household per-capita calcium and vitamin A intakes. In addition to income, data on a set of community-level prices for 18 food products was included in the analysis. Household-specific demographic variables included Family Size (number of people in the family), Education (years of schooling of household head), Gender (household head: 0 if female, 1 if male) and Age (age of household head). Regional dummies were included to capture the differences in diets and preferences in diets in China, specified as North (1 if household is in the North, 0 otherwise), Central (1 if in Central China, 0 elsewhere) and Urban (0 if located in a rural area, 1 if in urban area).

For every food in community price dataset, the CHNS survey could not find a price recorded in at least some local communities. In the case of most foods, this occurred in less than 3% of communities, and therefore non-availability was a relatively minor phenomenon. However, Milk is one food that whose non-availability can make a significant difference to both calcium and vitamin A intakes, *and* whose consumption is far from universal. Milk has never been a part of the traditional Chinese diet, and even though it has increased in popularity and availability in the past decade, community-level fresh milk prices were recorded for only 48% of households in our dataset. Therefore, we included dummy variables for community-level Fresh Milk Availability (0=not available, 1=available) and Powdered Milk Availability. To further account for the non-availability of prices for specific foods in some communities, the price variables in the regression were specified as appearing multiplicatively with dummies indicating availability.

Thus the equation to be estimated for calcium was specified as:

$$\ln(C_{it}) \;=\; \alpha + \sum_{a} \beta_a A_{ait} + \sum_{d} \gamma_d D_{dit} + \delta \ln(I_{it}) + \sum_{p} \beta_p T_{pct} \ln(P_{pit}) + (v_i + n_t + e_{it}) \qquad (1)$$

In (1), C is calcium intake per capita and i and t index households and survey waves (1997 and 2000) respectively. The **A** are the 'availability' dummies for fresh milk and powdered milk, indexed by a. The **D** are the demographic variables, indexed by d and I is income. The **P** are the food price variables, indexed by p, while T is the full set of community level price availability dummies and c represents the specific community to which i belongs. The household effects are given by v_i while the time effect is given by n_t, and e_{it} is the random error term. A parallel equation was specified for vitamin A.

The two equations were estimated using a random effects specification. Fixed effects modelling would have facilitated purging of any existing simulteneity/endogeneity. However, in the CHNS survey, food intake was estimated through dietary intake recording during a 3-day period following the year for which annual income was recorded. It is thus less prone to simultaneity concerns than typical nutrient demand study data. Also, the random effects specification affords identification of relatively time-invariant variables of interest, such as location. Thirdly, alternative fixed effects models produced poor and comparatively unintuitive results compared to the random effects models.

5. Results

5.1 Intakes and food sources

The China Nutrition Society provides recommended calcium intake levels of 800 mg and vitamin A intake levels of 800 µg, per person per day. We used this as our benchmark to evaluate current outcomes in our dataset. Tables 1 and 2 present the status of households in the sample with regard to these recommendations. Table 1 clearly shows that deficiencies are widespread for both micronutrients. On average, households are achieving only about half of the recommended intakes, although there has been some improvement from 1997 to 2000. Calcium intakes increase only very slowly across income tertiles, going up from 41% of recommended levels for the poorest to 49% for the richest in 1997, and from 48% to 56% in 2000. Vitamin A shows a more encouraging response to increased incomes, with average intakes increasing from 37% of recommended levels for the poorest to 64% for the richest in 1997, and from 40% to 75% in 2000. Table 2 shows that the vast majority of the sample is achieving less than 80% of recommended intake, and that furthermore, there has been little temporal progress in this statistic. Clearly, substantial progress is necessary with both micronutrients.

The data were also analyzed to investigate the relative contributions made by various foods in the overall intake of each micronutrient, and how these vary across time and income tertiles (not shown here due to space constraints). When we calculated the average calcium provided by major foods on the basis of **all** households in the sample, vegetables and tofu/beancurd proved to be by far the biggest contributors. Milk proved considerably less important. However, when we instead used only those consuming a specific food in the calculation, we found that fresh and powdered milk shot up the rankings, providing calcium matching levels from vegetables and beancurd.

Similar analysis undertaken for vitamin A indicated that eggs and vegetables were by far the most important sources of vitamin a, when averages were taken based on the overall sample. When adjustments were made, as before, to compute an alternative measure based on numbers of households actually consuming specific products, fresh and powdered milk once again became important, although to a lesser degree. Sources of vitamin A were found to much more restricted than sources of calcium, with many commonly consumed Chinese foods providing only trace amounts.

5.2 Nonparametric analysis

Figures 1 and 2 below show the results of the kernel regression procedures expressing 1997 and 2000 calcium and vitamin A per capita intakes as functions of household per capita income, all values expressed in logs. As can be seen, the micronutrients intakes broadly possess an increasing relationship with household per capital incomes. However, in the case of calcium, as first observed in Table 1, the relationship is very gradual. The Vitamin-A intake shows a somewhat stronger increasing relationship with income. Although these regression do not control for other factors that may impinge on the micronutrient-income relationship, they seem to broadly indicate that nutrient intakes increase with income, but only at a slow rate. Even though some minor changes of slope can be detected in the figures, it appears that it would not be unreasonable to characterize the relationships as broadly linear. Since the variables are measured in natural logs, this suggests a relatively constant elasticity.

5.3 Panel Regression Estimates

Table 3 presents the random effects regression estimates. Focusing on the calcium results first, it can be seen that the availability of fresh and/or powdered milk makes a substantial difference to the calcium intakes. Both the north and the central dummies are positive and significant, indicating that regional differences in diets and nutrient intakes are important. Education is usually considered a key variable in nutrient demand modelling, since it is a proxy for awareness of the connections between food intakes and nutrient and health outcomes. Although the education parameter has a positive sign, it is statistically insignificant with a t value of 1.5. The gender and urban dummies are similarly insignificant. Family size has a negative and significant coefficient, indicating that smaller families are able to achieve higher per-capita calcium intakes, all else held constant. This negative effect is seen consistently in most of the literature on nutrient demand in developing countries (*e.g.* Gibson and Rozelle, 2004; Abdulai and Aubert, 2004). Larger household size is viewed as usually reflecting a larger dependency ratio, with a greater proportion of children and aged relatives. Larger families are often found to achieve economies on food intake, resulting in lower intake per capita. In addition, children often eat separately from adults and the needs of aged relatives often receive low priority.

Price effects on nutrient demands in developing countries are usually important, but also inevitably complex (Behrman, 1995). With a range of substitutions occurring between foods, only part of which may be evident due to aggregation problems, interpretations are not always straightforward. Focusing on the prices of foods known to be important in calcium provision in the Chinese diet, we can see from Table 3 that fluid milk, powdered milk and beancurd price coefficients are all negative and statistically highly significant. Counterintuitively, however, the vegetable price coefficient indicates that a 10% increase in vegetable prices will result in a 0.41% increase in calcium intake. One possible reason for this anomalous result is the lack of adequate detail in the CHNS data on vegetable prices – in particular, detailed prices broken down on the basis of individual vegetables and groups are not available. Edible oil prices have positive coefficients, which is intuitive in that they are poor sources of calcium. Finally, turning to the key variable of interest, we can confirm the indications provided in previous sections that income has a positive but very mild effect on calcium intakes in China. The statistically significant coefficient value of 0.02 for ln(income) indicates that a 10% increase in income would result in a 0.2% increase in calcium per capita.

Milk availability is seen to have a positive influence on vitamin A as well, although only the fluid milk dummy is statistically significant. Interestingly, the regional dummies for North and Central are still significant, but bear an opposite sign to the calcium case. Clearly, regional effects are strong, but can affect different micronutrients in different ways. The expected positive effect of education on nutrient intakes comes through in the vitamin A case even though it was insignificant with calcium. Gender of the household head continues to be unimportant, but urban households are seen to have better vitamin A intakes than rural ones. A negative family size effect is found again. Turning to the price variables, price effects appear to be less important for vitamin A intake compared to the calcium case. 11 of the 18 price coefficients are statistically insignificant. Even though the price of eggs, the most important source of vitamin A, has an intuitively negative coefficient, it is not significant. However, at least one previous study has reported a very low price elasticity for eggs in China. Guo *et. al.* (1999) found that the price elasticity of demand for eggs was, along with coarse grains, the lowest among various food groups they considered, with a value of 0.1. Vegetable price once again has a counterintuitive sign, as in the calcium case. Although we find milk availability to be an important determinant of vitamin A intake, apparently milk prices are relatively unimportant, given their statistically insignificant coefficients. Finally, a positive income effect is confirmed, with the log(income) coefficient showing a statistically significant value of 0.149. A 10% increase in incomes would, *ceteris paribus*, raise vitamin A intakes by about 1.5%.

6. Conclusions

This research has explored the economic determinants of household demand for the two key micronutrients in China, calcium and vitamin A. Specifically, we have been interested in finding out whether steadily growing household incomes in China will in themselves solve existing deficiency problems. The conclusion is slightly mixed in that, although vitamin A is apparently more responsive to income increases than calcium, the effects are relatively small. Thus improving incomes will ameliorate the situation, but additional policies may be necessary for a speedier solution. Milk, particularly fresh milk, availability seems to be a key in improving outcomes with respect to both micronutrients. This notion provides strong backing for the nationwide school-milk program that China has embarked on. With milk and eggs being key sources, we are also reminded that the Chinese transition to diets more based on animal foods, often connected with negative outcomes related to fats, may actually prove useful in solving the two key micronutrient deficiencies.

Table 1. Household per capita Intake Percent of Requirement, by Income Tertile

Nutrient	Income Tertile			All
	Low	Middle	High	
1997				
Calcium	0.41	0.47	0.49	0.46
Vitamin A	0.37	0.44	0.64	0.48
2000				
Calcium	0.48	0.48	0.56	0.51
Vitamin A	0.40	0.54	0.75	0.56

Table 2. Percent of per capita Intake below 80 Percent of Requirements, by Income Tertile

Nutrient	Income Tertile			All
	Low	Middle	High	
1997				
Calcium	95	92	90	92
Vitamin A	91	88	80	86
2000				
Calcium	90	91	88	90
Vitamin A	90	83	80	84

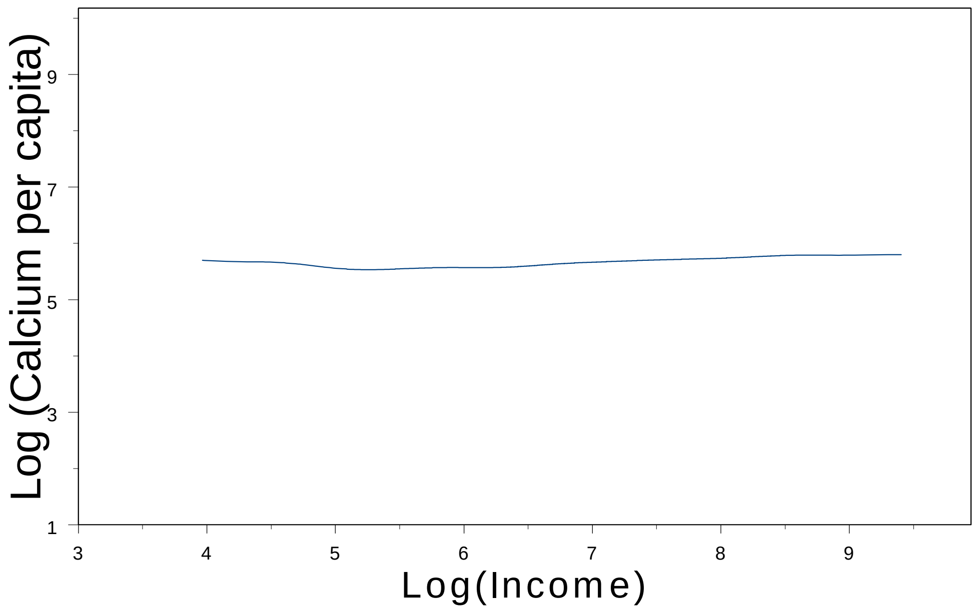
Table 3. Random Effects Regression Estimates for Ca. and Vitamin A per capita

	Calcium Estimates			Vitamin A Estimates	
Variable	**Estimate**	**T Stat***		**Estimate**	**T Stat***
Intercept	5.091	34.4***		2.688	10.0***
Fluid Milk Availability	0.260	7.2***		0.175	3.0***
Powd. Milk Availability	0.289	4.2***		0.143	1.3
North Dummy	0.112	2.6***		-0.484	-7.1***
Central Dummy	0.113	3.8***		-0.209	-4.4***
Education	0.002	1.5		0.007	3.4***
Age	0.002	2.8***		0.000	0.01
Gender	-0.042	-1.6		-0.010	-0.2
Urban Dummy	-0.024	-1.0		0.175	4.8***
Family Size	-0.057	-8.5***		-0.065	-6.1***
ln (Income)	0.022	2.0**		0.149	8.6***
Rice_Price	-0.056	-1.6		0.202	3.6***
Flour_Price	0.122	4.4***		-0.044	-1.0
Noodles_Price	-0.120	-3.4***		0.086	1.5
Cornflour_Price	-0.054	-2.7***		-0.022	-0.7
Millet_Price	-0.002	-0.1		-0.054	-1.9*
Rapeseed_Oil_Price	0.035	2.6***		-0.037	-1.8*
Soybean_Oil_Price	0.029	2.4**		0.020	1.0
Peanut_Oil_Price	0.002	0.3		-0.008	-0.5
Eggs_Price	-0.008	-0.4		-0.016	-0.4
Soysauce_Price	-0.048	-3.3***		-0.030	-1.3
Vegetables_Price	0.041	3.1***		0.129	6.1***
Pork_Price	0.292	7.5***		0.658	9.4***
Chicken_Price	-0.084	-3.0***		0.100	2.2**
Beef_Price	-0.069	-4.0***		-0.013	-0.5
Fluid_Milk_Price	-0.115	-4.0***		-0.046	-1.0
Powd._Milk_Price	-0.097	-3.8***		0.010	0.3
Fish_Price	0.046	2.1**		0.006	0.2
Beancurd_Price	-0.059	-3.1***		-0.112	-3.7***

*** represents significance at 1% level, ** at 5% level, * at 10% level

Figure 1. Nonparametric Estimates of the Calcium (per capita)-Income (per capita) Relationship

(a) 1997



(b) 2000

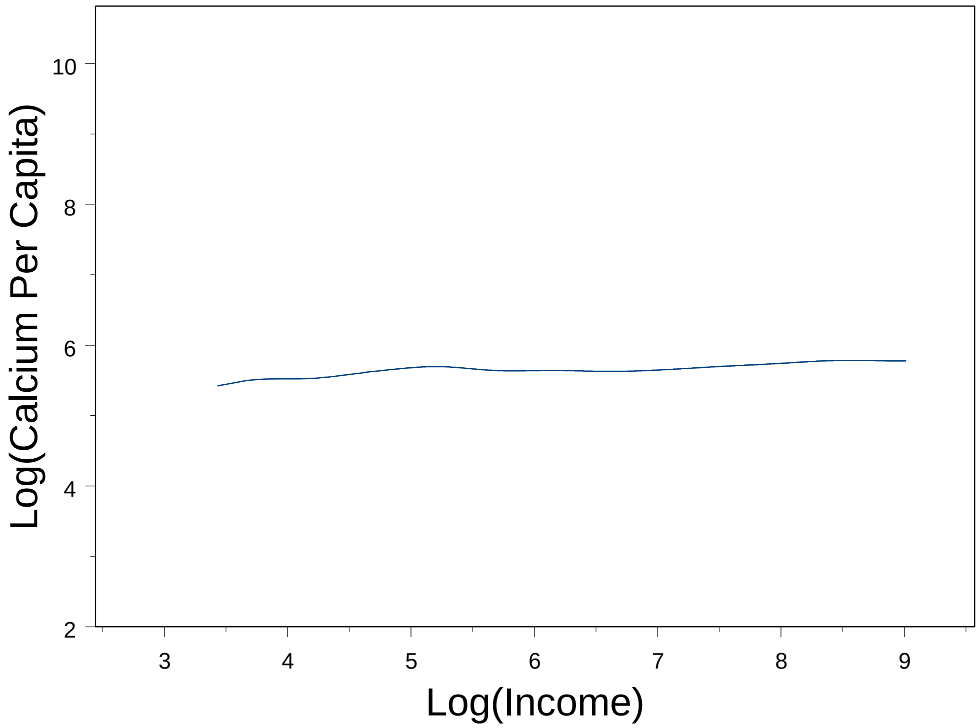
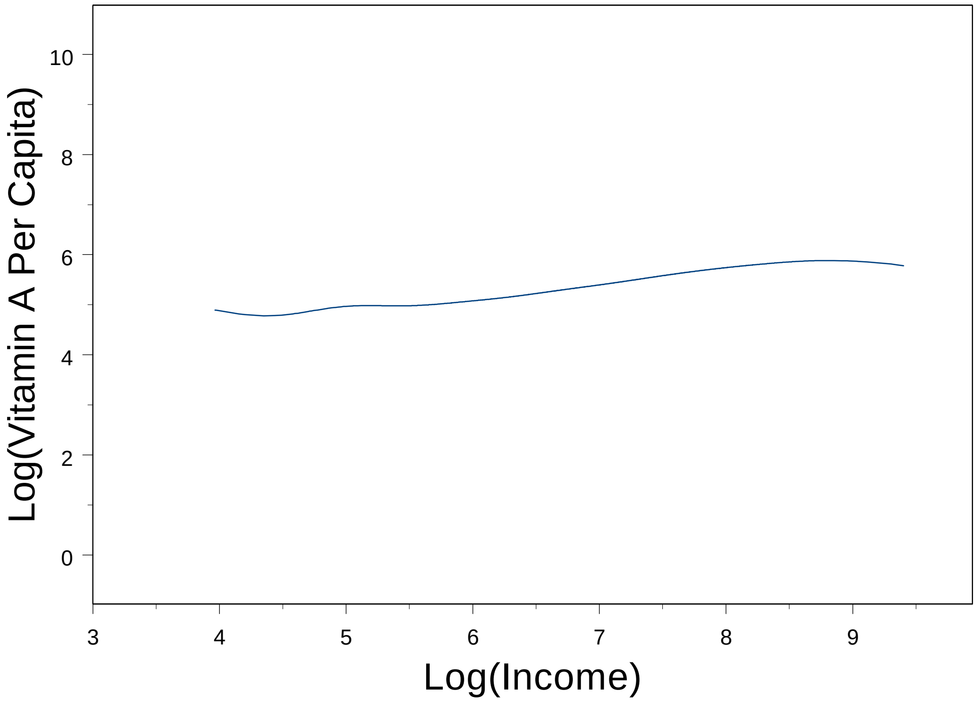
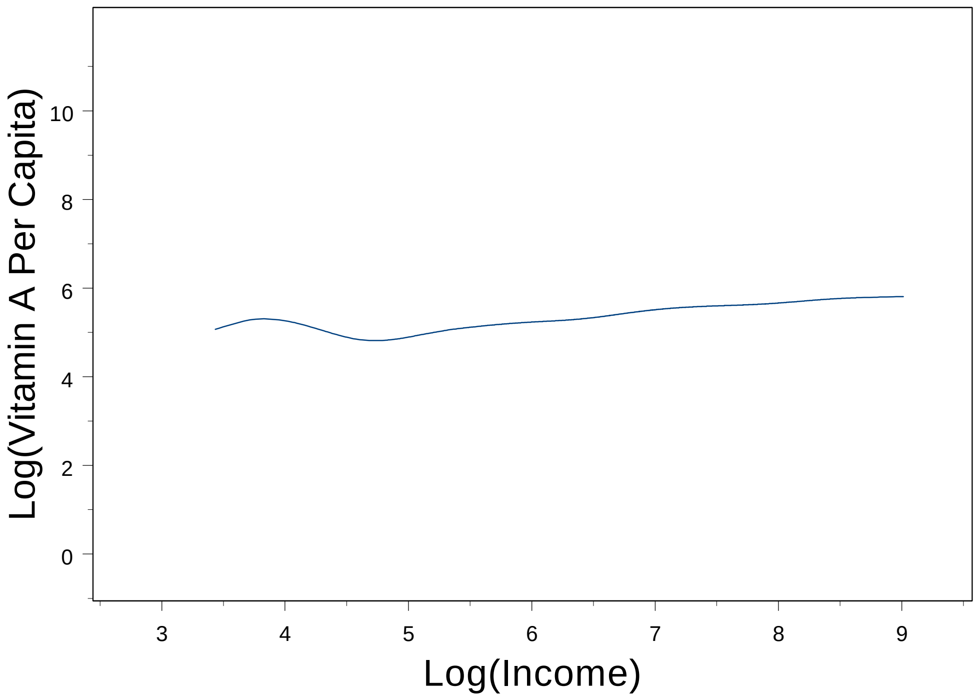


Figure 2. Nonparametric Estimates of the Vitamin A (per capita)-Income (per capita) Relationship

(a) 1997



(b) 2000



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