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Income, Consumption and Health in India: LOWESS and TSLS-IV Estimation of the Effect of Calorie Intake from Cereals on Nutrition

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Abstract: The unprecedented economic growth and the increasing incomes of households have not been accompanied by a corresponding reduction in poverty hunger and malnutrition in many poor economies. The inadequate calorie intake is further hampered by rising food prices in developing economies. This paper analyses the relationship between income and calorie intake from cereals, as cereals are the core of the Indian food system and the effect of food prices on calorie shares of cereals among the poor and non-poor households in Tamil Nadu. In the empirical analysis, parametric TSLS-IV and non-parametric LOWESS methods have been applied to the 68th round (July 2011-June 2012) of NSO data of rural and urban Tamil Nadu. Both methods of estimation show a significant positive relationship between the per capita calorie share of cereals in total calorie intake and monthly per capita expenditure. Rising prices of cereals and other food items reduce the calorie consumption from cereals. There is not much difference in cereal consumption between poor and non-poor in Tamil Nadu.

Keywords: Income, nutrition, cereals, calorie intake, LOWESS, TSLS-IV estimation

INTRODUCTION

The economic growth of India has been unprecedented since the economic reforms of the 1990s and now India is one of the fastest-growing economies in the world. However, despite this spectacular growth of the economy, the problems of poverty, undernourishment, malnutrition, underweight birth and child stunting continue to plague the population. Inadequate nutrition is perhaps the most important problem faced by the poor people in the world

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today. Despite the efforts to improve nutrient availability in household consumption, a large proportion of poor households in developing countries still have inadequate access to sufficient food. Further, malnutrition is a great and widespread problem in the developing world. The decline in calorie intake, especially from cereals across expenditure classes during a period of accelerated economic growth is puzzling. The World Bank articulates this view forcefully: "There is now a wide measure of agreement on several broad propositions. Malnutrition is largely a reflection of poverty: people do not have income for food. Given the slow income growth that is likely for the poorest people in the foreseeable future, large numbers will remain malnourished for decades to come. The most efficient long-term policies are those that raise the income of the poor" (World Bank, 1981, p.59). Thus, such malnutrition will disappear only with the improvements in income that accompany the development process.

The nutritious food consumption or calorie intake has been found to have a strong linkage with both human health and productivity. The human body needs dietary calorie energy to maintain normal body metabolic function and engage in activity related to good health and hygiene. In addition, calorie intake is the main determinant of undernutrition and malnutrition among people. It is needed for the growth and assimilation of micronutrients among children. An inadequate supply of calories lowers productivity, hinders learning and increases the risk of diseases. Although per capita daily calorie intake in developing countries has increased substantially, the number of undernourished people is still around 923 million and the increase in food prices triggers hunger worldwide (FAO, 2008).

The importance of calorie intake for health and development, coupled with the concern about undernourishment in developing countries, has led to an increasing number of studies on the determinants of calorie intake. More prominent in the empirical studies is the relationship between income and calorie intake (Abdulai and Aubert, 2004). There has been an intense debate on the exact nature of the relationship between income and calorie intake (Gibson and Rozelle, 2002). From the debates there emerged two types of empirical literature. The first group is of the opinion that the level of per capita calorie intake has a strong positive but non-linear relationship with income, and that increases in income will lead to a substantial increase in calorie intake (Subramanian and Deaton, 1996). On the contrary, the second group suggests that the linkage between income and calorie intake is weak and therefore, increases in income will not result in substantial improvement in calorie intake (Behrman and Deolalikar, 1987; Bouis and Haddad, 1992).

The main objective of this paper is to understand the nature of the relationship between income and calorie intake in India. This paper analyses the impact of monthly per capita expenditure and food prices on calorie shares of cereals, the cheapest and largest source of calories in India, among the poor and non-poor households in rural and urban Tamil Nadu. In the empirical analysis, the 68^{th} round (July 2011-June 2012) of NSO data pertaining to Tamil Nadu has been used. The estimates are obtained by applying the parametric IV/2SLS and the non-parametric LOWESS (Locally Weighted Scatter Plot Smoothing) methods. The variables used in this paper are calorie share of cereals, per capita monthly expenditure, prices of food items such as cereals, pulses, sugar, oil, fruits and vegetables and demographic variables such as household size, age of the household head, gender of the household head and proportion of adult males in the household.

REVIEW OF LITERATURE

Pitt and Rosenzweig (1985) analyse the changes in nutrient consumption and health of individual family members for changes in the price of particular food faced by a household. They use the National Socio-Economic Survey of Indonesia (April-June 1978 sub-round) data that provides information for a national probability sample of farm households on itemised weekly household consumption expenditures and on the incidence and severity of illness in the seven-day period preceding the survey. They assess the conditions under which inferences can be drawn about the health status of individual family members from information on commonly available household aggregate consumption data. They find that the incidence of illness significantly reduces with an increase in calorie consumption.

Variyam, Baylock and Smallwood (1996) estimate the relationship between the fibre-specific nutrition information level of U.S household meal planners and their dietary fibre intake. They use the 1989 and 1990 Continuing Survey of Food Intake of Individuals (CSFII) and the Diet and Health Knowledge Survey (DHKS) for the US and apply the Probit latent variable method. They incorporate information variables as endogenous and separate the indirect effects of various exogenous variables on intake (acting through information variables) from the direct effects of exogenous variables on intake. They find that the diet has a marginally significant negative direct effect, implying that those on a special diet tend to have slightly lower fibre intake than those not on a diet. However, those on a diet tend to possess a higher level of disease awareness as well as a better attitude toward consuming fibre-rich food.

Ohri-Vachaspati, Rogers, Kennedy and Goldberg (1998) study the calorie-income relationship using data from the 1986 (January and November) Dominican Republic household survey of over 1400 households applying two two-stage least squares method with an aim to improve the diets of the poor. The approach is to compare the calorie-expenditure elasticity derived from two sources of information on household calorie consumption: food prepared for consumption (PFC) and food purchased including home-produced (PIHP). The change in consumption with changing income levels has been measured in terms of calorie-income elasticity. The dependent variable has been the log of average calories computed from up to seven days of recall on PFC or PIHP divided by the number of adult equivalents in the household. From the estimated results, they infer that the calorie expenditure elasticity estimates vary due to a difference in the type of calorie variable used and purchase data provide less reliable estimates.

Skoufias (2003) use the Indonesian 1996 and 1999 SUSENAS survey data to study whether the relationship between income changes and caloric availability has changed and if so how the relationship between income changes and caloric availability has changed, using nonparametric as well as regression methods. Empirically, they examine two important relationships: the relationship between income and total calories, and the relationship between income and calories from cereals and other foods (excluding cereals and root crops). The estimated empirical results show that the income elasticity of the demand for total calories has been slightly higher in1999 (the crisis year with dramatically different relative prices) compared to its level in1996. In addition, the calorie-income elasticity for cereals as a group increases while the calorie-income elasticity for other food items decreases, consistent with the presence of a binding subsistence constraint.

Abdulai and Aubert (2004), employing both nonparametric and parametric methods, examine the impact of household expenditure on household demand for calories in Tanzania. They find a strong significant positive relationship between household expenditure and calorie demand and a negative and significant relationship between food prices and calorie demand. These results support the conventional wisdom that income growth can alleviate inadequate calorie intake and that effectively targeted food subsidies for very poor households may play a role in improving their calorie intake.

Orewa and Iyanbe (2010) attempt to identify the socio-economic and household characteristics that have a major impact on the level of the food calorie intake of rural and low-income urban households in Nigeria using a primary cross-sectional survey of 90 households applying the OLS multiple regression method. The study concludes that household size, age, educational level, sex, and salary earnings have a positive impact on the daily per capita calorie intake while dependency ratio and non-engagement in farming negatively affected it.

Ngwenya (2008), using the 2002 Vietnamese living standardised survey data and applying the instrumental variable method, investigate how widowhood influences food consumption choices and calorie intake in Vietnam. The focus has been on food poverty (calorie power) in widowhood instead of total expenditure poverty (general poverty). The IV estimates of the logarithm of per capita calorie intake show that widows and widowers are more calorie-vulnerable than non-widowed households. The calorie intake in widowed households responds slowly to improvements in income, compared to the sensitivity observed in non-widowed households.

Ayinde, Akerele and Dipeolu (2010) examine the calorie intake status in Nigeria, using data on 346 household members in 60 households applying multiple regression analysis. The study shows that the calorie intake of male household members has been significantly higher than that of their female counterparts across all age groups. The main socioeconomic factors that affect the calorie intake of household members are household monthly income and farm size, among other factors. The study recommends school meal subsidies, rural family nutrition enlightenment programmes and policies that would help improve household income, among others.

Babatunde, Adejobi and Fakayode (2010) investigate the relationship between income and calorie intake in rural areas of Nigeria, using primary data collected in 2006 from 220 farm households across 40 villages in the Kwara state of Nigeria. They use nonparametric kernel density estimation as well as parametric instrumental variable method. Estimating the effect of total income per capita in Naira on per capita daily calorie intake, the paper suggests that the study area is generally calorie-deficient and more attention is needed to bring calorie consumption to the recommended level of 2500 kilo calories per capita per day.

In India, Behrman and Deolalikar (1987) investigate the calorie-income relationship among the relatively poor population of rural south India. They estimate direct as well as indirect calorie-income elasticity. Direct elasticity estimation is the conversion of food group quantities into aggregate calories before estimation and indirect elasticity estimation is when the food group's expenditure elasticities are calculated and a weighted average is computed. They calculate calorie-income elasticities for the same households from two different methods viz. calorie intake as a function of predicted total expenditure (from a two-hourly recall of 120 foods) and food group expenditure as a function of predicted total expenditure in a non-system framework (for only 6aggregate food groups). The estimated results show that the direct nutrient elasticities are not significantly different from zero whereas indirect nutrient elasticities are close to one.

Sinha (2005) focus on investing in the nutrition demand pattern for rural households in India, using the nonparametric approach of quantile regression that characterises the entire distribution of calorie consumption. The estimated effect of income on per capita calorie consumption in rural India suggests that while providing food subsidies, the nature of food subsidies is also important. A subsidy on certain commodities might actually reduce the nutritional level of the households. A subsidy on less nutritious food might not be effective in improving the nutrition of the undernourished households whereas it might provide overnutrition for the over-nourished households.

Kaicker and Gaiha (2013) study the relationship between the calorie share of cereals and monthly per capita expenditure, using panel data from 1993 and 2004 NSO Consumer Expenditure Survey data. It is argued that food prices induce substitutions between different sources of calories. They estimate the effect on the proportion of calories obtained from cereals of per capita monthly expenditure, vector of food prices, household size, and proportion of adult males in the household, and a vector of state and caste dummy variables. The estimated results show significant food price elasticities. While the food price elasticities vary between food commodities across different subsamples and over time, they are substantially lower than expenditure elasticities, implying that expenditure has a much larger influence on calorie shares.

DATA AND METHODOLOGY

In the empirical analysis of the household calorie intake from cereals, this paper uses the nationwide 68th round (July 2011-June 2012) NSO consumer expenditure survey data pertaining to Tamil Nadu. The 68th round NSO survey is the ninth quinquennial consumer expenditure survey of India. The NSO provides estimates of household monthly per capita expenditure (MPCE) and the distribution of households and persons over the MPCE range separately for the rural and urban sectors of the country, for states and union territories, and for different socio-economic groups. The sample size for this study has been 6646 households, 3319 rural and 3327 urban households, covering all 31 districts of Tamil Nadu. The data has been collected using schedule type II of the NSO questionnaire, using 'last 7 days' for general food items and 'last 365 days' for the infrequently purchased categories. The food items contain 142 items of food including cereals, pulses, salt and sugar items, milk products, fruits, vegetables, oil, eggs, meat, etc. Among these 142 items, this paper considers cereals for empirical analysis.

In the empirical analysis, the dependent variable is the proportion of calorie intake from cereals per capita per day. The calorie intake of an item is derived from the quantities reported as consumed by the sample households. The nutrient content of each item per unit of quantity is based on the source Nutritive Values of Indian Foods (Gopalan, Rama Sastry and Balasubramanian, 2012). The per capita proportion of calories from cereals is calculated from calorie intake from cereals divided by total calorie intake and household size. The independent variables include income, price of various food items and demographic variables. As the income data is not available, the monthly per capita expenditure has been used as a proxy for income. As is widely understood, the MPCE is commonly used for comparison of average living standards between countries, between regions, and between social and occupational groups. The NSO calculates MPCE as,

$$\text{MPCE} = \frac{\textit{Household montly consumption expenditure}}{\textit{Household size}}$$

The natural logarithm of MPCE and its square are used along with other explanatory variables.

Fluctuations in food prices are also key factors for the calorie consumption of households. The NSO data does not provide prices of the food items directly, but the total value of these food items is provided. Therefore, using the data on the total value and total quantity of consumption of various food items, prices of cereals, pulses, salt and sugar, oils fruits and vegetables are computed in terms of rupees per unit (kg/ litre) as,

$$\text{Price} = \frac{\textit{Total value of consumption}}{\textit{Total quantity of consumption}}$$

The other independent variables used are defined and described in the descriptive statistics table. It is to be noted that the household size, the number of persons living together and taking food from a common kitchen, is used as an instrumental variable for MPCE.

Empirically, parametric and non-parametric approaches are used to estimate the determinants of calorie share of cereals. The relationship between calories and MPCE is generally characterised by non-linearities because the least well-nourished persons are likely to make the largest nutritional responses as their budget shifts (Ravallion, 1990). In other words, the poor may have much to gain from an increase in calorie intake while the rich have little to gain. Thus, it is important to identify the full range of nutritional responses, rather than aggregating them into a single-point estimate. To better understand the relationship between calorie and MPCE, nonparametric regression may be an appropriate tool because it makes no assumptions about functional form and allows the data to 'speak for themselves' (Delgado and Robinson, 1992). The non-parametric approach provides useful tools for non-linear modelling and helpful diagnostics. When there is sufficient data, it can also reveal features of the data that are invisible under parametric techniques. However, generally, the nonparametric approach is restricted to bivariate relationships only (Gibson and Rozelle, 2002). Ideally, it would be better to examine the effect of income on calorie intake after controlling for household and demographic characteristics. Therefore, this paper supplements the non-parametric estimates with parametric estimations.

LOCALLY WEIGHTED SCATTER PLOT SMOOTHING METHOD

A special non-parametric regression method, the Locally Weighted Scatter Plot Smoothing (LOWESS) approach, combines multiple regression models in a k-nearest neighbour-based meta-model. The LOWESS method, by looking at the data, uses locally weighted linear regression to smooth data. The smoothing process is considered local because, like the moving average method, each smoothed value is determined by neighbouring data points defined within the span. The process is weighted because a regression weight function is defined for the data points contained within the span. The locus of each smoothed value given by weighted linear least squares regression over the span is known as the LOWESS curve. The local regression smoothing process follows the following steps for each data point,

(i) Compute the regression weights for each data point in the span. The weights are given by the tricube function,

$$i. \quad w_i = \left(1 - \left\lceil \frac{x - x_i}{d(x)} \right\rceil^3 \right)^3 \tag{1}$$

(ii) where x is the predictor value associated with the response value to be smoothed, x_i are the nearest neighbours of x as defined by the span, and $d(x)$ is the distance along the abscissa from x to the most distant predictor value within the span. The weights have the characteristics that (i) the data point to be smoothed has the largest weight and the most influence on the fit, and (ii) the data points outside the span have zero weight and no influence on the fit.

(iii) A weighted linear least-squares regression is performed. For LOWESS, the regression uses a first-degree polynomial.

(iv) The smoothed value is given by the weighted regression at the predictor value of interest.

If the smooth calculation involves the same number of neighbouring data points on either side of the smoothed data point, the weight function is symmetric. However, if the number of neighbouring points is not symmetric about the smoothed data point, then the weight function is not symmetric. It is to be noted that, unlike the moving average smoothing process, the span never changes. For example, when the data points are smoothed with the smallest predictor value, the shape of the weight function is truncated by one-half, the left-most data point in the span has the largest weight, and all the neighbouring points are to the right of the smoothed value. In this paper, the LOWESS smoothing of the proportion of calories from cereals with a logarithm of monthly per capita expenditure is adopted, without specifying any functional form, with a bandwidth of 0.8 in order to fit the data closely.

The non-parametric LOWESS analysis of this paper is supplemented with parametric analysis. As the proportion of calorie share of cereals and monthly per capita expenditure are endogenous, the parametric approach used is the simultaneous equation model. When a structural equation is over-identified, the Two Stage Least Squares (TSLS) method is used. Under the circumstances that the structural equation is over-identified, each equation in a simultaneous equation model is instrumented with all exogenous variables. Hence, the two-stage least squares method is also called as Instrumental Variables (IV) method. The IV method is used when the dependent variable's error terms are correlated with the independent variables. The TSLS-IV method performs the OLS estimation at two stages.

Consider the structural model,

$$y_1 = \beta_0 + \beta_1 y_2 + \beta_2 z_1 + u_1 \tag{2}$$

where the variables y_2, and z_1, are the explanatory variables and u1 is the error term. This is a structural equation as the interest is in the estimation of β_j, the casual relationship. But, the dependent variable y_1 is endogenous as it is correlated with u_1. Assuming z_1 is exogenous, $E(u_1) = 0$ and z_1 is uncorrelated with u_1, the OLS estimates of equation (2) are biased and inconsistent. Hence, the variable y_2 needs to be instrumented with an exogenous variable that does not appear in equation (2), say z_2. The key assumptions are that z_1 and z_2 are uncorrelated with u_1. Thus, for IV estimation,

$$E(u_1)=0, Cov(z_1, u_1) = 0, Cov(z_2, u_1) = 0 \tag{3}$$

Given the zero mean assumption, the latter two assumptions are equivalent to $E(z_1 u_1) = E(z_1 u_1) = 0$. Then, the method of moments approach suggests obtaining estimators $\hat{\beta}_0, \hat{\beta}_1$ and $\hat{\beta}_2$ by solving the sample counterparts of equation (3),

$$\Sigma_{i=1}^{N}(y_{i1} - \beta_0 + \beta_1 y_{i1} + \beta_2 z_{i1}) = 0$$

$$\Sigma_{i=1}^{N} z_{i1}(y_{i1} - \beta_0 + \beta_1 y_{i2} + \beta_2 z_{i1}) = 0 \tag{4}$$

$$\Sigma_{i=1}^{N} z_{i2}(y_{i1} - \beta_0 + \beta_1 y_{i2} + \beta_2 z_{i1}) = 0$$

This is a set of three linear equations in the three unknowns β_0, β_1 and β_2, and it is easily solved given the data on y1, y2, z1 and z2.

With more than one exogenous variables z_2 and z_3 excluded (not appear in equation (2) and are both correlated with y_2, each of these variables could be used as an instrumental variable. There are two IV estimators and neither of these would in general be efficient. Since each of z_1, z_2 and z_3 is uncorrelated with u_1, any linear combination is also uncorrelated with u1, and therefore any linear combination of the exogenous variables is a valid instrumental variable. The best IV is the linear combination of z_1, z_2 and z_3 that is most highly correlated with y2, given by the reduced form equation for y_2, given by,

$$y_2 = \pi_0 + \pi_1 z_1 + \pi_2 z_2 + \pi_3 z_3 + v_2 \tag{5}$$

where, $E(v_2) = 0$, $Cov(z_1, v_2) = 0$, $Cov(z_2, v_2) = 0$ $Cov(z_3, v_2) = 0$ (6)

For this IV not to be perfectly correlated with z_1, at least one of π_2 or π_3 to be different from zero,

$$\pi_2 \neq 0 \text{ or } \pi_3 \neq 0 \tag{7}$$

which can be tested using the F-statistic. This is the key identification assumption when all z_j are exogenous.

A useful way to estimate the structural equation in (2) is to break y_2 into two components, the first is a part of y_2 that is uncorrelated with the error term, u_1, and the second component is a part of y_2 possibly correlated with u_1, which is why y_2 is possibly endogenous. Given data on the z_j, for each observation $\hat{y}_{2i}$ is computed, by regressing y_2 on z_j,

$$\hat{y}_2 = \hat{\pi}_0 + \hat{\pi}_1 z_1 + \hat{\pi}_2 z_2 + \hat{\pi}_3 z_3 \tag{8}$$

At this stage, it is important to verify the joint significance of z_2 and z_3 for IV estimation. Thus, $\hat{y}_2$ is thus an instrument of y_2. The three equations for estimating β_0, β_1 and β_2 are the first two equations of (4), with the third replaced by,

$$\Sigma_{i=1}^{N} \hat{y}_{2i}(y_{1i} - \hat{\beta}_0 - \hat{\beta}_1 y_{2i} - \hat{\beta}_2 z_{1i}) = 0 \tag{9}$$

Thus, the three equations are given as,

$$\Sigma_{i=1}^{N}(y_{i1} - \beta_0 + \beta_1 y_{i1} + \beta_2 z_{i1}) = 0$$

$$\Sigma_{i=1}^{N} z_{i1}(y_{i1} - \beta_0 + \beta_1 y_{i2} + \beta_2 z_{i1}) = 0 \tag{10}$$

$$\Sigma_{i=1}^{N} \hat{y}_{2i}(y_{i1} - \hat{\beta}_0 + \hat{\beta}_1 y_{2i} + \hat{\beta}_2 z_{1i}) = 0$$

solves for the three unknown parameters giving the IV estimators.

In general, at least as many excluded exogenous variables as there are included endogenous explanatory variables in the structural equation are needed for IV estimation. With multiple instruments, the IV estimator is also called the two-stage least squares (TSLS) estimator. Using the algebra of OLS, when $\hat{y}_2$ is used as an IV for y_2, the IV estimates $\hat{\beta}_0$, $\hat{\beta}_1$ and $\hat{\beta}_2$ are identical to the OLS estimates from the regression of y_1 on $\hat{y}_2$ and z_1. In other words, the TSLS estimator is obtained in two stages. The first stage is to run the regression in equation (8), where the fitted value $\hat{y}_2$ is obtained. The second stage is the OLS regression of y_1 on $\hat{y}_2$ and z_1. The TSLS estimates can differ substantially from the OLS estimates because $\hat{y}_2$ is used in place of y_2.

EMPIRICAL ANALYSIS

Without specifying any functional form, the LOWESS (Locally Weighted Scatter Plot Smoothing) smoothing with a default bandwidth of 0.8 is fitted with the data. The dependent variable is the share of calories from cereals and the explanatory variables are the income of the household per capita, as approximated by the log of monthly per capita expenditure (MPCE). Figure 1 presents the LOWESS results for rural Tamil Nadu for the 68th round NSO data for the year 2011-l2. The LOWESS plots strongly suggest a positive linear relationship between the proportion of calorie intake from cereals and monthly per capita expenditure. The calorie share threshold occurs at 0.20 and the corresponding MPCE is Rs.19.28. About 40% of individuals are expected to be below the calorie threshold and MPCE, 23% of individuals are consuming above the calorie threshold and spend above Rs. 19.28, 18% of individuals consume above the calorie threshold and MPCE and 19% of individuals consume less than 0.20 Kcal and spend above Rs. 19.28.

Figure 2 presents the LOWESS results for urban Tamil Nadu for the 68th round NSO data for the year 2011-l2. The results for urban Tamil Nadu also show a strong and positive relationship between calorie share from

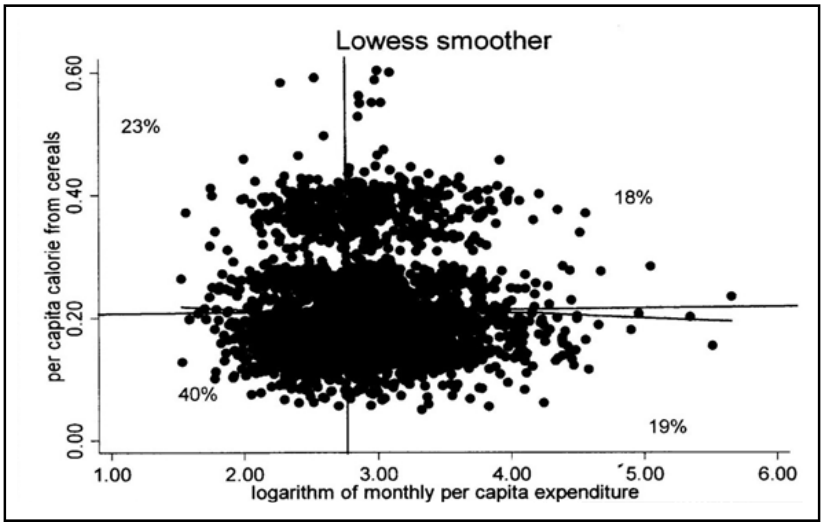

Figure 1: Distribution of Calorie Intake from Cereals by MPCE in Rural Tamil Nadu

cereals and monthly per capita expenditure. The calorie share again threshold occurs at 0.20 and the corresponding MPCE is Rs.23.47. Around 37% of individuals are below the calorie threshold and MPCE, 22% of individuals consume above the calorie threshold and spend above Rs.23.47, 21% of individuals consume above the calorie threshold and MPCE and 20% of individuals consume less than 0.20 Kcal and spend more than Rs.23.47. In Tamil Nadu, urban people spend about four rupees more than rural people to consume 0.20 shares of calories from cereals.

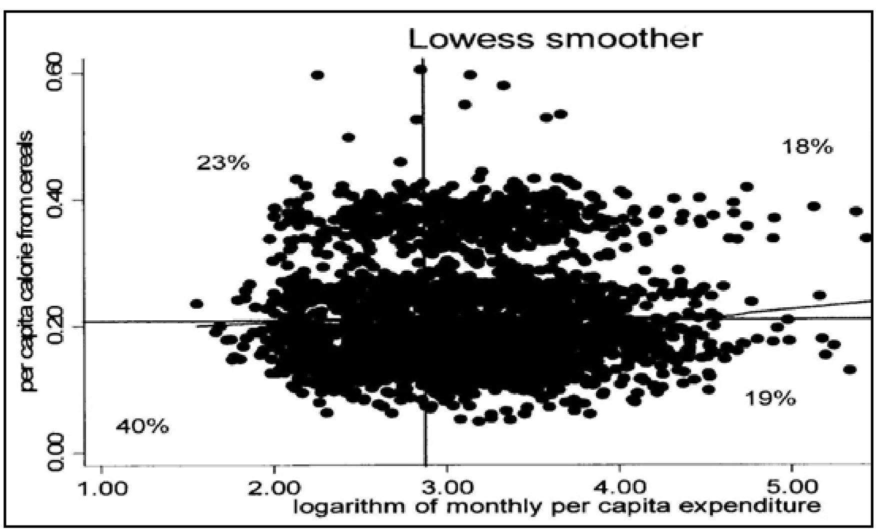

Figure 2: Distribution of Calorie Intake from Cereals by MPCE in Urban Tamil Nadu

Table 1: Descriptive Statistics of Variables Calorie Intake from Cereals

Variable	*Description*	*Rural Tamil Nadu*	*Urban Tamil Nadu*
CI	Calorie intake share from cereals in total calorie intake (Kcal/person/day)	0.24 (0.14)	0.23 (1.13)
ln(MPCE)	Log of monthly per capita expenditure (Rs.)	2.90 (0.50)	3.12 (0.58)
$\ln(MPCE)^2$	Log of monthly per capita expenditure square (Rs.)	8.69 (3.09)	10.07 (3.81)
ln(PC)	Log of price of cereals	2.76 (0.39)	2.92 (0.42)
ln(PP)	Log of price of pulses	3.91 (0.22)	3.96 (0.23)
ln(PS)	Log of price of sugar	2.72 (0.29)	2.80 (0.31)
ln(PO)	Log of price of oil	4.14 (0.46)	4.17 (0.46)
ln(PF)	Log of price of fruits	0.48 (1.21)	0.72 (1.26)
ln(PV)	Log of price of vegetables	2.35 (0.33)	2.45 (0.32)
HHHAge	Age of household head (years)	48.01 (12.89)	48.10 (12.69)
HHHMale	If male household head=1, 0 otherwise	0.85 (0.35)	0.85 (0.32)
HHSize	No. of household members	3.87 (1.63)	3.71 (1.52)
HHAdults	Proportion of adult males	0.28 (0.23)	0.22 (0.24)
SC	If scheduled caste community=1, 0 otherwise	0.20 (0.40)	0.13 (0.34)
ST	If scheduled tribe community=1, 0 otherwise	0.01 (0.12)	0.01 (0.08)
BC	If backward class community=1, 0 otherwise	0.76 (0.42)	0.80 (0.39)
GC	If general community=1, 0 otherwise	0.01 (0.13)	0.04 (0.21)
N	Number of sample observations	3079	3019

Table 2 OLS and TSLS Estimates of Calorie Intake from Cereals

Dependent variable: CI (calorie share from cereals in total calorie intake)

Variable	*Rural Tamil Nadu*		*Urban Tamil Nadu*	
	OLS	*TSLS*	*OLS*	*TSLS*
ln(MPCE)	0.195* (6.03)	7.029* (10.16)	0.174* (6.39)	6.260* (9.57)
$\ln(MPCE)^2$	-0.016* (3.05)	-1.083* (10.02)	-0.013* (3.22)	-0.910* (9.43)
ln(PC)	-0.064* (9.22)	-0.186* (6.26)	-0.057* (7.61)	-0.193* (7.31)
ln(PP)	-0.044* (3.86)	-0.027 (0.59)	-0.015 (1.31)	-0.084*** (1.71)
ln(PS)	-0.073* (8.92)	-0.189* (5.55)	-0.044* (5.54)	-0.035 (1.07)
ln(PO)	-0.018* (3.49)	-0.072* (3.49)	0.001 (0.22)	-0.141* (5.14)
ln(PF)	-0.018* (9.54)	-0.033* (4.49)	-0.024* (12.72)	-0.043* (3.32)
ln(PV)	-0.057* (8.22)	-0.160* (5.51)	-0.079* (10.88)	-0.175* (5.45)
HHHAge	0.002* (7.63)	0.002* (2.59)	0.0008* (5.18)	0.002* (3.26)
HHHMale	-0.131* (21.91)	-0.114* (4.84)	-0.129* (21.38)	-0.153* (6.01)
ST	0.031*** (1.81)	0.127*** (1.87)	-0.011 (0.44)	-0.044 (0.42)
BC	0.010** (1.98)	-0.049** (2.29)	-0.003 (0.50)	-0.142* (4.74)
GC	0.009 (0.61)	-0.026 (0.43)	0.003 (0.32)	-0.038 (0.80)
Constant	0.607* (9.42)	-9.033* (9.11)	0.444* (7.28)	-7.797* (8.58)
District dummies	yes	yes	yes	Yes
R^2/Wald Chi^2	0.35	209.06	0.32	166.92

Note: Absolute t-values (OLS) and z-values (TSLS) are in parentheses. *,**,*** Significant at 1, 5, 10% levels.

The OLS and TSLS-IV estimates of the per capita share of calorie intake from cereals in total calorie intake for rural and urban Tamil Nadu in 2011-12 are presented in Table 2. In both rural and urban Tamil Nadu, the estimated TSLS coefficients of MPCE are positive and its square is negative and both are statistically significant at 1% level. The estimated results indicate that a 1% increase in household MPCE increases the calorie share from cereals by 29.3% in rural and 27.1% in urban households of Tamil Nadu. An increase in the price of cereals significantly reduces its calorie intake by 1.08% in rural and 0.91% in urban Tamil Nadu. Similarly, the calorie intake significantly decreases in Tamil Nadu with increases in the prices of other food items. The calorie share of cereals in food consumption is influenced not just by expenditure and food prices but also by demographic characteristics. The variable age of the household head influences the calorie share positively and its effect is statistically significant at 1% level while the effect of male household head on calorie intake is significantly negative. The coefficients of scheduled tribe and backward community are significantly positive and negative respectively in rural households of Tamil Nadu compared to scheduled caste households. In urban Tamil Nadu, only the BC dummy is statistically significant and its coefficient is also negative. Among the district dummies, the estimated coefficients are generally positive in relatively developed districts and negative for most of the backward districts of Tamil Nadu. Thus, the calorie share is sensitive to household income/expenditure, food prices and household demographic characteristics. Hence, the finding of this paper does not support the notion that cereal consumption will not increase with a higher standard of living.

The results of Durbin and Wu-Hausman tests for endogeneity and Sargan and Basmann tests for identification restrictions for rural and urban samples are presented in Table 3. The endogeneity test has been performed to determine whether endogenous repressors in the model are in fact exogenous. The difference between the Durbin and Wu-Hausman tests of endogeneity is that the former uses estimates of the error variance based on the model assumption that the variables being tested are exogenous, while the latter uses estimates of the error variance based on the model assumption that the variables being tested are endogenous. Both tests are highly significant for both rural and urban Tamil Nadu, so both reject the null of exogeneity. Therefore, the MPCE has to be treated as endogenous, and the chosen instruments are not weak because minimum Eigenvalue statistics of 52.9 for rural and 48.48 for urban exceed the critical value of the F statistic.

The Sargan and Basmann tests for over-identifying restrictions test two different things simultaneously: whether the instruments are uncorrelated with the error term, and whether the equation is miss-specified in that one or more of the excluded exogenous variables should in fact be included in the structural equation. In both tests, the null hypothesis is rejected at 10% level of Chi-square significance for rural and 5% level for urban Tamil Nadu. Thus, the two instrumental variables, household size and proportion of adult males in the household, are valid and the structural model is specified correctly.

Table 3: Endogeneity and Identification Restrictions Tests

Hypothesis	*Test*	*Rural Tamil Nadu*		*Urban Tamil Nadu*	
		Estimate	*p-value*	*Estimate*	*p-value*
Endogeneity	Durbin chi^2	1581.44	0.000	1588.81	0.000
	Wu-Hausman F	3204.00	0.000	3304.96	0.000
Identification	Sargan chi^2	2.958	0.085	3.873	0.049
	Basmann chi^2	2.919	0.088	3.821	0.051

A calorie intake of 2400 Kcal per day is considered adequate for a typical adult engaged in physically strenuous work of a certain duration in rural India. If an individual consumes a per capita calorie intake per day less than 2400 Kcal per day, he is considered poor or in poverty, and consumption of more than 2400 Kcal per day is considered to be above poverty or non-poor. Therefore, the paper also performs empirical analysis for poor and non-poor samples or order to identify the differential effects of the determinants of calorie intake from cereals in poor and non-poor households in Tamil Nadu. Table 4 presents the descriptive statistics for poor and non-

Table 4: Descriptive Statistics of Variables in the Calorie Intake for Poor and Non-Poor Households

Variable	*Rural Tamil Nadu*		*Urban Tamil Nadu*	
	Poor	*Non-poor*	*Poor*	*Non-poor*
CI	0.23 (031)	0.28 (0.17)	0.22 (0.12)	0.26 (0.16)
ln(MPCE)	2.82 (0.45)	3.36 (0.53)	3.01 (0.55)	3.51 (0.52)
ln(MPCE)^2	8.20 (2.67)	11.61 (3.80)	9.37 (3.48)	12.62 (3.92)
ln(PC)	2.74 (0.39)	2.84 (0.40)	2.89 (0.41)	3.02 (0.38)
ln(PP)	3.90 (0.21)	3.96 (0.21)	3.94 (0.23)	4.02 (0.20)
ln(PS)	2.71 (0.29)	2.77 (0.30)	2.79 (0.30)	2.86 (0.32)
ln(PO)	4.12 (0.46)	4.22 (0.41)	4.14 (0.47)	4.27 (0.39)
ln(PF)	0.33 (1.14)	1.37 (1.24)	0.51 (1.18)	1.47 (1.25)
ln(PV)	2.35 (0.33)	2.38 (034)	2.44 (0.31)	2.49 (0.32)
HHHAge	47.59 (12.94)	49.23 (12.53)	17.48 (13.19)	49.08 (11.97)
HHHMale	0.86 (0.33)	0.78 (0.41)	0.86 (0.34)	0.83 (0.37)
SC	0.21 (0.40)	0.15 (0.36)	0.14 (0.35)	0.10 (0.30)
ST	0.01 (0.12)	0.01 (0.09)	0.08 (0.08)	0.01 (0.06)
BC	0.75 (0.43)	0.81 (0.38)	0.79 (0.40)	0.84 (0.36)
GC	0.02 (0.14)	0.01 (0.12)	0.04 (0.20)	0.05 (0.22)
N	2641	438	2372	647

Note: Standard deviations are in parentheses.

poor households in rural and urban Tamil Nadu. The mean calorie intake from cereals is 0.23, 0.28, 0.22 and 0.26 respectively for poor and non-poor in rural and urban Tamil Nadu.

Table 5: TSLS Estimates of Calorie Intake from Cereals of Poor and Non-Poor Households

Dependent variable: CI (calorie share from cereals in total calorie intake)

Variable	*Rural Tamil Nadu*		*Urban Tamil Nadu*	
	Poor	*Non-poor*	*Poor*	*Non-poor*
ln(MPCE)	8.523* (8.88)	10.504* (3.16)	8.594* (6.92)	11.028* (2.86)
$\ln(MPCE)^2$	-1.392* (8.80)	-1.413* (3.13)	-1.312* (6.86)	-1.426* (2.85)
ln(PC)	-0.111* (3.68)	-0.463* (2.92)	-0.033* (5.53)	-0.383** (2.51)
ln(PP)	-0.027 (0.56)	-0.102 (0.58)	-0.089 (1.34)	-0.192 (1.01)
ln(PS)	-0.187* (5.04)	-0.355** (2.35)	-0.041 (0.89)	-0.272** (2.09)
ln(PO)	-0.060* (2.74)	-0.272* (2.40)	-0.153** (4.03)	-0.353** (2.36)
ln(PF)	-0.031 (1.58)	-0.047*** (1.80)	-0.028** (2.47)	-0.051*** (1.93)
ln(PV)	-0.167* (5.16)	-0.184*** (1.71)	-0.203* (4.43)	-0.170*** (1.70)
HHHAge	0.002* (2.74)	-0.0003 (0.12)	0.003* (3.18)	-0.0005 (0.20)
HHHMale	-0.134* (5.07)	0.035 (0.39)	-0.154* (4.31)	-0.180** (2.24)
ST	0.144** (1.98)	-0.288 (0.87)	-0.061 (0.44)	-0.245 (0.57)
BC	-0.012 (0.86)	-0.114 (1.24)	-0.156* (3.76)	-0.066 (0.66)
GC	-0.003 (0.04)	0.102 (0.41)	0.077 (1.16)	0.105 (0.65)
Constant	-11.033* (8.17)	-15.030* (2.92)	-10.92* (6.45)	-15.857* (2.71)
District dummies	yes	yes	yes	yes
Wald Chi^2	155.99	27.17	78.94	24.53

Note: z-values in parentheses. *,**,*** Significant at 1, 5, 10% levels.

The estimated two-stage least square regression results are presented in Table 5 for poor and non-poor in rural and urban Tamil Nadu. In both the poor and non-poor rural households, the household expenditure and its square have significant positive and negative effects respectively on calorie intake from cereals. The results indicate that a 1% increase in MPCE results in a 38.72% and 37.5% increase in calorie intake from cereal consumption respectively in poor and non-poor rural households in Tamil Nadu. The poor rural scheduled tribe households consume a relatively higher calorie share than scheduled caste households. The prices of cereals, sugar, oil and vegetables have a significant negative effect on calorie consumption from cereals indicating higher prices of food products lead to lower household calorie consumption from cereals. In rural Tamil Nadu, relative to poor households, for non-poor households calorie consumption from cereals is less for an increase in food prices, probably due to a shift towards junk food in non-poor households. Again, both poor and non-poor households in the relatively developed districts consume more calories than their counterparts in backward districts of Tamil Nadu.

The TSLS results for urban Tamil Nadu are somewhat different from the rural estimates in some respects. Among the urban households, though the expenditure elasticities are significantly positive and negative respectively for MPCE and its square and its square, the effects are higher relative to rural households of Tamil Nadu. A 1% increase in MPCE results in a 39.04% increase in calorie intake from cereal consumption in poor urban households and a much higher 42.38 increase in calorie intake from cereal consumption in non-poor urban households. The backward-class poor households have a lower calorie share relative to scheduled caste households. The price effects and regional effects are the same as that of rural Tamil Nadu.

Table 6: Endogeneity and Identification Restrictions Tests for Poor and Non-Poor Households

Hypothesis	*Test*	*Rural Tamil Nadu*		*Urban Tamil Nadu*	
		Poor	*Non-poor*	*Poor*	*Non-poor*
Endogeneity	Durbin chi^2	1333.59	225.46	1340.26	300.06
		(0.00)	(0.00)	(0.00)	(0.00)
	Wu-Hausman F	2649.02	417.94	3022.83	520.68
		(0.00)	(0.00)	(0.00)	(0.00)
Identification	Sargan chi^2	5.004	0.010	1.004	1.115
		(0.03)	(0.92)	(0.32)	(0.29)
	Basmann chi^2	4.930	0.009	0.986	1.039
		(0.03)	(0.93)	(0.32)	(0.31)

Note: p-values are in parentheses.

The endogeneity tests for poor and non-poor in rural and urban Tamil Nadu, presented in Table 6, are highly significant and reject the null of exogeneity and allow lnMPCE as endogenous. The instruments are also not weak as the minimum Eigenvalue statistics exceed the critical value of the F-statistic. The tests of over-identifying restrictions reject the null hypothesis suggesting that the two instrument variables are valid and the structural model is specified correctly.

CONCLUSION

Around the world, economic growth is supposed to improve not only standards and quality of life, but also to eliminate poverty, hunger, hygiene, disease, ill-health, and child mortality. For these to be achieved, there has to be proper availability and access to nutrition for the poor and undernourished. The nutritious food consumption or calorie intake has strong linkages with not only human health but also determines the efficiency and productivity and even the learning and achievement of children. Despite the all-round development of economies, and all-out efforts to improve nutrient availability inadequate nutrition is perhaps the most important problem faced by the poor people and poor economies around the world today. The decline in calorie intake, especially from cereals across expenditure classes during a period of accelerated economic growth is puzzling. The relationship between income and nutrition or calorie intake has been at the core of an intense debate. The empirical literature has produced controversial findings. Some evidences suggest that the level of per capita calorie intake has a strong positive but non-linear relationship with income, and that increases in income will lead to a substantial increase in calorie intake. On the contrary, some results suggest that the linkage between income and calorie intake is weak and therefore, increases in income will not result in substantial improvement in calorie intake. Further, rising food prices and household composition have been shown to have significant effects on calorie intake.

Therefore, this paper tries to understand the nature of the relationship between income and calorie intake in India. As cereal consumption forms the core of the Indian food system, this paper analyses the effect of income (monthly per capita expenditure) and food prices on calorie shares of cereals, the cheapest and largest source of calories in India, among the poor and non-poor households in Tamil Nadu. In the empirical analysis, the 68th round (July 2011-June 2012) of NSO data pertaining to rural and urban Tamil Nadu has been used and methods of parametric TSLS-IV and non-parametric LOWESS (Locally Weighted Scatter Plot Smoothing) are used. The nonparametric LOWESS estimation of the relationship between the per capita calorie share of cereals in total calorie intake and monthly per capita expenditure reveals a positive and non-linear relationship. In Tamil Nadu, urban people spend about four rupees more than rural people to consume 0.20 shares of calories from cereals. The results of the parametric analyses also indicate a positive and strongly significant relationship between per capita calorie share of cereals and monthly per capita expenditure. Increases in the price of cereals, pulses, oil, fruits and vegetables lead to a decline in the calorie consumption from cereals in both rural and urban Tamil Nadu. Analysis of poor and non-poor calorie intake from cereals shows that there is not much difference between poor and non-poor in cereal consumption in urban Tamil Nadu, indicating not much difference in lifestyle between poor and non-poor in urban Tamil Nadu.

The empirical results of this paper suggest that the shifting pattern of calorie intake by non-poor with growing income from cereals to more expensive non-cereal food products needs to be taken into designing food subsidy programmes. A subsidy on less nutritious food might not be effective in improving the nutrition of the under-nourished households whereas it might provide over-nutrition for the over-nourished households. Further, lowering food prices may play a critical role in improving the calorie intake of poor households, for which effective targeted food subsidies could be used to improve the nutritional needs of very poor households. Further, lowering food prices may play a critical role in improving the calorie intake of poor households, for which effective targeted food subsidies could be used to improve the nutritional status of vulnerable poor households.

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