An Empirical Investigation into Measurement and Determinants of Food Security in Slums of Kolkata

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Abstract

This paper examines the association between two alternative indicators of food access – traditional calorie-based indicators which provide objective data and the experiential indicators which address the psychological dimensions of food insecurity. In the process of modelling the relationship between the two indicators, the study also identifies the determinants of experience-based food security and provides a simple mechanism to identify households at greater risk of food insecurity, given certain economic and socio-demographic characteristics of the household. The exercise is based on the information collected from a survey of 500 randomly selected slum households of Kolkata in 2010-11. The experience-based indicator of food security was constructed following the U.S. Household Food Security Survey Module (US HFSSM). A nine-item food security scale was constructed, based on which households were classified as highly food secure, marginally food secure, moderately food insecure and severely food insecure. The modelling framework is based on simultaneous ordered probit with continuous endogenous explanatory variable and also on instrumental variable linear regression model. Results indicate that the experiential indicator and calorie-based indicators are aligned in the same direction. The paper has a strong policy emphasis since it establishes the nutritional relevance of the experiential food security indicator and at the same time identifies possible threats to household food security, some of which include lack of assets, low level of education, female headship of households and low share of working age adults in the household.

Keywords: food access, calorie intake, experiential, food security scale, scale score, simultaneous ordered probit, endogeneity, instrumental variable, female headed .

JEL Classification: C31, C42, C43, O12, I 30.

1 Introduction

Food security is an elusive concept (Barrett, 2010). The multidimensional nature of the phenomenon poses considerable challenge to researchers in terms of operationalizing the concept. Thus, measuring food security becomes a daunting task which, if inappropriately done, might lead to errors in identifying the truly food insecure, rendering targeting ineffective. Food as a human right is seldom disputed, but in order to stimulate policy decisions and mobilize resources in the right direction, research needs to focus on something more.

First, food security research has to be clear about which dimension of food security is being measured - availability, access, utilization or vulnerability to food insecurity. These dimensions are sometimes overlapping and there is no single indicator which can capture all. Therefore it may be necessary to employ multiple indicators for better identification of the vulnerable households and there is no "gold standard" against which to assess practical measures (Barrett, 2002; 2010; Kennedy, 2003; Jones et al., 2013; Heady and Ecker, 2012).

Second, it is important to understand the threats to food security – factors that cause food insecurity. As Barrett (2002) argues, the research in this direction has become more advanced with continuous evolution in the concept of food security from the first generation focus on food availability at the aggregate level to second generation focus on individual and household level access to food, to a third generation emphasis on risk and uncertainty. However, much remains to be done yet. Barrett and Lentz (2010) identifies two types of threats to food security - 'covariate' threats or causes that are common to a broad population (for example, famine) and hence require generalized interventions at the community or national level (for example, food aid) or 'idiosyncratic' causes which are more relevant at the level of individuals or households (for example, poverty, ethnicity, gender) and are required for successful targeting of interventions to particular food insecure individuals/households.

In line with the above thoughts, this paper addresses some of the measurement issues related to the 'access' dimension of food security – the most multifaceted and hence the most difficult-to-measure component, among the three pillars of food security (Barrett, 2010) availability, access and utilization. More specifically, we examine the association between the two most commonly used outcome indicators of food access – calorie-based indicators and perception-based indicators, more popularly termed as experiential indicators. We examine the issue in the context of urban India.

The calorie-based indicator we used is calorie availability at the household level. The experiential indicator was constructed on the basis of a survey of 500 randomly selected slum households in Kolkata, India, in 2010-11. We also address the second important concern about understanding the threats to food security by providing a simple mechanism to identify a vulnerable household focusing on the 'idiosyncratic' causes of household food insecurity in the relevant population, with a view to suggest directions for cost-effective targeting.

The major motivations behind the study are as follows.

The first is a general concern regarding the association between experiential food security indicators and calorie-based indicators. Experience-based measures can capture the psychological dimension of food insecurity relating to worries and anxiety over food needs. The additional advantages with these indicators are their cost effectiveness (relatively easy to collect compared to calorie data) and ability to identify food insecurity at a disaggregated level - household as well as individual, which allows measuring intra-household disparity in hunger.[1] However, these indicators have their disadvantages as well, some of the main concerns being response bias (Pinstrup-Andersen, 2009; Maxwell and Caldwell, 2008)[2] and obscurity in deciding on cut-offs to classify the food insecure population into various categories by severity of food insecurity. There are also concerns regarding ordering of questions (Deaton, 2011 as cited in Heady and Ecker, 2012) and gender of respondents (Coates et al., 2010) affecting survey responses.

Such concerns with experiential indicators necessitate close examination of their association with other established objective indicators of food security of which calorie intake is of prime interest in our context. The emphasis on calories in our study stems from the fact that an ideal food security indicator must have a nutritional relevance – the concept of food security being nested in the broader sphere of nutrition security (Jones et al., 2013). Even though micronutrient deficiencies present equally grave, if not more, serious challenge to nutrition

[1] Calorie-based indicators can also measure food insecurity at individual level. However, collecting data for every individual member in the household is enormously time and resource-intensive and requires considerable expertise. Experiential measures offer relatively simple, quicker and less expensive technique for identifying food insecurity at more disaggregated levels.

[2] However, there's evidence that response bias relating to data collection with respect to experience-based food security measures might be minimal (Deitchler et al., 2010).

security, we focus on calories because calorie based indicators are one of the oldest indicators of food security (Heady and Ecker, 2012) and "analysts operate on the principle that other needs are usually satisfied when calorie intake is sufficient" (Maxwell and Smith, 1992, p. 9). Calorie deprivation has long been used as a measure of hunger, globally, by Food and Agricultural Organization (FAO).[3] Moreover, countries like India rely considerably on trends in household calorie availability as measures of food and nutrition security.

However, recent research, in India has raised concerns over the relevance of calorie as an indicator of food security (Deaton and Dreze, 2009), and this brings us to the second motivation behind this study. The Indian economy is being faced with the peculiar paradox of declining calorie intake and rising undernourishment in the face of rapid economic growth and declining poverty ((Radhakrishna, 2005; Dutta and Ramaswami, 2001; Mehta and Venkatraman, 2000, Ray and Lancaster, 2005; Sen, 2005; Suryanarayan and Silva, 2007; Patnaik, 2004; Li and Eli, 2010; Deaton and Dreze, 2009; Gaiha et al., 2010; Basu and Basole, 2012). Moreover, trend in self-reported hunger as reported by National Sample Survey Organisation (NSSO, 1983; 1994; 2007b)[4] seems to be uncorrelated with calorie figures (Deaton and Dreze, 2009). As noted by Deaton and Dreze (2009, page 12), "this lack of correlation might be taken as casting further doubt on the validity of the hunger questions, or on the relevance of the calorie norms, or even both".

Finally, India has recently passed the National Food Security Bill[5] which aims to provide food subsidies to the billions of hungry Indians on the basis of a right-based approach to food. This has caused the urgency to find a simple and cost-effective mechanism of targeting the food insecure households a more pressing need than ever. As mentioned before, passing the legislation is not adequate; the response to promote food security can be effective only when they are guided by accurate identification of the vulnerable population. Hence, the need for further research in this direction.

[3] Calorie deprivation, referred to as undernourishment by FAO, is the FAO measure of hunger and is described as a situation "when caloric intake is below the minimum dietary energy requirement" (FAO, 2008).

[4] National sample Survey Organisation (NSSO) has been including a question on food adequacy in its consumption surveys since 1983. In 1983 and 1993-94 the question was whether everyone in the household got "two square meals a day" and from 1999-00 the question was revised as "whether everyone in the household got enough food every day." Going by this question, self-reported hunger has declined in both rural and urban India between 1983 and 2004-05 (Deaton and Dreze, 2009).

[5] The National Food Security Act, 2013 (or Right to Food Act) was signed into law on September 12, 2013, retroactive to July 5, 2013. This law aims to provide subsidized food grains to approximately two thirds of India's 1.2 billion people.

In the absence of reliable official data on self-reported measure of hunger, we constructed an experience-based indicator, following the U.S. Household Food Security Survey Module (US HFSSM). This indicator is supposed to be more reliable compared to an indicator based on a single question, being grounded on a wider range of questions (18 items) that try to capture food insecurity at different levels of severity (see Hamilton et al. 1997a; 1997b for details). Moreover, it takes into account the vulnerability and uncertainty elements of food insecurity and also underlines the fact that food insecurity relates not just to insufficient ‘quantity’ but to inadequate ‘quality’ of food as well (Kennedy, 2003). The initial motivation behind the development of the U.S. measure was the need to develop a measure of hunger that would distinguish between medical definition of hunger and poverty-related hunger (Kennedy, 2003).

Hence, despite the fact that both calorie-based indicators and experiential indicators measure access to food, there is a subtle difference between the two which needs to be recognized. The experience-based indicators measure economic access to food and look at food insecurity more as a socio-economic condition leading to unequal access to food, consistent with Sen’s (1981) ‘entitlement’ approach (Ballard et al., 2013) while calorie-based indicators measure adequacy of consumption/acquisition of food (Jones et al., 2013). It is not obvious that the two measures will always correspond because one can see cases of food secure households with inadequate dietary intake which could result from lack of appetite, lack of knowledge about food needs, being too busy to eat, consuming low calorie diet and so forth. Therefore, we examine whether the two indicators are aligned in the same direction. More specifically, we ask the question: Do the households which have inadequate access to food in terms of calorie availability also have restricted economic access to food, in terms of the experiential indicator?

We address the above concern by estimating two alternative models. First, we estimate a bivariate model consisting of a simultaneous ordered probit and a linear regression, with three categories of food security status (highly food secure, marginally food secure and food insecure) as the outcome of interest and calorie intake as a continuous endogenous explanatory variable, controlling for households’ socio-demographic and economic characteristics. We use Maximum Likelihood (ML) to estimate the model, using Stata’s user-written IV-Oprobit command (Roodman, 2009). Next, we specify food security score as a continuous dependent variable and estimate a linear Instrumental Variable (IV) model instead, keeping the remaining specifications with respect to calorie intake and other covariates same as in the previous model.

In course of addressing the above objective, we also accomplish the equally significant task of identifying the characteristics of the food insecure households and then predicting the food security status as well as the food security scale score of households on the basis of their specific economic and socio-demographic traits. Given certain characteristics including calorie intake, education and gender of household head, household size, homeownership status and so forth, the predicted probability of falling into food insecurity can be calculated and actions taken accordingly. The paper delivers a strong policy signal in this respect too, in addition to examining the correspondence between the two most commonly used outcome indicators of access to food.

We conduct the analysis in the context of an urban sample because urbanization has emerged as a major threat to food security in recent years and India is no exception. Food access becomes an issue of critical importance for the urban poor, especially during a crisis period like the 2008 twin food and fuel inflation, because the urban poor are 'net buyers' of food (FAO, 2008) – a severe disadvantage which gets compounded by other factors like weaker safety net to provide transfers, restricted borrowing capacity, asset poverty and consequent inability to smooth consumption (Maxwell, 1999; Barrett and Lentz, 2010).

Results indicate that experiential food insecurity in these urban slum households is strongly associated with the calorie-based indicator. To what extent the results can be generalized in the context of urban India as a whole is not clear at this stage, in the absence of a larger and more representative sample and panel data. However, this does not demean the significance of the present research because it is aligned with the most recent mandate in food security research which emphasises on a shift towards survey-based indicators "to improve the disaggregated identification of food-insecure subpopulations and their targetable characteristics and behaviours" (Barrett, 2010, p.827).

Rest of the paper is organized as follows. Section 2 briefly discusses the data; Section 3 presents the empirical model and the variables, Section 4 and 5 present results and discussion respectively; and Section 6 concludes by drawing some policy implications and providing directions for future research.

2 Data and Descriptive Statistics

2.1 Data

The experience-based food security indicator measures economic access to food and was constructed by adapting the US HFSSM, in the context of slum households in Kolkata. Two measures of household food security can be computed from the core module data: Household Food Security Scale which is a continuous measure and Household Food Security Status which is a categorical measure (Bickel, 2000). Scales are estimated using a Rasch measurement model, a form of non-linear factor analysis, in the family of Item Response Theory (IRT) models. The detailed methodology of construction of the Kolkata Food Security Scale is available in Maitra (2014).

The sample of 500 households was drawn randomly out of the 15 slum blocks in Kolkata Metropolitan Corporation (KMC) area, stratified by gender of household head - 426 male headed and 74 female headed households.[6] The survey questionnaire has two main sections - the first part collected information on socio-economic, demographic and environmental characteristics of the slums and also on details of the consumption expenditure pattern of the surveyed households, the latter being essential for the calculation of household's food, non-food and total expenditures and intakes of calorie, protein and fat. The second part of the questionnaire presents the 19 food security scale items – 11 of which relate to adult food security conditions at the household and the remaining eight items to food security conditions of children in the household. However, we present results for the adult scale only. [7]

Out of the 11 items, nine met the Rasch model assumptions, based on which the Kolkata Food Security Adult Scale was constructed (henceforth, for the rest of the paper we would refer to it as Kolkata Food Security Scale). On this scale, four categories of food security status were identified - highly food secure, marginally food secure, moderately food insecure and severely food insecure, based on cut-offs corresponding to raw scores three, five and seven, respectively. Accordingly, 84.6% of households in the Kolkata sample were food secure including 76.2% highly food secure and 8.4% marginally food secure; and 15.4% were

[6] Details of survey methodology are available upon request.
[7] This is due to the fact that external validation of the child scale could not be not implemented due to lack of separate information on nutrient intake and anthropometry of children. This information could not be collected, in the survey, due to time and resource-constraint.

food insecure, including 12.8% moderately food insecure and 2.6% severely food insecure. However, for the purpose of the present paper, we consider three categories of food security status: highly food secure ($0 \leq$ raw score <3), marginally food secure ($3\geq$ raw score <5) and food insecure (raw score ≥ 5). Households with moderate and severe food insecurity are analysed as a single category because only a small number of households (only 13) are present in the latter category.

Based on Part A of the Survey Questionnaire, calorie intake was computed by collecting data on the quantity and value of food items consumed by the households during a period of last 30 days preceding the date of inquiry. The quantity estimates of the food items consumed by a household were measured in units of calorie, protein and fat after application of conversion factors appropriate to the items of food, using the Nutrition Chart provided in NSSO (2012).[8] The estimates of total nutrient equivalent of all food consumed by the household during the reference period was derived by aggregation over different groups (components) of food.[9] Finally, the required figure on the level of calorie, fat and protein intake per day per person was calculated by sub-dividing this aggregate by the product of total number of members in the family and the duration of the reference period which was 30 days.[10] The calorie 'availability' figures, thus computed, were adjusted by the 'number of meals taken outside home' and 'meals consumed by guests', using adjustment factor proposed by Minhas (1991) to arrive at calorie 'intake' which is believed to be closer to true intake.[11]

2.2 Descriptive Statistics

[Table 1 here]

We examine the pattern of nutrient consumption of the households in terms of food security status. Table 1 presents a simple description of the data - intake of calorie, fat, protein and selected food items for two categories of food security status – food secure ($0 \leq$ raw score <5) and food insecure (raw score ≥ 5). We note the following: (i) average consumption of all nutrients and food items are much higher in food secure households

[8] The nutrition chart is based on "Nutritive Values of Indian Foods" by C. Gopalan, B.V. Ramasastry and S.C. Balasubramanian, revised and updated by B.S. Narasinga, Y.G. Deosthale and K.C. Pant, 1991.
[9] The eight major food groups that have been considered are: cereals, pulses and soybean, milk & milk products, vegetables and fruits, sugar and honey, meat-egg-fish, edible oil and miscellaneous food products.
[10] For durable goods, the question was asked both with reference to 30 days and 365 days.
[11] See Strauss and Thomas (1995) for discussion on the distinction between calorie availability and calorie intake. Also see NSSO (2012) for discussion on calorie adjustment by number of meals, using Minhas (1991).

compared to food insecure households and the differences are statistically significant; (ii) not only do the food secure households consume higher quantities of nutrients and selected food items, but also the consumption of the items is adequate with respect to the Indian Council of Medical Research (ICMR) prescribed norm (ICMR, 1988). Cereals and milk are the only two items which food secure households consume inadequately while the only item those food insecure households consume adequately is vegetables.

Since our interest relates to calories in particular, we also compute the rank correlation between food security scale score and per capita per day calorie intake, which turns out to be -0.36 ($p<0.001$) for the ICMR specification [-0.035 ($p<0.001$) for the NSSO specification]. This implies if households are ranked according to calorie availability and food security scale score, a high degree of correspondence is noted between the rankings by the two alternative indicators.

Next we compute the association between prevalence rates of food insecurity and calorie deprivation. We now specify calorie as a binary variable representing shortfall from a standard norm which coincides with FAO's concept of undernourishment. A household is categorized as undernourished in terms of three alternative specification of calorie intake – if per capita per day calorie intake is less than the ICMR prescribed calorie norm of 2100 kcal per capita per day or the FAO recommended calorie norm of 1820 kcal per capita per day (see von Grebmer et al., 2008) or NSSO prescribed norm of 2700 kcal per consumer unit per day, which is based on adult equivalence scales (NSSO, 2001).[12] Henceforth, we would refer to the alternative calorie specifications as ICMR, FAO and NSSO, respectively.

The tetrachoric[13] correlation between binary food security status (1 if food insecure, 0 otherwise) and undernourishment status (1 if per capita per day calorie intake < 2100 kcal, 0 otherwise) is high at − 0.56 (S.E 0.07, $p<0.001$), indicating strong association between experiential food insecurity and undernourishment. Using the alternative calorie norms for

[12] NSSO defines 'consumer unit' as a normative rate of equivalence of a given age-sex specific person in relation to a 'standard' male person aged 20-39 years and doing sedentary work who is taken to be equivalent to one consumer unit. The other coefficients are worked out on the basis of calorie requirements. The corresponding norm has been determined as 2700 calories per consumer unit per day, for India. The relevant adult equivalent scales are available in the NSSO report on nutritional intake for India (NSSO, 2001).

[13] If two ordinal variables are obtained by categorizing a normally distributed underlying variable and those two unobserved variables follow a bivariate normal distribution then the (maximum likelihood) estimate of that correlation is the polychoric correlation. If each of the ordinal variables has only two categories, then the correlation between the two variables is referred to as tetrachoric (Greene and Hensher, 2009).

NSSO and FAO, the respective correlations are -0.44 (S.E: 0.09, p<0.001) and -0.60 (S.E: 0.06, p< .001).

We also cross tabulate binary undernourishment status, computed according to the three alternative norms (ICMR, NSSO and FAO) and three categories of food security status (highly food secure, marginally food secure and food insecure). The polychoric[14] correlations among the variables give us some preliminary idea on the degree of correspondence between the two measures. Results are presented in Tables 2, 3 and 4, respectively.

[Tables 2, 3 and 4 here]

According to the ICMR calorie norm, 55% of the highly food secure households are undernourished and the prevalence of undernourishment increases to 91%, for the food insecure households (Table 2). The corresponding percentages for the NSSO specification, ranged from 72% to 94%, across the highly food secure to food insecure households (Table 3). It is somewhat surprising that such a high proportion of households are undernourished, even among the highly food secure households. However the polychoric correlation is weakly significant. Using the FAO cut-off, the percentage of undernourished households increased from about 44% among the highly food secure households to 88% among the food insecure households (Table 4) and the polychoric correlation of 0.53 is significant in this case.

Generally speaking, proportion of undernourishement rises with food insecurity in the sampled households. The polychoric correlations are not always significant (as with ICMR specification), but it can be expected this is only due to small sample size.

[Table 5 here]

We also try to examine whether there are significant differences between selected socio-demographic characteristics of the households which are food insecure by experiential status and those which are food insecure in terms of calorie deprivation. We call the former food insecure and the later undernourished and report the results in Table 4. Interestingly, the two groups of households seem to be exhibiting very different characteristics. Poverty rate is much higher among the food insecure households compared to the undernourished

[14] If two ordinal variables are obtained by categorizing a normally distributed underlying variable and those two unobserved variables follow a bivariate normal distribution then the (maximum likelihood) estimate of that correlation is the polychoric correlation. In our case one of the variables is binary (Greene and Hensher, 2009).

households and the former group of households is also relatively more asset poor. Moreover, food insecure households seem to be dominated much more by female headship, casual labor households and illiterate household heads compared to the undernourished. These observations offer reasons to believe that food insecure and undernourished households are two different groups altogether. However, only an appropriate empirical analysis, controlling for other covariates influencing food security status can throw light into the issue.

3 Modelling the Relationship between Experiential Food Security and Calorie Intake

Our empirical model underlines the nutrition-productivity linkage on well-being which reflects important feedback effects of good nutrition on economic access to food (Barrett 2002; Dasgupta, 1993). It stresses on the notion that low income and poor nutrition might have important feedback effects. Thus, in determining whether calorie intake and experiential food security are aligned in the same direction, the most general specification of the model would be the one that assumes that the variables are jointly determined. The same unobservable factors which affect calorie intake at a particular point of time are also likely to affect economic access to food as represented by the experiential food security measure we have constructed. Hence, any econometric investigation modelling the relationship between food security status and calorie intake, should take account of this endogeneity.

In conformity with the above, we estimated two alternative models, with respect to alternative specifications of the outcome variable – food security status as a categorical variable and food security score as a continuous variable.[15] Since the outcome of interest is an ordered response in the first specification, an ordered probit is used to model it. To take account of the endogeneity of calorie intake, a bivariate model consisting of a simultaneous ordered probit and linear regression is estimated by maximum likelihood. The second specification refers to a linear IV model where a negative coefficient of calorie intake would imply that the two measures are moving in the same direction.

[15] We also examined the correspondence between calorie deprivation or undernourishment status (according to three alternative calorie specifications of ICMR, FAO and NSSO) using a bivariate semi-ordered probit model with three categories of food security status (highly food secure, marginally food secure and food insecure) and binary undernourishment status as the joint outcomes. The results indicate positive and significant association between the two measures of food insecurity. Results are available upon request.

3.1 IV-Ordered Probit Model

The following econometric model is specified for modelling the relationship between three categories of food security status and average daily calorie intake computed per person (per consumer unit). This is a generalization of the familiar IV-probit estimator of Amemiya (1978) and Newey (1987).

Self-reported food security category F, is used as a proxy for the latent unobservable individual's true level of food security, F^*. For an individual i,

$$F_i = \begin{cases} 0 & if\ highly\ food\ secure \\ 1 & if\ marginally\ food\ secure \\ 2 & if\ food\ insecure \end{cases} \tag{1}$$

Following Greene (2012), an ordered probit model with latent food insecurity F_i^*, gives,

$$F_i = \begin{cases} 0 & if\ F_i^* \le 0 \\ 1 & if\ 0 < F_i^* \le \mu \\ 2 & if\ \mu < F_i^* \end{cases} \tag{2}$$

and

$$F_i^* = x_i\beta + \varepsilon_i \tag{3}$$

where F_i^* denotes latent food insecurity, $\boldsymbol{\beta}$ is a vector of unknown parameters, x_i denotes a row vector of variables representing calorie intake and household's economic and socio-demographic characteristics, ε_i represents a normally distributed error term in the equation and *i* denotes an individual household, *i* = 1, 2.....499.[16]

Since the model was estimated in Stata which does not include a constant term in the food insecurity Equation 3, the ordered probit model is written as:

$$F_i = \begin{cases} 0 & if\ F_i^* \le \mu_1 \\ 1 & if\ \mu_1 < F_i^* \le \mu_2 \\ 2 & if\ F_i^* > \mu_2 \end{cases} \tag{4}$$

[16] Initially there were 500 households but one observation was dropped due to missing value on food security score.

Thus, in addition to β there are two unknown parameters, μ_1 and μ_2 to be estimated such that $0 < \mu 1 < \mu 2$. The predicted probabilities for the single equation ordered probit model will now be;

$$P(F_i = 0) = \Phi(\mu_1 - x_i\beta) \tag{5}$$

$$P(F_i = 1) = \Phi(\mu_2 - x_i\beta) - (\mu_1 - x_i\beta) \tag{6}$$

$$P(F_i = 2) = 1 - \Phi(\mu_2 - x_i\beta) \tag{7}$$

The above approach is not appropriate for evaluating the effect of a dummy variable, which can be analysed by comparing the probabilities that result when the dummy variable takes its two different values (0,1) with those that occur with other variables held at their sample means. That is, as $P[F \mid x = 1] - P[F \mid x = 0]$.

For the three probabilities the partial effects of changes in the regressors are as follows:

$$\frac{\delta(Prob(F = 0|x)}{\delta x} = -\Phi(\mu_1 - x_i\beta)\beta \tag{8}$$

$$\Phi(\mu_1 - x_i\beta) - \Phi(\mu_2 - x_i\beta)]\, \beta \tag{9}$$

$$\frac{\delta(Prob(F = 2|x)}{\delta x} = \Phi(\mu_2 - x_i\beta)\beta \tag{10}$$

In these expressions "$\Phi(.)$" denotes the probability density function of a standard normal distribution, and its values are always positive. Consequently, the sign of the parameter β is opposite the direction of the marginal effect for the lowest category, but it indicates the direction of the marginal effect for the highest category. The direction of marginal effect for the middle category goes one way or the other, depending on the sign of the difference in brackets.

As calorie intake is an explanatory variable for the food security status of a household, Equation 3 is written as:

$$F_i^* = x_i\beta + \varepsilon_i = \theta C_i + x_{1i}\beta_{1i} + \varepsilon_{1i} \tag{11}$$

Where C_i denotes the level of calorie intake for each household, θ is an unknown scalar which denotes the effect of calorie intake on food security status of a household, $\boldsymbol{\beta_1}$ is the vector of unknown parameters, $\boldsymbol{x_1}$ denote the vector of exogenous variables representing household's economic and socio-demographic characteristics and ε_{1i} represents the error term in the equation.

If it is assumed that food security status and calorie intake are jointly determined, ML estimation of the ordered probit model by itself will not consistently estimate β_1. Maximum likelihood estimation, in this case, will require a relevant instrumental variable z_i such that $E(\varepsilon_i z_i | x_i = 0)$, and $E(\varepsilon_i z_i \neq 0)$.

The ML estimation requires a full specification of the model, including the assumption that underlies the endogeneity of C_i. Hence, this essentially becomes a simultaneous equation model. Assuming that there is a vector of instrumental variables x_i, the model equations will now be:

$$F_i^* = \theta C_i + x_{1i}\beta_{1i} + \varepsilon_{1i}$$

$$C_i = \alpha + z_i\beta_{2i} + x_{2i}\beta_{3i} + \varepsilon_{2i} \tag{12}$$

Ordered probit estimation based on F_i and the variables (x_{1i}, C_i) will not consistently estimate (β, θ) because of the correlation between C_i and ε_{1i}, induced by the correlation between ε_{1i} and ε_{2i}. The joint distribution of the error terms is specified as:

$$\varepsilon | x \sim N(0, \Sigma) \; where \;\; \Sigma = \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \tag{13}$$

The diagonal entries of Σ are 1, in order to normalize scales for both equations. A test of the null hypothesis of exogeneity of *C* is equivalent to the test of $H_0: \rho = 0$.

Equation 11 might be referred to as the structural equation. The reduced form equation mainly explains the variation in exogenous variable only, in terms of strictly exogenous variables including the variable *z* that is excluded from the structural equation. This is necessary for identification of the parameters of the structural equation. Given the specifications of the structural and simultaneous equations, the estimation can be sequential or simultaneous.

One way of estimating the above system of equations would be to apply a two-step method suggested by Rivers and Vuong (1988), which was originally proposed in the context of probit regression variable. In this method, the estimated residual from the first-stage regression is added as an explanatory variable in the second-stage probit regression to obtain consistent estimates (of the scaled coefficients). Rivers and Vuong (1988) indicated that adjustment is needed for the variance-covariance matrix in the second stage probit to get asymptotically correct errors. They also pointed out that the coefficient of the residual will constitute a test for the endogeneity of the suspected endogenous variable (calorie in the present case). The two-step procedure can be extended to the ordered probit case where the dependent variable has more than two categories.

The alternative would be to use Full-information Maximum Likelihood (FIML) estimation of the two equations, directly testing the significance of the correlation between the error terms in the two equations. Simultaneous estimation that takes into account the full covariance structure is in general more efficient. Since FIML estimation is computationally intensive and time-consuming, particularly in the context of ordered choice models, two step method would have been preferred by many researchers. But with the development of new software programs the estimation difficulties can now be overcome. Stata's user-written "cmp" (conditional mixed process) (Roodman, 2009) is one such program which allows FIML estimation of recursive system of equations of the type encountered in this study.

The model can be estimated consistently by FIML in the spirit of seemingly unrelated regression.[17] In models like this, one proof of endogneity would be testing the significance of the reported 'anthrho' statistic (which measures the Fisher´s Z transformation of the correlation between error from both models) (Kawatsu and Largey, 2009). If we fail to reject the exogeneity test (H0 : anthrho = 0) then the estimators of the single equation ordered probit model (Equation 11) should be valid. However, before estimating the full model using

[17] Roodman's (2009) "cmp" is fundamentally a SUR estimation program. But it turns out that the ML SUR can consistently estimate parameters in an important subclass of mixed-process simultaneous systems: ones that are recursive, with clearly defined stages; and that are fully observed, meaning that endogenous variables appear on the right hand side only as observed.

FIML, an exogeneity test was carried out using the Rivers and Vuong methodology, for robustness.

We used the extent of crowding in the household represented by the 'number of rooms available per capita in the household' as an instrument (z) in the calorie equation (Equation 12). As suggested by Haddad et al. (1994), sometimes relatively simple indicators like 'number of rooms per capita' perform well in predicting households' nutritional adequacy. This variable has also been previously used in the literature, in estimating calorie demand functions (Haddad, 1992; Iram and Butt, 2004). However, extent of crowding in the household may not directly influence a household's experiential food security status which allows its use as an instrument to address the endogeniety of calorie intake in the present case. We use the variable in logarithmic form as reported previously by Iram and Butt (2004).

[Figure 3 and Figure 4 here]

The correlation between log of rooms per capita and per capita calorie intake is high, 0.48 ($p<0.001$). The relationship is clearer in Figure 3 which shows the lowess plot of the two variables. Similar results are obtained for calorie intake per consumer unit (Figure 4).

There is no direct method for testing (identification tests) instrument validity in models such as the IV-Ordered Probit. If the instrument is significant, this might be a good indication of its acceptance. However, in the next section, we outline a linear IV model with food security score as a continuous outcome variable, which allows us to conduct the tests of over-identification and under-identification, for the same specifications as above. The results of linear IV confirm that 'number of rooms per capita' may not be a weak instrument (see Appendix A).

3.2 Linear Instrument Variable (IV) Model

The instrumental variable regression is a two-stage regression where the first stage regresses per capita (per consumer unit) calorie intake on the variable 'logarithm of number of rooms available per capita' (z), in addition to the other covariates specified in vector $\boldsymbol{x_{2i}}$ (Equation 15). The second stage IV regression uses the predicted value of average calorie intake from first stage regression to estimate the equation of food security score (Equation 14).

$$score_i = \theta' C_i + B'_{1i} x_{1i} + \varepsilon'_{2i} \tag{14}$$

$$C_i = \alpha + z_i \beta_{2i} + x_{2i} \beta_{3i} + \varepsilon_{2i} \tag{15}$$

where Equation 15 (identical to Equation 12 in Section 3.1) includes the instrument *z*.

The standard Durbin-Hu-Hausman test was conducted to examine whether endogeneity of per capita (consumer unit) calorie intake was a genuine concern and the test strongly rejected the null hypothesis of exogeneity. The test for instrument validity (in a just identified model) revealed that 'log availability of rooms per capita' may not be a weak instrument (see Appendix A for details).

3.3 The Variables

In both models, the explanatory variables included in the food security equations (Equations 11 and 14) are household size (in logarithmic form), household's ownership of durable assets[18], homeownership status which represents ownership of fixed tangible assets like dwelling; gender, education and religion of household head; and household composition represented by share of kids, working age adults and seniors in the household.[19] The variables come from the list of socio-economic indicators of food and nutrition security provided in Haddad et al. (1994) and Frankenberger (1992).

The variables included in the calorie equations (Equations 12 and 15) include, in addition to the above, "availability of room per capita" as an identifying instrument. They also include households' monthly per capita expenditure (MPCE)[20] and household employment status (whether a casual labor household or not)[21] as covariates. However, we exclude the variable

[18] Household's asset ownership status is a binary variable named "asset" –1 if the household possesses zero asset or only fan and, 0 if it possesses more than 1 asset other than fan. Other assets include refrigerator, black and white TV, colour TV, telephone, mobile, motorbike, cycle, car.
[19] However, we have only included the share of working age adults and kids in the model, to avoid collinearity.
[20] We replace income by expenditure as a determinant of calorie intake because expenditure might be generally more reliable than income because of fewer reporting errors and because it is less subject to shocks. Moreover, household expenditure is typically a better proxy for permanent income because while income might be subject to transitory fluctuations, households typically use a variety of mechanisms to smooth consumption over time. A study by Haddad et al. (1994), for instance, found that household total expenditures and food expenditures were both more closely correlated, than household income, with indicators of calorie adequacy. .
[21] Following NSSO (2006), information was collected on four types of occupations: self-employed, regular salaried, casual labor and others. Out of these four categories, the dummy variable "hhtype" was created which classifies households into two broad categories - casual labor households and non-casual labor households where the latter is the reference group and includes self-employed/regular salaried or other group of workers.

asset ownership status from the calorie equation. Since asset ownership renders consumption smoothing which helps mitigate risk and uncertainty (Barrette, 2002), this variable is more likely to be directly related to experiential food insecurity rather than calorie intake.

It is important to justify the exclusion of MPCE from the food security equations (Equations 11 and 14). It is an important determinant of both experiential food security status and calorie intake and therefore, theoretically, should be included in both equations. However, including the variable in both equations was problematic as the model did not converge. This might be due to its endogeneity with respect to both experiential food security and calorie intake, which certainly needs to be taken care of. It is hoped that excluding the variable from the first equation and including it in calorie equation, while also instrumenting calorie intake by the extent of crowding in the household, would address this issue to some extent.[22]

3.4 Summary Statistics of the Variables

Table 6 presents definitions and summary statistics of all variables included in the model.

[Table 6 here]

Approximately, 76% of households in the sample are highly food secure, with 8% marginally food secure and 15% food insecure. Average calorie intake in the sample falls short of the required minimums both in terms of ICMR prescribed calorie norm of 2100 kcal per person per day and NSSO prescribed calorie norm of 2700 kcal per consumer unit per day, and is adequate only with respect to the FAO norm of 1820 kcal per capita per day. However, average MPCE in the sample is much above the poverty line expenditure, which is Rs. 856.28 for urban West Bengal for 2010-11[23], bringing out the stark contrast between undernourishment status and income-related economic access, for these households. Consistent with above-poverty-line expenditure, majority of the households are asset owners. A substantial proportion of households are headed by illiterate persons and 22.4% of households in the studied sample are casual labor households, reflecting the degree of concentration of employment in the urban informal sector.

[22] The model was also estimated by dropping the expenditure variable altogether, from both equations, and the results remained qualitatively similar. This implies inclusion of "MPCE" in the model and the resulting endogeneity problem has not distorted the basic results of the model. Results are available upon request.

[23] Poverty line expenditure for Kolkata, 2010-11, was determined by updating the poverty line expenditure for urban West Bengal, 2004-05, using the Consumer Price index for urban Industrial Workers (base 2001).

4 Results

4.1 Results: IV-Oprobit Model

Prior to the estimation of the full model parameters using maximum likelihood, a test of the exogeneity of food security status and calorie intake (for both ICMR and NSSO specifications) were conducted, applying the Rivers and Vuong two-step method, for robustness (the methodology and the full set of results are presented in Appendix B). The results provide evidence of possible endogeneity of calorie intake, with respect to experiential food security. Whether the above results are corroborated by the FIML model can now be tested.

[Table 7 here]

The ML estimates of the full model parameters from the bivariate simultaneous equation model obtained using IV-Oprobit are presented in Table 7, for both specifications of calorie intake (ICMR and NSSO). Consistent with the Rivers and Vuong results mentioned above, the 'athrho' statistic is highly significant which, as previously mentioned (in section 3.1) would be an indication of presence of endogeneity in the model.

Co-efficient of calorie intake, θ, is negative and statistically significant. This implies, in the context of an ordered probit model, with increase in calorie intake, the probability of being highly food secure $P\ [Fi = 0]$ increases and the probability of being food insecure $P\ [Fi = 2]$ decreases (Greene, 2012; Greene and Hensher, 2009), given other covariates. The sign of the co-efficient in the middle category ($P\ [F = 1]$) is ambiguous but usually there should be a sign change in the intermediate category, consistent with "single crossing effect".[24]

The remaining covariates which significantly influence food security status are somewhat different for the ICMR and NSSO specifications. Asset ownership, household size and education of household head are common across both specifications. However, homeownership status influences food security status in the ICMR specification alone, while gender of household head and household composition variables represented by proportion of kids and working age adults in the household are significant in the NSSO specification only.

[24] In discrete choice models, set of partial derivatives will change sign exactly once in the sequence from 0 to J, a property that Boes and Winkelmann (2006) label the single crossing characteristic.

Finally, for both calorie specifications, the coefficient of z representing 'number of rooms per capita' is significant. In the absence of formal tests for instrument validity in non-linear models of the present form, the significance of z provides an indication that it is a valid instrument in the present sample.[25]

4.1.1 Marginal Effects at Mean and Adjusted Predictions at Mean

[Table 8 and Table 9 here]

We report adjusted predictions (predicted probabilities) at mean (APM), for food security status, in Table 8 and Table 9, for ICMR and NSSO specifications respectively. For ICMR specification reported in Table 8, APM for being highly food secure is 0.76 which would imply, for an average slum household, the likelihood of being highly food secure is 76%, when all covariates are held constant at mean. The chances of being marginally food secure and food insecure are 8% and 17%, respectively. The corresponding values for the NSSO calorie specification are higher for the category food insecure (20%) (Table 9).

In ordered probit models, marginal effects would be more meaningful than co-efficients since the latter only give some indication of direction of effect without providing any additional information on magnitude of effects. In Table 10, we present the marginal effects at mean (MEM) of the explanatory variables for both ICMR and NSSO specifications of calorie intake.

[Table 10 here]

The marginal effects for the two calorie specifications are mostly similar in direction except for gender of household head and the household composition variables represented by share of kids and working age adults in the family. Magnitudes are smaller in general for the NSSO specification, except for gender of household head and household composition variables again.

For a household with an average calorie intake of 1876 kcal per capita per day, a unit increase in calorie intake increases the probability of being "highly food secure" by 0.1 percentage points, when all other variables are held at their sample means and, decrease the probability

[25] However, as mentioned before, one can refer to the results of underidentification test and instrument validity, reported in Appendix A.1 for linear IV model described in Section 3.2.

of being food insecure by an equal amount. Consistent with 'single crossing effect', sign of the middle category 'marginally food secure' is negative however the effect of increased calorie intake is very small in this case (approximately 0.013 percentage points). The marginal effects for NSSO specification are similar in direction but, as stated above, the magnitudes are smaller.

Asset ownership is a strong predictor of food security status – compared to households possessing other assets, households with 'zero asset or only fan' have 15.4 percentage points lower probability of being highly food secure and 12.2 percentage points higher probability of being food insecure, for ICMR specification, holding all other covariates at sample mean.

As for household size, holding constant all other variables at their mean, for a household of average size 5 (antilog 1.37), a one percent increase in household size will lead to 0.0026 increase in the probability of being highly food secure, and .0021 decrease in the probability of being food insecure.

Households headed by persons having primary to secondary level education and by graduates or post graduates have, 7.1 percentage points and 27.5 percentage points higher probability of being highly food secure, respectively, as opposed to households headed by an illiterate person, for the ICMR specification. These two categories of households have, respectively, 5.7 and 21.9 percentage point lower probability of being food insecure compared to households headed by illiterate persons. However, the former category has weakly significant effect in terms of ICMR calorie specification and no impact at all in terms of NSSO calorie specification.

Homeownership status which represents possession of tangible fixed assets, is significant in the ICMR specification alone. The sign of the effect is positive for the highly food secure category implying, compared to renters, homeowners have approximately 7.3 percentage point higher probability of being highly food secure and 5.8 percentage point lower probability of being food insecure.

Interestingly, gender of household head emerges as a strong predictor of food security status for the NSSO specification, as opposed to having no impact in the ICMR specification. The result seems to be an outcome of expressing calorie intake in adult equivalence scale where both gender and age composition of a household are accounted for in computing a household's average calorie intake. Compared to a male headed household, a female headed household is 14.3 percentage points less likely to be highly food secure and 12.0 percentage points more likely to be food insecure. Similar results are noted for the household composition variables. One percent increase in the share of kids and working age adults in the household will decrease the likelihood of food insecurity by 0.0035 and 0.0042, respectively.

Marginal effects of the remaining variables are insignificant. For all variables, the effects are much smaller in magnitude and insignificant in most cases, for the marginally food secure households. The result seems to be driven by smaller number of households present in this category.

4.1.2 Marginal Effects and Adjusted Predictions at Representative Values – Benchmark Male-headed Household

Marginal effects and average predictions at mean may not always be the best option if the model has several binary regressors because these are set equal to their sample averages, which is not particularly meaningful. Moreover, the effect of a particular variable on the probability of success is supposed to vary with the characteristics of the household. For example, the effect of education of household head on the likelihood of food insecurity would vary with gender of household head, ceteris paribus. Thus, having primary to middle level education reduces the likelihood of food insecurity more for a female headed household (5.2 percentage points) than for a male headed household (4.8 percentage points), following the ICMR specification. The effect is equally pronounced for higher level of education – having graduate level education reduces the likelihood of food insecurity by 20.1 percentage points for a female headed household compared to 18.7 percentage points for a male headed household.

Therefore, a superior alternative could be to compute marginal effects at representative values (MER) and adjusted predictions at representative values (APR). This can be illustrated by assigning benchmark values – creating an index case for which the calculation of marginal effects would be more meaningful. To illustrate, we use examples of male headed and female headed households.

A benchmark household with a male head is specified with the following characteristics, using sample averages of male-headed households for continuous variables and modal values for categorical variables: an average calorie intake of 2000 kcal per person per day/2260 kcal per consumer unit per day, owning some assets with a household size of five with one kid (proportion of kids in the household is 0.20), three working age adults (proportion is 0.40) and one senior (proportion is 0.20), household head aged 47 years, with primary to middle level education, Hindu in religion, and a renter. The marginal effects obtained for this benchmark male-headed household are presented in Table 11.

[Table 11 here]

The same variables have statistically significant effect as before and the direction of effect is also similar (Table 11). However, the magnitude of effects at the representative values is smaller. For example, for the ICMR specification, not owning any durable asset lowers the likelihood of being highly food secure by 11.5 percentage points for the benchmark male headed household, as against 15.4 percentage points at mean of explanatory variables. Similar pattern is noted for the marginal effects reported for the NSSO specification.

The likelihood of being highly food secure for the benchmark male headed household, for the ICMR specification, is 85% as opposed to 76% calculated at their mean value, and the chance of being food insecure is correspondingly lower – 10% for the benchmark male headed household as against 17% for the average household (Table 8). For the NSSO specification, likelihood of food insecurity rises from 20% at sample mean to 23% at the representative values (Table 9).

4.1.3 Marginal Effects and Adjusted Predictions at Representative Values – Benchmark Female-headed Household

It would be an interesting exercise to examine how the marginal effect and predicted probability of food security status change if the same analysis is repeated for female headed households. The same specification of household characteristics as in the case of benchmark male headed household (Section 4.1.2) would give a somewhat higher predicted probability of being food insecure (13%) and consequently a lower probability of being highly food secure (80%) for a female headed household, compared to the benchmark male-headed household, for the ICMR specification (Table 8). However, if the exercise is repeated with an alternative set of specifications consistent with the characteristic of female households alone, then the results change markedly.

Since female headed households generally exhibit very different characteristics as opposed to the male headed households, this exercise would be more meaningful if it is possible to identify a benchmark female headed household by alternative specifications of the representative values, which would be consistent with the typical characteristics of a female headed household. In specifying these characteristics one can follow the broad literature, for example, female headed households tend to have higher dependency burden and lower income relative to the male headed households and are more likely to be casual labourers engaged in informal labor market (Buvinic and Gupta, 1997; Baros et al.,1997; Gangopadhy and Wadhwa, 2003). Another way of assigning benchmark specifications would be to use the sample averages for female headed households for the continuous variables and modal values for categorical values, as before. For the purpose of this paper, we have used the latter approach.

Accordingly, the benchmark values of the same explanatory variables, for a female headed household, are specified as follows – average calorie intake of 1879 kcal per capita per day/2449 kcal per consumer unit per day, average family size of four with two working adults (proportion is 0.50), one kid (proportion is 0.25) and one senior member (proportion is 0.25), headed by a person who is 52 years of age with below primary level or no education, Hindu in religion, renter and owning no asset. For such a household, the predicted probabilities for the two calorie specifications (ICMR and NSSO) are presented in Tables 8 and Table 9, respectively and marginal effects of the explanatory variables are presented in Table 12.

In the first instance what strikes one in Tables 8 and Table 9, is the fact that the benchmark female headed household is much less food secure – following the ICMR specification, the likelihood of being highly food secure is now only 52%   as opposed to 85% for a benchmark male headed household and 80% for the female headed household having similar characteristics as the benchmark male headed household. Accordingly, the likelihood of being food insecure is higher, 37% as opposed to 10% and 13%, for the other two groups of households (Table 8) respectively. For the NSSO specification, likelihood of food insecurity increases from 23% to 38% to 46% across the benchmark male-headed household, to the female headed household displaying similar characteristics as a male headed household, to the benchmark female headed households, respectively (Table 9).

[Table 12 here]

As before, the only explanatory variables which exhibit statistically significant effects other than calorie intake are, asset ownership, household size, education of household head, home ownership status of household head (for ICMR specification only), gender of household head and share of kids and working age adults in the household (for NSSO specification only) (Table 12). The direction of effects remains unchanged but the magnitudes are much higher now. For example, not owning any durable asset lowers the likelihood of being highly food secure by 19.5 percentage points for the benchmark female headed household, as against 11.5 percentage points for the benchmark male headed household and 15.4 percentage points for the household having average sample characteristics.

4.2 Results: Linear IV Model

[Table 13 here]

The results of linear IV model are qualitatively similar to that of the simulations ordered probit model presented in Section 4.1. The coefficient of calorie intake is negative which implies, with an increase in calorie intake food security score decreases, indicating an improvement in food security status. Asset ownership and household size are significant for both ICMR and NSSO calorie specifications whereas education variables are significant only for the former. Gender and share of kids and working age adults are reported as significant only for the NSSO specification, as with the ordered probit model in the previous section. For these variables, direction of effect is also similar to those reported for the previous model. In the present case, the coefficients are also the marginal effects of the covariates and hence are more informative, indicating both magnitude and direction of effect. However, of more interest are the predicted values of scores or adjusted predictions — APM and APR, reported in Table 14.

[Table 14 here]

We conduct a similar exercise as before and find adjusted predictions at mean and representative values differ substantially for both specifications of calorie intake (Table 14). Predicted household score on the Kolkata Food Security Scale for ICMR specification is 1.89 which declines to 1.24 for a benchmark male-headed household, rises gently to 1.61 for a female-headed household with similar characteristics as a male-headed household, and then rises sharply to 3.59 for a benchmark female-headed household. The corresponding values for the NSSO specification are 1.89, 1.83 and 3.85, respectively.

5 Discussion

The results of the above model are important in several ways. First, the results indicate, experiential food security and calorie-based indicators are aligned in the same direction. Therefore, a household which consumes fewer calories is also identified as food insecure, having inadequate economic access to food. Comparison of results with existing studies is difficult in the absence of limited comparable work in this area. One study that can be mentioned is by Migotto et al. (2005) who compare information on self-perceived food consumption adequacy from the subjective modules of household surveys with standard quantitative indicators, namely calorie consumption, dietary diversity and anthropometry, using datasets from four countries: Albania, Madagascar, Nepal and Indonesia. They report weak correlation between the "subjective" indicator and the standard quantitative indicators but the subjective measure that they used was based only on the Consumption Adequacy Question (CAQ).[26] Hence, it may be possible to conclude, on the basis of the results from the present study, that improved subjective food security modules that are contextually sensitive may offer better insights into the question of the degree of association between the alternative indicators.

Second, the model provides a mechanism through which it would be possible to identify 'at risk' households using simple yet powerful statistical tools like marginal effects and adjusted predictions. All we have to do is to keep in mind the fact that averages can obscure difference in effect across cases. Thus, education of household head will have differential impact on probability of food insecurity according to the gender of household head – the impact of better education on household food security status is more pronounced for a female headed household compared to a male headed household.

Thus, once it is possible to construct the food security scale on the basis of a sufficiently representative sample, and the specific household economic and socio-demographic characteristics associated with a particular food security status or food security scale score are identified, in the manner we have detailed in this study, it is possible to predict the expected food security status or food security scale score for given household or set of households. The ordered model allows us to predict the likelihood of belonging to a particular food security

[26] The CAQ is generally worded as follows: "Concerning your food consumption, which of the following is true?" Answers are generally coded as: 1) more than adequate; 2) just adequate; and, 3) less than adequate.

category (highly food secure, marginally food secure or food insecure) and the linear IV model is able to predict a household's possible score on the food security scale, once these socio-economic characteristics are known. Thus, one can expect that a typical Hindu family of five members, with three working age adults, one kid and one senior, with an average calorie intake of 2000 kcal per capita per day (2260 per consumer unit per day) and headed by a 47 year old male having primary to middle level education, who does not own a home but owns some durable assets, will have approximately 10% chance of being food insecure, which increases to 37% when all these specifications are modified with respect to a female headed household.

Using the linear IV model, we can go a step further and predict that this particular benchmark male-headed household is expected to have a food security score of 1.52 on the 9-item Kolkata Food Security Scale which is likely to increase sharply to 3.59 when all specifications change in accordance with the characteristics of a female-headed household. Thus, both the ordered and the linear IV models have immense practical value in providing a simple and quick method of identifying the "at risk" households.

Third, the models help us to identify the 'idiosyncratic' causes of experiential food insecurity which basically reflects a household's economic access to food. We particularly refer to the IV-Ordered probit model in isolating the covariates which are likely to influence the food security status of households. We have identified that household size, asset ownership, homeownership status, gender and education level of household head and household composition variables are significant predictors of experiential food insecurity for various specifications of calorie intake. If we compare among benchmark male headed and benchmark female headed households, magnitude of effects for all variables are larger for the latter in terms of both specifications, but the direction of effect is similar.

Given other covariates, an increase in household size decreases the likelihood of food insecurity. The result may seem counter intuitive at first, but is quite plausible. A large number of these low income slum households are self-employed where all family members, including children and seniors work as unpaid family members. A large household size in that sense contributes to total income of the household. As Ravallion and Lanjaouw (1995, p.21) argue, larger households in developing economies tend to have more children who may achieve a given level of welfare at lower cost. Besides, as the number increases, economies of size may play a role and the proportionate increase in food costs may decline which would free more resources for the households, leading to a decrease in the probability of being food insecure.

Consistent with theoretical expectations (Barrette, 2002), asset ownership is a significant predictor of food security status in these urban slum households. Asset poverty is one of the six structural threats to food security as identified by Barrette (2002), since it makes a household more vulnerable to poverty and food insecurity by adversely affecting its ability to smooth consumption. This is true of both tangible fixed assets like shelter and durable assets like refrigerator or television. The result is consistent with the recent focus on poverty reduction through social protection, which highlights the concept of sustainable livelihood undergoing a shift in focus from income and consumption, to directly address the critical roles that assets and capabilities play in improving well-being (Carney, 1998). The adverse effect of asset poverty might be particularly prominent in case of urban households, because in face of a sudden shock like job loss and price rise, the urban poor are likely to suffer more being net food purchasers and due to weaker safety net in cities. One of the arguments advanced in favour of the view that assets can help reduce poverty is that asset-ownership yields an independent “asset-effect” which urges individuals to save more and act in a more responsible manner (Gamble and Prabhakar, 2005).

As for education of household head, the finding that higher educational level generally increases the chances of a household being food secure, reflect the fact that in urban areas education and its attendant skills are associated with improved employment prospects and earning capacity. In terms of Kolkata sample, the current findings are consistent with Gupta et al. (2009) which states that more than 50% of poor households (hence likely to be food insecure) in Kolkata slums were headed by persons with no education, in 2005-06. The findings also reflect those of Benson (2007) who, while researching in the slum areas of urban Bangladesh, found that most food secure households were headed by a literate head who, in most cases, had attained more than eight years of education.

Home ownership status has a weak influence on food security status for the ICMR specification and no impact for the NSSO specification of calorie intake. Theoretically, dwelling is a productive asset which is likely to have a positive effect on food security status since it imparts an ability to maintain consumption against adverse circumstances. However, with respect to the age-old Kolkata slum dwellers, home ownership status seems to be driven more by historical factors rather than by economic factors. In majority of cases the home owners in slums do not have property rights which do not allow them to enjoy the economic benefit associated with an increase in asset price. Undocumented ownership with no legal title also prevents them from applying for mortgage. This implies, the typical advantages associated with home ownership may not be present in the context of the slum dwellers of Kolkata. Moreover, shelters might deteriorate rapidly in city slums which makes dwelling more prone to asset depreciation in this particular setting, reducing its value as an asset relatively faster compared to that in other settings.

Gender of household head is significant for the NSSO specification alone. As mentioned previously, this particular outcome might be the consequence of specification of calorie intake in terms of adult equivalence scale which takes account of gender and age composition of the household in determining the average household calorie intake. Theoretically, it is consistent with the literature on ‘feminization of poverty’ which emphasizes that female headed households are likely to be poorer and hence more food insecure compared to male headed households (Sen, 1990; Fukuda-Parr, 1999; Fuwa, 2001; Mallick and Rafi, 2010). For women, food insecurity particularly causes health damage, increasing health expenditure and loss of productivity resulting in vicious cycle of poverty and low income (Barrett, 2002).

Similar results hold for the household composition variables which influence food security status for the NSSO specification alone and hence seem to be the result of use of equivalized scales again. An increase in the share of working age adults decreases the likelihood of food security which is understandable because a larger share of working age adults in the household implies less dependency burden, hence greater earning capacity for the household, which will have implications for food security as well. There are enough evidences in the literature, of such of effects of household composition on poverty and food security (Chung et al, 1997; Baulch and McCulloh, 2002; Tawodzera, 2011).

However, what is less obvious is why an increase in the share of kids is likely to decrease the likelihood of food insecurity for a household. It may point out to the notion that having more kids act as an economic asset to poor households, where a family may send the children to labor market when the family's income from non-child labor drops to very low level (Basu and Van, 1998).[27]

The results in the present study are somewhat sensitive to specification of calorie intake – as to whether it is expressed in per capita terms or household equalized scales. The adjusted predictions vary across the two specifications and as for marginal effects, for some of the variables, not only the significance but sometimes magnitude of effect is different across the two specifications. To examine the issue more closely a larger sample and panel data might be more informative.

However, qualitatively the results for the two calorie specifications are similar as they do not affect the main conclusions regarding the alignment between the experiential indicator and the calorie-based indicators in the same direction, and the usefulness of the existing econometric models in providing a framework for predicting food security status and food security scale score of households, along with identifying the determinants of experiential food security which in the ultimate analysis reflects households' economic access to food.

6 Conclusion

In harmony with the multidimensional nature of the concept of food security, the latest mandate in food security research emphasizes on identifying appropriate indicators in accordance with the relevant dimension of food security one is trying to measure and in understanding the threats to food security, so that policy makers can initiate timely and relevant actions to combat food insecurity. This has enhanced the significance of survey-based research which would generate context-specific information because food security is best understood using micro level data – household if not individual.

Consistent with the above thoughts, this paper focused on examining the association between two alternative indicators of measuring access to food – traditional calorie-based indicator which provides objective data and the recently developed experiential indicators which are supposed to incorporate psychological dimensions into measurement of food insecurity. In modelling the relationship between the two indicators, it also identifies the determinants of experience-based food insecurity and provides a simple mechanism to predict a household's

[27] Basu and Van (1998) call this 'luxury effect' in their model on child labor.

food security status and food security scale score, given its associated socio-demographic and economic characteristics. The entire exercise is based on the information collected from a survey of 500 randomly selected households in the slums of Kolkata, India. The experience-based indicator of food security was constructed following the US HFSSM.

The paper has a strong policy focus. First, it establishes the association between calorie-based indicators and experience-based indicators of access to food which is not always obvious because food insecurity and calorie adequacy may not be the same. This result is important in two ways. First, it establishes the nutritional relevance of the experience-based indicator which may further enhance its acceptance as a tool to measure food insecurity. Second, specifically in the context of India, since self-reported hunger and calorie based measures are moving in opposite directions in the country, it raises a concern regarding targeting because if the two indicators of food access identify different groups of households as food insecure, social protection policies like food subsidies or income transfers might be misdirected resulting in errors of wrong exclusion. This becomes particularly relevant in the context of the recently passed National Food Security Bill which adopts a right-based approach to providing food subsidies to millions of hungry Indians, imposing a huge financial commitment on part of the government.

Second, provided the socio-demographic and economic characteristics associated with a large predicted probability of food insecurity or predicted value of food security score are known, simply on the basis of collecting information on those specific characteristics, a policy maker can identify 'at risk' households.

Third, we have also attempted to identify the most binding constraints to enhancement of food security in these urban slum households. As 'idiosyncratic' causes of household food insecurity we come upon, paucity of assets, lack of education, female-headship of household head and lower share of working age adults in the household. Large households as well as a larger share of kids in the household have been identified as exerting positive impact on household food security status but the policy implication of these results is not clear at this stage – a larger and more representative sample might bring out the implications more clearly. In general, the findings are consistent with the recent dictate in poverty-reduction policies which emphasises on social protection policies that aim at long term risk prevention strategies as means to promote poverty-alleviation.

The main limitation of the study is its small sample size and cross section focus – to obtain greater reliability in results a large sample size is needed. Moreover, reporting bias and other standard concerns associated with subjective assessment, may be present in our case too. Given the fact that our study sample was low income urban slum households in Kolkata, to what extent the results can be generalized in the context of the broader setting of urban India also remains a question. We recommend further development of this experiential measure of food security so that the interrelationships among various food security indicators can be tested more reliably. Given the scope of the present analysis we suggest the above exercises as issues which future research can address.

The objectives and conclusions of the paper are aligned with the post-2015 vision of a world where development would be sustainable (UN, 2013). As a starting point of this journey to a more sustainable and peaceful world, some of the goals and targets recommended in the roadmap suggested by the UN expert panel include eradicating poverty, ensuring food security and global nutrition, achieving gender equality, providing quality education and lifelong learning, which broadly get reflected in the findings from the present study. It's high time we embrace this philosophy of inclusive growth which would allow us to envisage "a world in 2030 where extreme poverty and hunger have been ended……a world where the principles of equity, sustainability, solidarity, respect for human rights and shared responsibilities in accordance with respective capabilities, has been brought to life by our common action" (UN, 2013, p. 27).

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Tables and Figures

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Table 1: Average Intake of Nutrients and Selected Food Items and Food Adequacy by Food Security Status (with respect to ICMR norms), Kolkata, 2010-11.

Average Consumption Nutrient/Food Items	Food Security Status		Difference in Average Consumption	Adequacy		
	Food Secure (N=422)	Food Insecure (N=77)	t-statistic	Food Secure	Food Insecure	ICMR Norm[a]
Calorie (kcal per person per day)	1968.70	1370.40	8.61	0.94	0.65	2100
Fat (gm. per person per day)	47.16	20.96	4.43	0.92	0.41	51.1
protein (gm. per person per day)	55.61	33.72	9.50	1.08	0.66	51.3
Cereals (gm. per person per day)	286.41	239.58	3.48	0.68	0.57	420
Vegetables (gm per person per day)	276.05	201.75	5.11	2.21	1.61	125
Fish (gm per person per day)	32.48	13.74	4.97	1.30	0.55	25
Meat (gm per person per day)	27.58	10.36	4.57	1.10	0.41	25
Milk (gm per person per day)	89.47	27.56	5.10	0.60	0.18	150
Oil (gm per person per day)	23.98	14.77	5.43	1.09	0.67	22

Note: [a] Based on the recommendations of the Expert Group, Indian Council of Medical Research (ICMR, 1988). ICMR norms reported from MSSRF (2002).

Table 2: Cross Tabulation of Households by Food Security Status and Undernouridshment Status (ICMR specification), Kolkata, 2010-11.

	Highly food secure ($0 \leq$ raw score <3)	Marginally Food Secure ($3 \geq$ raw score <5	Food Insecure (raw score ≥ 5)	Total
Well-nourished (>=2100 kcal)[a]	172 (45.14)	12(29.27)	7(9.09)	182(38.28)
Undernourished (<2100 kcal)	209 (54.86)	29 (70.73)	70 (90.91)	317(63.53)
Total	381(100)	41(100)	77(100)	499(100)

Polychoric rho: 0.49 (.063); Pearson G2 = 2.49, P(chi2(1) < .12); LR X2 = 2.60, P (chi2(1) < .11)

Note: N=499, because in constructing the food security scale, 1 observation was deleted for missing value. Figures in parenthesis represent column percentage. [a]The calorie threshold of 2100 kcal per capita per day, for an average urban Indian, was recommended by the Indian Council of Medical Research (ICMR, 1988).

Table 3: Cross Tabulation of Households by Food Security Status and Undernouridshment Status (NSSO specification), Kolkata, 2010-11.

	Highly food secure (0≤ raw score <3)	Marginally Food Secure (3≥ raw score <5	Food Insecure (raw score ≥5)	Total
Well-nourished (>=2700 kcal)[a]	105 (27.56)	9 (21.95)	5 (6.49)	119 (23.85)
Undernourished (<2700 kcal)	276 (72.44)	32 (78.05)	72 (93.51)	380 (76.15)
Total	381(100)	41(100)	77(100)	499(100)

Polychoric rho: 0.35 (.076), Pearson G2 = 2.75, P (chi2(1) < .097), LR X2 = 2.95, P (chi2(1) < .09)

Note: N=499, because in constructing the food security scale, 1 observation was deleted for missing value. Figures in parenthesis represent column percentage. [a]The calorie threshold of 2700 kcal per capita per day, for an average urban Indian, is recommended by the National sample Survey Organisation (NSSO, 2001).

Table 4: Cross Tabulation of Households by Food Security Status and Undernouridshment Status (FAO specification), Kolkata, 2010-11.

	Highly food secure (0≤ raw score <3)	Marginally Food Secure (3≥ raw score <5	Food Insecure (raw score ≥5)	Total
Well-nourished (>=1820 kcal)[a]	213 (55.91)	16 (39.02)	9 (11.69)	238
Undernourished (<1820 kcal)	168(44.01)	25(60.98)	68(88.31)	261
Total	381(100)	41(100)	77(100)	499

Polychoric rho: 0.53 (.057); Pearson G2 = 3.85, P(chi2(1) < .05); LR X2 = 3.99, P (chi2(1)) <.045)

Note: N=499, because in constructing the food security scale, 1 observation was deleted for missing value. Figures in parenthesis represent column percentage. [a]This calorie threshold of 1820 kcal per capita per day, for an average urban Indian person, is recommended by the FAO (von Grebmer et al., 2008).

Table 5: Selected Socio-Demographic Characteristics of Food Insecure and Undernourished Households, Kolkata Slums, 2010-11.

	Food Insecure (raw score ≥ 5)	Undernourished
Monthly per capita expenditure (MPCE) (Rs.)	880.14	1256.44
Poor (MPCE < Rs.856.28)[a]	0.53	0.21
No durable asset or only fan	0.43	0.14
At least one asset other than fan[b]	0.57	0.86
Casual labour	0.48	0.25
Others (self-employed, regular salaried and others)	0.52	0.75
Female headed	0.31	0.19
Illiterate	0.57	0.36
Primary-Middle	0.40	0.57
Graduate & above	0.03	0.07
Home Owner	0.32	0.36
Rented/ encroached	0.68	0.64
Households with depratio[c]>1	0.24	0.23

Note: [a]Poverty line expenditure for Kolkata, 2010-11, was determined by updating the poverty line expenditure for urban West Bengal, 2004-05, using the Consumer Price index for urban Industrial Workers (base 2001). [b]Household durable assets other than fan include refrigerator, TV black and white, TV colour, bicycle, mobile phone and car.
[c] Dependency ratio is the ratio of dependents, ie. people younger than 15 or older than 64, to the working-age population (those aged 15-64) (World Bank, 2014).

Table 6: Summary Statistics of Variables, IV-Oprobit Model, Kolkata, 2010-11.

Variables	Definition	Mean
FI	=0 if household highly food secure	0.76
	=1 if household marginally food secure	0.08
	=2 if household food insecure	0.16
pckclf	Adjusted calorie intake (per capita per day)	1876.37(600.24)
pckclu	Adjusted calorie intake (per consumer unit per day)	2296.15 (871.90)
MPCE	Monthly per capita expenditure (Rs.)	1629.92 (865.16)
lnhhsize	Logarithm of household size	1.37 (0.54)
hage	Age of household head (years)	47.86 (13.77)
asset[a]	=1 if no durable asset or only fan, 0 otherwise	0.13
genderh	=1 if female, else 0	0.19
dwelling	=1 if owns home else 0 (hired or encroached)	0.33
relig0	Omitted base group household belongs to Hinduism	0.52
relig1	Equals 1 if household belongs to Islam, else 0	0.44
relig2	Equals 1 if household belongs to 'Christianity or Others' else 0	0.04
headlit0	Omitted base group household head lliterate/ below primary level education	0.33
headlit1	=1 if household head has primary to middle level education, 0 otherwise	0.58
headlit2	=1 if household head is graduate and above, 0 otherwise	0.09
kids	Omitted base group share of kids (1-14 years) in the household	0.18(0.20)
workadult	Share of working age adults (15-64 years) in the households	0.75(0.23)
senior	Share of seniors aged 65 years and above	0.07(0.16)
hhtype	=1 if casual labor household, else 0	0.22
lncrowd	Logarithm of number of room available for sleeping per capita	-1.13 (0.57)

Notes: Total number of households: 499. Standard Errors in parenthesis reported for continuous variables only. [a]Durable assets other than fan include TV black and white, TV colour, mobile phone, refrigerator, motorbike, bicycle and car.

Table 7: Results of IV-Ordered Probit Model, Kolkata, 2010-11.

Variables	Coefficient (S.E.)	Coefficient (S.E)
Index Function for Food Security Status		
	ICMR (Per Capita Per Day)	NSSO (Per Consumer Unit Per Day)
Calorie intake	-0.002***	-0.001***
	(0.000)	(0.000)
Ownership of durable assets	0.491***	0.418**
	(0.141)	(0.136)
Logarithm of household size	-0.826***	-0.749***
	(0.132)	(0.118)
Age of household head	-0.002***	0
	(0.006)	(0.005)
Household head has primary to middle level education	-0.228*	-0.116
	(0.127)	(0.116)
Household is graduate or above	-0.878**	-0.582**
	(0.274)	(0.256)
Household is female headed	0.193	0.432**
	(0.149)	(0.160)
Household belongs to Islam	0.076	0.071
	(0.116)	(0.111)
Household belongs to Christianity and other religions	-0.427	-0.417
	(0.434)	(0.391)
Home ownership status	-0.233*	-0.094
	(0.117)	(0.099)
Share of kids in the household	-0.384	-1.262**
	(0.545)	(0.576)
Share of working age adults in the household	-0.103	-1.498**
	(0.444)	(0.554)
cut_1_1	-4.952***	-5.065***
	(0.643)	(0.858)
cut_1_2	-4.679***	-5.065***
	(0.642)	(0.858)
atanhrho_12	1.185***	1.334***
	(0.189)	(0.240)
rho_12	.830	.870
	(.049)	(.058)
N= 499.		
Log likelihood :	-3969.87	-4184.22

Note: One household was dropped in constructing the food security scale. Robust standard errors reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Instrument : Logarithm of number of rooms available per capita (*lncrowd*). Instrumented variable: per capita (per consumer unit) calorie intake per day. Results of calorie equation not reported here. For the calorie equation, *lncrowd* is significant at 5% level for both specifications of calorie intake. IV-Oprobit estimation in Stata does not include a constant term in the food security equation and hence report two cut-offs.

Table 8: Adjusted Prediction at Mean (APM) and Adjusted Prediction at Representative Value (APR) of Food Security Status: ICMR specification, Kolkata, 2010-11.

	Highly Food Secure	Marginally Food Secure	Food Insecure
APM	.757	.0769	.166
	(.028)	(.013)	(.030)
APR for Benchmark Male Headed Household	.849	.055	.097
	(.030)	(.012)	(.025)
Female Headed Household	.799	.067	.133
	(.045)	(.017)	(.038)
APR for Benchmark Female Headed Household	.521	.107	.372
	(.098)	(.024)	(.085)

Note: Standard errors in parenthesis. All estimates significant at 1% level of significance.

Table 9: Adjusted Prediction at Mean (APM) and Adjusted Prediction at Representative Value (APR) of Food Security Status: NSSO specification, Kolkata, 2010-11.

	Highly Food Secure	Marginally Food Secure	Food Insecure
APM	.723	.0729	.198
	(.042)	(.013)	(.047)
APR for Benchmark Male Headed Household	.689	.078	.231
	(0.039)	(.015)	(.058)
Female Headed Household	.525	.093	.381
	(.059)	(.023)	(.059)
APR for Benchmark Female Headed Household	.449	.0949	.457
	(.089)	(.023)	(.080)

Note: Standard errors in parenthesis. All estimates significant at 1% level of significance.

Table 10: Marginal Effects at Mean Value of Covariates, IV-Oprobit Model, Kolkata, 2010-11.

	MEM	S.E.	MEM	S. E.
Highly Food Secure (F=0)				
	ICMR (Per Capita Per Day)		NSSO (Per Consumer Unit Per Day)	
Calorie intake	0.001***	0.000	0.0005***	0.000
Ownership of durable assets	-0.154***	0.041	-0.139***	0.040
Logarithm of household size	0.259***	0.045	0.248***	0.045
Age of household head	0.001	0.002	0.000	0.002
Household head has primary to middle level education	0.071*	0.039	0.038	0.038
Household is graduate or above	0.275***	0.082	0.193**	0.080
Gender of household head	-0.060	0.046	-0.143***	0.047
Household belongs to Islam	-0.024	0.037	-0.023	0.036
Household belongs to Christianity and others	0.134	0.134	0.138	0.128
Home ownership status	0.073**	0.036	0.031	0.033
Share of kids in the household	0.120	0.171	0.418**	0.183
Share of working age adults in the household	0.032	0.139	0.497***	0.168
Calorie intake	0.000***	0.000	-0.00008**	0.000
Ownership of durable assets	0.031**	0.013	0.022*	0.013
Logarithm of household size	-0.053***	0.013	-0.040***	0.013
Age of household head	0.000	0.000	0.000	0.000
Household head has primary to middle level education	-0.014	0.009	-0.006	0.007
Household is graduate or above	-0.056**	0.025	-0.031	0.020
Gender of household head	0.012	0.010	0.023*	0.014
Household belongs to Islam	0.005	0.007	0.004	0.006
Household belongs to Christianity and others	-0.027	0.024	-0.022	0.023
Home ownership status	-0.015*	0.009	-0.005	0.006
Share of kids in the household	-0.024	0.031	-0.067	0.042
Share of working age adults in the household	-0.007	0.024	-0.079*	0.047
Food Insecure (F=2)				
Calorie intake	-0.001***	0.000	-0.0004***	0.000
Ownership of durable assets	0.122***	0.031	0.117***	0.031
Logarithm of household size	-0.206***	0.044	-0.209***	0.047
Age of household head	-0.001	0.001	0.000	0.001
Household head has primary to middle level education	-0.057*	0.031	-0.032	0.031
Household is graduate or above	-0.219***	0.064	-0.162**	0.066
Gender of household head	0.048	0.036	0.120***	0.037
Household belongs to Islam	0.019	0.029	0.020	0.030
Household belongs to Christianity and other s	-0.107	0.106	-0.116	0.107
Home ownership status	-0.058**	0.029	-0.026	0.028
Share of kids in the household	-0.096	0.137	-0.352**	0.151
Share of working age adults in the household	-0.026	0.110	-0.418***	0.133

Note: One household was dropped in constructing the food security scale. *** p<0.01, ** p<0.05, * p<0.1. See Greene (2008, pp. 783-785) for discussion on standard errors using delta methods.

Table 11: Marginal Effects for Benchmark Male Headed Household, at Representative Value, IV-Oprobit Model, Kolkata, 2010-11.

	MER	S. E.	MER	S. E.
Highly Food Secure (F=0)				
	ICMR (Per Capita Per Day)		NSSO (Per Consumer Unit Per Day)	
Calorie intake	0.001***	0.000	0.001***	0.000
Ownership of durable assets	-0.115***	0.035	-0.148***	0.044
Logarithm of household size	0.194***	0.037	0.264***	0.046
Age of household head	0.001	0.001	0.000	0.002
Household head has primary to middle level education	0.053*	0.028	0.041	0.040
Household is graduate or above	0.206***	0.067	0.205**	0.088
Gender of household head	-0.045	0.034	-0.153***	0.051
Household belongs to Islam	-0.018	0.027	-0.025	0.038
Household belongs to Christianity and other religions	0.100	0.102	0.147	0.137
Home ownership status	0.055*	0.030	0.033	0.036
Share of kids in the household	0.090	0.133	0.445**	0.205
Share of working age adults in the household	0.024	0.105	0.529***	0.192
Marginally Food Secure (FI=1)				
Calorie intake	-0.000***	0.000	-.00007***	0.000
Ownership of durable assets	0.031**	0.013	0.020	0.013
Logarithm of household size	-0.053***	0.011	-0.036**	0.014
Age of household head	0.000	0.000	0.000	0.000
Household head has primary to middle level education	-0.015	0.009	-0.006	0.007
Household is graduate or above	-0.056**	0.023	-0.028	0.019
Gender of household head	0.012	0.010	0.021	0.014
Household belongs to Islam	0.005	0.007	0.003	0.006
Household belongs to Christianity and others	-0.027	0.029	-0.020	0.021
Home ownership status	-0.015*	0.008	-0.005	0.005
Share of kids in the household	-0.025	0.036	-0.061	0.039
Share of working age adults in the household	-0.007	0.029	-0.072	0.045
Food Insecure (F=2)				
Calorie intake	-0.0003***	0.000	0.000***	0.000
Ownership of durable assets	0.084***	0.025	0.128***	0.036
Logarithm of household size	-0.141***	0.034	-0.228***	0.049
Age of household head	0.000	0.001	0.000	0.002
Household head has primary to middle level education	-0.039*	0.020	-0.035	0.033
Household is graduate or above	-0.150**	0.050	-0.177	0.075
Gender of household head	0.033	0.024	0.132**	0.041
Household belongs to Islam	0.013	0.019	0.022***	0.032
Household belongs to Christianity and other religions	-0.073	0.074	-0.127	0.118
Home ownership status	-0.040*	0.022	-0.029	0.031
Share of kids in the household	-0.066	0.098	-0.385**	0.178
Share of working age adults in the household)	-0.018	0.077	-0.457***	0.163

Note: One household was dropped in constructing the food security scale. *** p<0.01, ** p<0.05, * p<0.1. See Greene (2008, pp. 783-785) for discussion on standard errors using delta methods.

Table 12: Marginal Effects for Benchmark Female Headed Household, at Representative Value, IV-Oprobit Model, Kolkata, 2010-11.

	MER	S.E.	MER	S.E.
Highly Food Secure (F=0)				
	ICMR (Per Capita Per Day)		NSSO (Per Consumer Unit Per Day)	
Calorie intake	0.001***	0.000	0.001***	0.000
Ownership of durable assets	-0.195***	0.058	-0.166***	0.051
Logarithm of household size	0.329***	0.051	0.296***	0.049
Age of household head	0.001	0.002	0.000	0.002
Household head has primary to middle level education	0.091*	0.051	0.046	0.045
Household is graduate or above	0.350***	0.110	0.230**	0.099
Gender of household head	-0.077	0.060	-0.171***	0.060
Household belongs to Islam	-0.030	0.046	-0.028	0.044
Household belongs to Christianity and others	0.170	0.173	0.165	0.154
Home ownership status	0.093**	0.047	0.037	0.039
Share of kids in the household	0.153	0.218	0.499**	0.222
Share of working age adults in the household	0.041	0.177	0.593***	0.209
Marginally Food Secure (FI=1)				
Calorie intake	0.000	0.000	0.000	0.000
Ownership of durable assets	0.010	0.010	-0.000	0.009
Logarithm of household size	-0.017	0.020	0.001	0.015
Age of household head	0.000	0.000	-0.000	0.000
Household head has primary to middle level education	-0.005	0.005	0.000	0.002
Household is graduate or above	-0.018	0.020	0.001	0.012
Gender of household head	0.004	0.004	-0.000	0.009
Household belongs to Islam	0.002	0.003	-0.000	0.001
Household belongs to Christianity and other	-0.009	0.012	0.000	0.009
Home ownership status	-0.005	0.006	0.000	0.002
Share of kids in the household	-0.008	0.012	0.001	0.026
Share of working age adults in the household)	-0.002	0.008	0.001	0.031
Food Insecure (FI=2)				
Calorie intake	-0.001***	0.000	-0.001***	0.000
Ownership of durable assets	0.186***	0.062	0.166***	0.056
Logarithm of household size	-0.312***	0.048	-0.297***	0.046
Age of household head	-0.001	0.002	0.000	0.002
Household head has primary to middle level education	-0.086*	0.050	-0.046	0.047
Household is graduate or above	-0.332***	0.110	-0.231**	0.103
Gender of household head	0.073	0.060	0.171***	0.065
Household belongs to Islam	0.029	0.043	0.028	0.044
Household belongs to Christianity and other	-0.161	0.167	-0.165	0.156
Home ownership status	-0.088*	0.045	-0.037	0.039
Share of kids in the household	-0.145	0.210	-0.500**	0.233
Share of working age adults in the household	-0.039	0.169	-0.594***	0.227

Note: One household was dropped in constructing the food security scale. *** p<0.01, ** p<0.05, * p<0.1. See Greene (2008, pp. 783-785) for discussion on standard errors using delta methods.

Table 13: Results of Linear IV Regression of Calorie Intake on Food Security Score, Kolkata, 2010-11.

Dependent Variable: Food Security Scale Score	ICMR (Per Capita Per Day)	NSSO (Per Consumer Unit Per Day)
	Robust Coefficient (S. E.)	Robust Coefficient (S. E.)
Calorie intake	-0.003*** (0.001)	-0.002*** (0.001)
Ownership of durable assets	1.296*** (0.358)	1.145*** (0.395)
Logarithm of household size	-1.169*** (0.344)	-1.295*** (0.398)
Age of household head	-0.005 (0.007)	-0.001 (0.008)
Household head has primary to middle level education	-0.577** (0.221)	-0.439* (0.232)
Household is graduate or above	-0.874** (0.310)	-0.619* (0.351)
Household is female headed	0.365 (0.248)	0.766*** (0.271)
Household belongs to Islam	0.069 (0.183)	0.076 (0.199)
Household belongs to Christianity and other religions	-0.241 (0.540)	-0.285 (0.554)
Home ownership status	-0.227 (0.173)	-0.073 (0.177)
Share of kids in the household	-0.228 (0.890)	-1.718 (1.144)
Share of working age adults in the household	-0.494 (0.700)	-2.621*** (0.929)
Constant	9.475*** (1.726)	11.038*** (2.134)
R^2	0.175	0.021
N	499	499

Note: Regressor tested: per capita calorie intake per day. Instrument: logarithm of number of rooms available per capita. The set of other covariates used in estimating the calorie equation are monthly per capita expenditure (MPCE), household size, age, gender, religion and education level of household head, household's employment status (whether a casual labor household), household composition represented by share of working age adults and kids in the household. Robust standard error reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 14: Predicted Value of Food Security Score on the Kolkata Food Security Scale: at Mean and at Representative Value.

	ICMR (Calorie Intake Per Capita Per day)	NSSO (Calorie Intake Per Consumer Unit Per Day)
APM	1.89	1.88
	(.082)	(.090)
APR for Benchmark Male Headed Household	1.24	1.82
	(.172)	(0.212)
Female Headed Household	1.61	2.59
	(.284)	(0.325)
APR for Benchmark Female Headed Household	3.60	3.85
	(.508)	(0.595)

Note: All estimates significant at 1% level of significance.

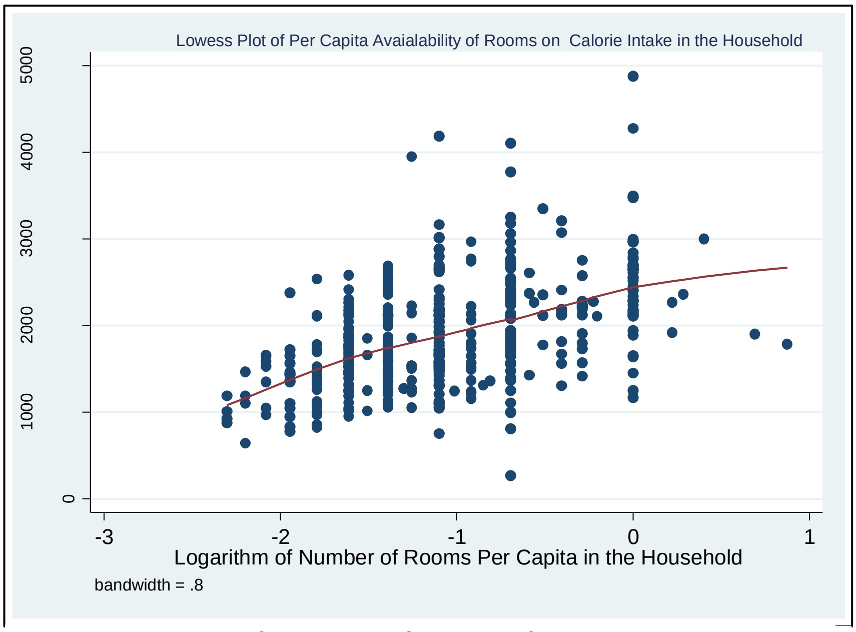

Figure 3: Lowess Plot of Logarithm of Number of Rooms per Capita on Calorie Intake (Per Capita Per Day).

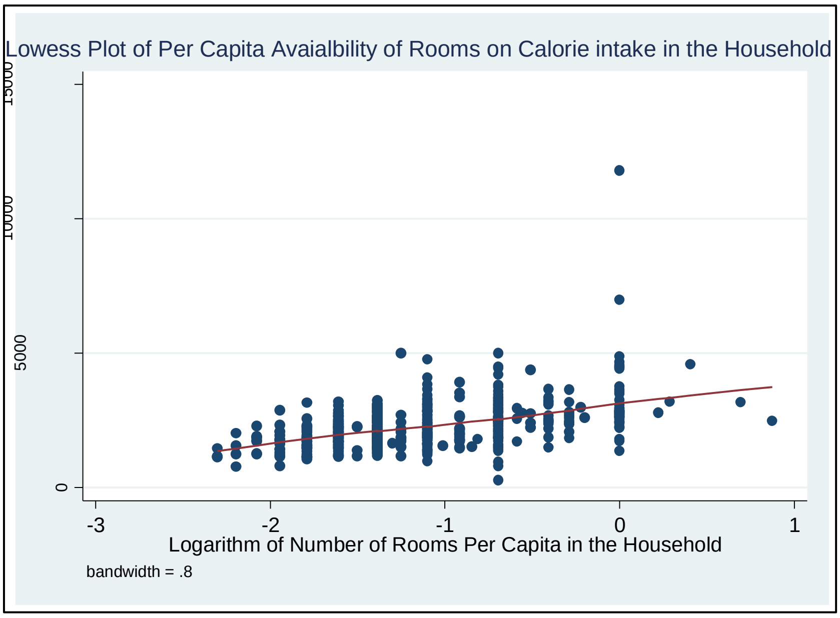

Figure 4: Lowess Plot of Logarithm of Number of Rooms Per Capita on Calorie Intake (Per Consumer Unit Per Day).

Appendix A: Results of Tests of Instrument Validity in Linear IV Model

Table A.1: Instrument validity in Linear IV Model: Regressing Calorie Intake (ICMR) on Food Security Score, Kolkata, 2010-11.

Output from First–stage Regression of Calorie Intake (per capita per day)	
Partial R-squared of excluded instruments:	0.0438
Test of excluded instruments:	
F(1, 486):	26.91
Prob > F	0.0000
Variable	*pckclf*
Shea Partial R2	0.0472
Partial R2	0.0472
F(1, 486)	26.91
P-value	0.0000
Underidentification test[a] (Kleibergen-Paap rk LM statistic):	26.611(p<0.001)
Weak identification test (Kleibergen-Paap rk Wald F statistic):	26.910 (p<0.001)
Stock-Yogo weak ID test critical values[b]: 10% maximal IV size	16.38
15% maximal IV size	8.96
20% maximal IV size	6.66
25% maximal IV size	5.53
Hansen J statistic (overidentification test of all instruments) (equation exactly identified)	0.000
Endogeneity test of endogenous regressors: Robust score chi2(1):	p<0.04

Note: Instrumented variable : calorie intake per capita per day (*pckclf*). Excluded instrument: logarithm of number of rooms available per capita (*lncrowd*) . Included Instruments: asset ownership, household size, education of household head, age of household ahead, gender of household head, religion, homeownership status, share of kids and working age adults in the household. [a]H_o: matrix of reduced form coefficients has rank=K1-1 (underidentified). H_a: matrix has rank=K1 (identified). [b]Source: Stock-Yogo (2005) and Critical values are for Cragg-Donald F statistic and i.i.d. errors.

First, to isolate the explanatory power of *lncrowd* on *pckclf* , two statistics are given . The partial R2 of 0.0438 is that between *pckclf* and *lncrowd* after controlling for the remaining covariates and it is somewhat low. However, the F-statistic for the joint significance of the instruments excluded from the structural model is a test on just *lncrowd* and F=26.91 is considerably larger than the rule-of-thumb value of 10 that is sometimes suggested (Cameron and Trivedi,). This suggests *lncrowd* is not a weak instrument.

Second, if we tolerate distortion for a 5% Wald test based on the IV estimator (2SLS), so that the true size can be at most 10%, then we reject the null hypothesis if the test statistic exceeds 16.38. Using robust standard errors we get critical value of F statistic for 2SLS estimator as 26.91. Hence we are comfortable in rejecting the null hypothesis of weak instrument.

Third, when ivreg2 is invoked with robust option, it reports the LM and Wald versions of the Kleibergen-Paap rk statistic, which is an LM test of whether the equation is identified, i.e., the excluded instruments are relevant. In our case the null hypothesis of underidentification is rejected which indicates that the matrix is full column rank or the model is identified. As a test of weak instrument, we also get robust Kleibergen-Paap Wald rk F statistic and the critical values reported by ivreg2 for the Kleibergen-Paap statistic are the Stock-Yogo critical values for the Cragg-Donald i.i.d. case which in our case is 26.91, greater than critical value of 16.38, again.

Table A.2: Instrument validity in Linear IV Model : Calorie Intake (NSSO) on Food Security Score, Kolkata, 2010-11.

Output from First–stage Regression of Calorie Intake (Per Consumer Unit Per Day)	
Partial R-squared of excluded instruments:	0.0438
Test of excluded instruments:	
F(1, 486)	24.85
Prob > F	0.0000
Variable: *pckclu*	
Shea Partial R2	0.0351
Partial R2	0.0351
F(1, 486)	24.51
P-value	0.0000
Underidentification test[a] (Kleibergen-Paap rk LM statistic) :	25.145 (p<0.001)
Weak identification test (Kleibergen-Paap rk Wald F statistic) :	24.846 (p<0.001)
Stock-Yogo weak ID test critical values[b]: 10% maximal IV size	16.38
15% maximal IV size	8.96
20% maximal IV size	6.66
25% maximal IV size	5.53
Hansen J statistic (overidentification test of all instruments) (equation exactly identified):	P<0.000
Endogeneity test of endogenous regressors: Robust score chi2(1):	p<0.04

Notes: Instrumented variable: calorie intake per capita per consumer unit (*pckclu*). calorie intake per capita per day (*pckclf*). Excluded instrument: logarithm of number of rooms available per capita (*lncrowd*) . Included Instruments: asset ownership, household size, education of household head, age of household ahead, gender of household head, religion, homeownership status, share of kids and working age adults in the household. [a]H_o: matrix of reduced form coefficients has rank=K1-1 (underidentified). H_a: matrix has rank=K1 (identified). [b]Source: Stock-Yogo (2005) and Critical values are for Cragg-Donald F statistic and i.i.d. errors.

Appendix B: Rivers and Vuong Exogeneity Test

Table B.1: Results of Rivers and Voung Exogeneity Test of Calorie Intake on Food Security Status, Kolkata, 2010-11.

Index Equation for Food Security Status		
	Robust Coefficient (S.E)	Robust Coefficient(S.E)
	ICMR	NSSO
Calorie intake	-0.004***	-0.001***
	(0.001)	(0.000)
Ownership of durable assets	0.882***	0.971***
	(0.208)	(0.204)
Logarithm of household size	-1.481***	-0.525**
	(0.286)	(0.167)
Age of household head	-0.005	-0.006
	(0.007)	(0.006)
Household head has primary to middle level education	-0.408**	-0.401**
	(0.152)	(0.153)
Household is graduate or above	-1.590***	-0.952*
	(0.448)	(0.396)
Household is female headed	0.345*	0.624***
	(0.175)	(0.171)
Household belongs to Islam	0.134	-0.051
	(0.167)	(0.149)
Household belongs to Christianity and other	-0.762	-0.769
	(0.572)	(0.608)
Home owner	-0.418**	-0.126
	(0.162)	(0.149)
Share of kids in the household	-0.701	-0.542
	(0.683)	(0.655)
Share of working age adults in the household	-0.179	-1.589**
	(0.544)	(0.548)
Residual[a]	0.004***	0.001*
	(0.001)	(0.000)
cut1	-8.913***	-4.238***
	(1.490)	(0.980)
cut2	-8.426***	-3.805***
	(1.482)	(0.972)
Log pseudolikelihood	-241.84	-263.93
Pseudo R2	0.3073	0.2441
Ordered probit regression number of observations:	499	

Notes: Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. [a]"Residual" is the residual from OLS regression of calorie intake on the excluded instrument 'logarithm of number of rooms available per capita' and the remaining covariates which include monthly per capita expenditure, household size, age, gender, religion and education level of household head, household's employment status (whether a casual labor household), household composition represented by share of working age adults and kids in the household.

Table B.1 reports results of the Rivers and Vuong exogeneity test (Rivers and Vuong, 1988). We explain the methodology, in terms of the results of the ICMR specification, as follows: i) First, calorie intake per capita per day is regressed on the set of household characteristics contained in vector $\boldsymbol{x_{2i}}$, Equation 11 and the instrument z, which is the extent of crowding in the household represented by 'number rooms available per capita' in logarithmic form; (ii) Next, the residual from the above equation is saved as "*r*", reported as "*residual*" in Table B.1*)*; and (iii) finally the ordered probit equation for food security status is estimated regressing the former on "*residual*" and the remaining household characteristics included in vector $\boldsymbol{x_{1i}}$ in Equation 12. A simple *t* test of "*residual*" is used as a test of the null hypothesis that food security status and calorie intake are independent. Rejection of the null hypothesis will indicate that these two variables are jointly determined. The co-efficient of "*residual*", in the present model, is significant at 1% level which gives evidence on the endogeneity of calorie intake.