Measuring maternal autonomy and its effect on child nutrition in rural India

Wiji Arulampalam, Anjor Bhaskar and Nisha Srivastava

March 2023   No: 1455

Warwick Economics Research Papers

Measuring maternal autonomy and its effect on child nutrition in rural India

Wiji Arulampalam[*], Anjor Bhaskar[**] and Nisha Srivastava[***]

March 2023

[*]Corresponding author: Department of Economics, University of Warwick, Coventry, CV4 7AL, UK. Email: wiji.arulampalam@warwick.ac.uk. Tel: +44 (0)2476523471

[**]Azim Premji University, Bangalore, India. Email: anjorbhaskar@gmail.com

[***] Institute for Human Development, Delhi, India. nisha2000@ gmail.com

<u>Abstract</u>

We examine the link between a mother's autonomy - the freedom and ability to think, express, make decisions, and act, independently - and the nutritional status of her children. We design a novel statistical framework that accounts for the cultural and traditional environment to create a measure of maternal autonomy treating this as a latent characteristic that is fixed in the short term. Using data from India, we deal with two econometric challenges: (i) creation and measurement of the 'autonomy' index, and (ii) endogeneity caused by selection due to son preference. We find: (i) one standard deviation (SD) higher autonomy score is associated with a 0.16 SD higher Height-for-Age Z-scores (HAZ); and an (ii)10% lower prevalence of stunting (HAZ <-2 SD). The latter is equivalent to the prevention of approximately 300,000 children from stunting, indicating the important role of maternal autonomy.

Keywords: *Child Nutrition; Latent Factor Models; Maternal Autonomy; Endogenous selection; Son preference.*

JEL Classification: I15, I14, C38

1. <u>Introduction</u>

In addition to playing a pivotal role in increasing childhood mortality, poor nutrition in childhood causes irreversible damage to cognitive development and future health (Dreze, (2004), Sumner, *et al.,* (2009); Saxena, (2018); Victora, *et al*., (2008)).   Child undernutrition is also strongly associated with shorter adult height, less schooling, reduced economic productivity, lower adult body-mass index, and mental illness (see Victora, *et al*., (2008) for a systematic review). Thus, the importance of good nutrition during childhood cannot be emphasised enough. Recognising this, the Government of India introduced the Integrated Child Development Services (ICDS) Scheme as far back as 1975 in select blocks (administrative units) in the country. The scheme was eventually expanded to all administrative blocks in the country. In 2014-2015, the Government of India had budgeted nearly Rs. 181.95 billion to run the scheme through its 1.346 million Anganwadi (Mother and Child Care) Centres across all villages and towns of India.[1] These Centres provide a vast range of health and nutrition services to children, adolescents, and pregnant and lactating women. Yet, despite the massive spread of the policy and the huge investments in it, child undernutrition has been stubbornly high in India. India contributes to 1/3rd of the global burden of childhood stunting (a measure of chronic undernutrition).[2]

Given the importance of proper child nutrition and the persistence of high levels of undernutrition in India, various studies in recent decades have attempted to understand the proximate and underlying factors relevant to child nutrition. These studies have

---

[1] Data obtained from the website of the Ministry of Women and Child Development, Government of India (http://icds-wcd.nic.in/icds.aspx) – accessed 09 March 2023.

[2] https://www.unicef.org/india/what-we-do/stop-stunting accessed 10th March 2023.

helped identify various factors which are crucial for child nutrition (exclusive breastfeeding in the first 6 months, maternal health etc.) and have also contributed to policymaking. The focus of this paper, however, is on one factor whose relationship with nutrition is less understood in the literature - the role of maternal autonomy. In doing so, we need to overcome two important econometric challenges, which we discuss next.

The first challenge is how to define and measure autonomy. The term autonomy has often been confused with empowerment, though the latter is a process and the former the outcome (at least partly) of the process. We specifically focus on the outcome. Many different definitions and measurements exist in the literature. One strand of the literature assumes that 'autonomy' is a directly observed trait and measures it using an arithmetic average of binary answers to a set of questions that are elicited by surveys (Jensen and Oster, (2009), Paul and Saha (2022)), or the answers to these questions directly in the equation (Dancer and Rammohan (2009), Imal, et al. (2014)).[3][4][5] Another strand of the literature uses definable and easily measurable variables such as education and health (for example, see Imai, et al (2014)) as proxies for autonomy. In the same vein, Chilinda and Wahlqvist, *et al.,* (2021) use a composite score to capture decision-making power, tolerance of domestic violence, and financial independence as a proxy for maternal autonomy. Yet another strand of the literature, which is more related to what we do,

---

[3] Some but not all, of the questions that are used by Jensen and Oster (2009), are similar to the ones we use in this study although the surveys are different. In contrast to our approach, the authors use Autonomy as an *observable* variable and measure it using the average of answers given to six questions/measurements with some overlap with our measures. Unlike our method, all answers were equally weighted in the construction of the index. Also, see the replication study by Iversen and Palmer-Jones (2014) and the response by Jensen and Oster (2014).

[4] In a recent paper, Paul and Saha (2022) using NFHS-4, define 'autonomy' to be low/medium/high based on the values of the sum of dichotomous variables defined over nine different answers, and find autonomy to be significantly associated with lower odds of malnourished children (see our footnote 10).

[5] This is similar to the literature which assumes test scores measure unobserved ability (see for example, Heckman et al. (2006)).

assumes that the autonomy trait is essentially not observable and the answers to a set of questions (to be listed later), give you some proxy mismeasured information about autonomy, and uses principal component analysis to construct/extract a measure of 'autonomy' (Chakraborty and De (2011)).[6]

In this paper, we build on the last approach (from the ones mentioned above) which assumes that autonomy is an underlying/latent trait which cannot be observed directly (like traits such as confidence or empathy) but expresses itself in how one thinks and acts. We create an index of 'autonomy' based on the following: (i) autonomy *expresses* itself in several ways, such as: having decision-making power; mobility; and command and control over resources; (ii) the enabling factors in exercising autonomy are education, position in the household, closeness to kin, economic status of the woman and her household, access and availability of infrastructure, and norms and attitudes of the larger community; (iii) it is an unobserved trait that is fixed in the short term, and the answers given to the set of questions are *fallible measures* of autonomy. We use Bayesian Shrinkage methods (Goldstein, (2003)) within a latent factor model, to create an index of autonomy accounting for traditional and cultural environments. Our approach, which is new to this literature, allows us to separate the direct associations of maternal and family characteristics in our model for nutrition, from their indirect associations that work through maternal autonomy.

---

[6] The autonomy index *a* is sometimes estimated as the first principal component from the set of measurements (Chakraborty and De (2011)). This is another data dimension reduction technique similar to what we use, and the first component is a linear combination of the observed data (measurements) and this explains the largest variation in the observed measurements. Unlike ours, this measure does not allow socioeconomic variables to play a role in woman's autonomy. Our model estimated using this method produced a coefficient estimate that was smaller than the one from using our method. Results are available on request from the authors.

The second major challenge is how to deal with possible biases due to the endogenous sex composition of children in the sample (Yamaguchi, (1989)). The prevalence of 'son preference' in India can manifest itself in differences in nutritional status (Barcellos et al. (2014) and Jayachandran and Kuziemko (2011)). If a family sex-selects the second and subsequent children by using prenatal sex selection, even the nutritional status of the firstborn will be affected by the presence of subsequent children in this family.[7] To mitigate this bias, our preferred model restricts our analysis to firstborns, and we check for sensitivity of our results to the different age compositions of these children used in the analysis.[8] [9]

Our sample comes from the third round of the National Family Health Survey (NFHS3, 2005-06) (IIPS and Macro International, (2007a)).[10] The survey provides information on the three commonly used anthropometric indicators of the nutritional status of children: Height for Age Z-score (HAZ score), Weight for Height Z-score (WHZ

---

[7] Information on nutritional status of children is usually collected for children born in the last 3 or 5 years of the survey.

[8] For example, Hu and Schlosser (2015) present some indirect evidence of possible pre-natal sex selection in India.

[9] Barcellos et al (2014) use the first round (1992) of the same data source to look at the effect of child sex on parental investments to avoid the issues related to sex selective abortions. Since it is assumed that there is no prenatal sex selection in the early '90s, their concern was regarding families possibly following a male-biased stopping rule. They address this by selecting a sample of last children aged less than 15 months at the time of the interview, assuming that the family has not had time to react to the sex composition of the existing children. For comparison with this set of results, we also provide estimates based on the sample of last-borns.

[10] More recent NFHS surveys (NFHS 4 & 5) only interviewed 15% of the eligible women at the state level for the module on the variables we use in the construction of our autonomy index. Not all the women interviewed would have had a child less than 5 years of age at the time of the interview and thus resulting in a much smaller sample for our analysis (IIPS 2017 and 2021).

score) and Weight for Age Z-score (WAZ score).[11] [12] The survey indicates that 48% of children under 5 years of age in India are chronically malnourished (i.e., stunted); 43% are underweight; and 20% are acutely malnourished (i.e., wasted) (IIPS and Macro International, (2007a, 2007b)). These figures are extremely high since statistically, one would expect about 2-3% of the population of children aged less than five to fall in the range below -2SD.[13]

Our main results indicate that our autonomy index is a positive and significant predictor of better nutrition among rural children.[14] Among the sample of firstborn children aged less than 18 months, the estimated association is positive and significant in the long-term child nutrition (i.e., HAZ score) equation, and negative on the probability of the child being stunted.[15] Based on these magnitudes, a back-of-the-envelope calculation indicates that a one-standard-deviation (SD) higher autonomy score is associated with a 10% lower (0.3 million) number of stunted children among the firstborns (2.1 million) (30.5% to 27.3%).[16] These numbers indicate the important role of

---

[11] The Z scores are the number of standard deviations above or below a set of standard deviation-derived growth reference curves by the Centre for Disease Control obtained from a reference population from the U. S. National Centre for Health Statistics, as recommended by the WHO (2006). The recommendations are based on evidence that differences in "unconstrained growth" across children of different ethnic and racial background, socioeconomic status and feeding, are so minor for children under 5 years of age that it is appropriate to use a common reference.

[12] Children with a HAZ (WHZ, WAZ) score less than -2 std deviation are classified as stunted (wasted, underweight). Each index provides different information about the growth of a child. The HAZ score provides information about long-term nutritional status; it does not vary according to recent dietary intake. The WHZ score is an indicator of current nutritional status; a low WHZ score can indicate recent inadequate food intake, or a recent episode of illness. The WAZ score, which reflects body mass relative to chronological age, is a composite indicator.

[13] Even in the latest NFHS-5 survey (2019-21), the percentage of children under 5 years of age stunted (wasted) is still high at 36% (19%).

[14] 63% of our sample of women reside in an area classified as rural. Since we did not find significant effects of autonomy on nutritional status of urban children, we focus on the results for the rural households.

[15] The results are very similar when we use only the sample of firstborns but born after 2003 where the interviews were held during 2005 and 2006 (see Table 5).

[16] The autonomy index is normalised to have zero mean and unit variance.

maternal autonomy in child nutrition. We do not find any differential effects of autonomy by sex of the child.

The paper is organized as follows: the next section discusses the relevant literature for India. Discussions on the data and sample selected are in Section 3. Section 4 discusses the methodology, while Section 5 provides descriptive statistics. Section 6 presents the main results and addresses the issue of sample selection in the presence of son preference. The paper concludes with Section 7.

2. Overview of the literature

One of the earliest studies by Dyson and Moore (1983) on kinship structures and women's autonomy, defined autonomy as the capacity to obtain information and make decisions about one's private concerns and those of one's intimates. In a similar vein, Safilios-Rothschild (1982) in the context of demographic change in the third world, defines autonomy as 'the ability to influence and control one's personal environment'. The essential elements of autonomy - namely the ability and capacity to make decisions in a way that can influence one's environment - are reflected in other definitions, such as that by Jejeebhoy (2000), according to whom, autonomy is the "extent to which women exert control over their own lives within the families in which they live at a given point of time." As stated by Agarwala and Lynch (2006), "These definitions assert a single construct that captures the multifaceted ability to gain control over the circumstances of one's life."[17]

---

[17] For other definitions, see for example Caldwell (1986) who defines opportunities for women to receive an education and work outside the home to proxy autonomy, while Mason (1986) uses control over household and societal resources to the same purpose.

The nutritional status of a child is strongly related to the characteristics of the mother, as many studies have shown. Mother's education is associated with child survival (Murthi, *et al.,* (1995); Cleland, (2010)), and the nutritional status of a child (Borooah, (2004); Frost, *et al.,* (2005)). Mother's health is also reflected in health outcomes for children. At birth, one-third of Indian infants are underweight, and 20% are stunted because of poor intrauterine growth (Mamidi, *et al.,* (2011); Ramachandran and Gopalan, (2011)). Carlson, *et al.,* (2015), review some of the current literature on the relationship between maternal autonomy, children's nutritional status, and child-feeding practices. The authors conclude that while enhancing maternal autonomy is important for improving children's nutritional status, gaps in the current knowledge exist that are confounded by complexities of how autonomy is measured.

In summary, autonomy has intrinsic relevance for a woman's own well-being and also contributes to enhancing the quality of life for the family. It determines largely her ability to make effective choices and to exercise control over her life. While most studies have looked at readily definable and easily measurable variables to proxy for autonomy, this paper treats 'autonomy' as a latent trait that is fixed in the short-run and only fallible measures of this trait are available to researchers.

3. Data and the sample

The data are from the third round of the National Family Health Survey (NFHS-3) for India, 2005, which is part of the Demographic and Health Survey (DHS). DHS surveys collect extensive information on population, health, and nutrition, with an emphasis on women and young children. In addition, they gather information concerning household decision-making, as well as answers to some questions relating to the "autonomy" status of surveyed women.

The NFHS-3 interviewed over 230,000 women (aged 15-49) and men (aged 15-54) from 29 Indian states, during the period December 2005 to August 2006 (IIPS, 2007a). All children aged less than 60 months and living in the household at the time of the survey, were weighed, and their heights were measured.

We select our sample based on the following criteria: (i) currently married women who are 'usual' residents and living in an area classified as rural; (ii) mothers who had at least one surviving child born in the past 60 months; (iii) had non-missing values for the main variables of interest. We keep our autonomy index fixed over our different sample cuts in the estimations of the nutrition equation. All our estimations account for clustering at the district level.

4. Modelling the main variables of interest

4.1 Nutritional status

We focus on two outcome variables: Height-for-Age Zscore (HAZ) and 'stunted', which indicate long-term nutritional status. 'Stunted' is a binary indicator for HAZ less than -2 according to the WHO definition. All children in the family who were aged less than 60 months at the time of the interview, and who had valid measurements for these variables, form the main sample.

All equations are specified as a linear regression model and estimated by OLS. All reported standard errors are bootstrapped and allow for clustering at the district level.[18]

---

[18] Reported standard errors are bootstrapped to account for the fact that the autonomy measure is a 'generated regressor'. We chose to use a LP model instead of either a logit or a probit because of the generated regressor issue in the specification as it does not make sense to calculate bootstrapped standard errors when the model specification is fully parametric. The average partial effect associated with maternal autonomy in the logit was very similar to the one obtained from OLS.

The equation for the measure of nutritional status y (HAZ and Stunted) for child k of mother i is specified as:

$$y_{ik} = x_{ik}'\beta + z_i'\gamma + \delta a_i + \varepsilon_{ik} \qquad i=1,..,n \quad \text{and} \quad k=1,..,K \qquad (1)$$

x_{ik} contains the child-specific characteristics such as age, and sex, etc. z_i contains the mother, father, and household characteristics, such as levels of education, religion, caste, wealth indexes, etc. a_i is the mother's autonomy trait which we assume to be *unobserved*.

The challenge here is to obtain a consistent estimator of equation (1) coefficients, where the parameter of interest is δ. Endogeneity of some of the covariates in equation (1) can occur if the proxy used for a_i does not capture fully the correlation between the covariates and the error term and thereby leaving some mother-level unobservable (e.g. 'son-preference') in the equation that is still correlated with the regressors. First, we discuss how we proceed with the measurement and the generation of a_i, allowing for social and cultural environments to play a part, and then turn to the issue of how we deal with the endogenous sex composition in the sample (see Introduction).

4.2   *Defining and measuring maternal autonomy*

Based on the literature, we choose the answers given to the following questions in the NFHS as indicative of woman's "*autonomy*" to think, speak, decide, and act independently.[19]

The following responses, categorised in terms of the three dimensions we consider, are all coded as binary indicators.

---

[19] We experimented with many more measurements and found the additional measures did not significantly add to the estimation of the autonomy index. The ranking of mothers in terms of their estimated autonomy status did not change with the addition of other measures.

<u>Related to Physical Autonomy</u>: Woman is allowed to go <u>alone</u> to (i) the to the market (m1), (ii) the health clinic (m2), and (iii) places outside the community (m3).

<u>Related to Decision Making Autonomy</u>: Woman decides <u>alone</u> on purchases for daily needs (m4); Woman decides <u>alone</u> or <u>jointly</u> with her husband on (i) her own health care (m5), (ii) large household purchases (m6), (iii) when they could visit family and friends (m7), and what to do with husband's money (m8).

<u>Responses Related to Economic Autonomy</u>: Woman has money of her own that she can decide how to spend (m9).

A measure of autonomy based on a simple average, masks variations within dimensions across women.[20] We let the data tell us about the importance of the differential role of autonomy on different dimensions. Since all measurements ($j=1,..,9$) are binary, we use a logit model for woman i (conditional on her autonomy trait a_i):

$$\Pr ob(m_{ij} = 1 \mid \eta_i) = \Delta(\mu_j + \lambda_j a_i) \qquad (2)$$

$$\text{and} \quad a_i \sim N(\theta's_i, \sigma_a^2)) \qquad (3)$$

Δ is the logistic distribution function, and μ_j and λ_j are the intercepts and factor loadings respectively, in (2). The enabling factors of autonomy enter as a set of variables in s in (3). All mother, father, and household characteristics that are in z (equation (1)) and, an additional variable that is the age difference between the husband and wife are included in (3).[21] The expectation is that the larger the age difference between the

---

[20] A simple average can be thought of as an estimate of the mother-level 'fixed-effect' in a simple regression of the measurements without any controls. This implies equal weighting of the measurements in the construction of this index. Our model estimated using this sample produced a smaller coefficient compared to the model using our index. The results are available on request from the authors.

[21] Note, for identification purposes, we do not require any additional variables as our autonomy index is a non-linear function of the variables in the equation. Including additional variables provide extra

partners, the higher the autonomy of the wife *ceteris paribus* because the husband will be able to make decisions that do not constrain him to follow customs and traditions to some extent. Unlike in the existing literature, we control for cultural norms via the specification of (3).

We impose the normalisation that the first loading is 1 in (2) for identification. The Model given by equations (2) and (3) is jointly estimated using maximum likelihood methods. We then use the estimated posterior conditional mean (Empirical Bayes) $E(a_i$ |data) of the latent variable a_i, to construct our index of autonomy for every woman in the sample.[22]

In the language of Item Response Theory (IRT) (Carlson and von Davier (2013)), the intercepts μ_j are called the item "difficulty" and factor loadings (i.e. slope coefficients) λ_j are called item "discrimination". Comparing two intercepts, the larger the intercept, the larger the probability of saying yes to the question for the same measure. Hence, the smaller intercept measurement is said to be a more "difficult" item. In terms of the factor loadings, the probability of saying yes to this measurement that has a larger slope (factor loading) will be more sensitive to small changes in the autonomy trait compared to the one with the lower slope and hence said to be more discriminatory. Hence (i) a larger intercept implies that women are more autonomous in this dimension, in general; (ii) the larger the slope, the better would be the measurement in distinguishing

---

variation in the index without relying on functional form for identification. This is similar to the issues in 2-step Heckman method for correcting for sample selection.

[22] This is the Bayesian shrinkage estimator, see Goldstein (2003), which can be used for estimating unobserved individual specific heterogeneity (Train, 2009: Chapter 11) within a random-effects model specification. Simply put, this estimator is

$$E\left(a \mid m_1,...,m_9\right) = \int a\, f(a \mid m_1,...,m_9)da = \frac{\int a\, f(m_1,...,m_9 \mid a)f(a)da}{f(m_1,...,m_9)}.$$

autonomy traits between different women. In our model, even a small change in the autonomy index will be associated with a larger probability of the woman being autonomous in that dimension. It is important to account for the differential role of autonomy in different dimensions.

5. **Descriptive statistics of the variables**

The anthropometric information was collected on surviving children who were under 5 years old at the time of the interview. The sample selection criteria used are provided in Section 3. Descriptive statistics for the main variables of interest are given in Table 1, and the full list of summary statistics of all the variables is in the online Appendix Table A1.

*Variables in the autonomy specification (3) alone – s***:** The excluded variable in our model is the age gap between the partners as discussed earlier and we expect this variable to have a positive effect on autonomy. As per Table 1 Panel [1], in nearly 50% of the families, the husband is three to five years older than the wife.

Child Characteristics: As per Panel [2], 48% of children are female children. The average age of children in the sample is 30 months, and 53% are either first or second-born. It is interesting to note that around half of the births were after 2-3 years of the previous birth. There are two possible explanations for this: either the births are properly spaced, or some families are engaged in pre-natal sex selection. We will come back to this issue when we discuss the results in Section 6.

Nutritional status variables: Summary statistics for the nutritional status variables are in Panel [3]. 48% of children are stunted according to the WHO definition. This is very large compared to the predicted proportion of children who would be classified as stunted according to the WHO distribution. The HAZ scores, the smoothed HAZ score by age in months, and the probability of being stunted by age, are provided in Figures 1

to 3 respectively. Three points are noteworthy here. First, the distribution of HAZ is shifted to the left relative to the WHO distributions. Second, HAZ scores deteriorate with age but stabilise after the child reaches approximately 24 months. Third, the proportion of children classified as stunted also rapidly increases with age till the age of about 36 months.

Autonomy measurements: As shown in Panel [4], the score created by summing all the means of the autonomy-related measures is only 4.24. That is, on average, rural women only have autonomy in four dimensions. The frequency distribution of the score is provided in Table 2. Around 8% of women do not have any autonomy at all according to our chosen measurements. Only a very small proportion of women (2.2%) are recorded saying that they have full autonomy based on the answers to the selected questions.

6. **Results**

6.1 Autonomy index

The coefficient estimates of equation (2) parameters are provided in Table 3. The rest of the results are provided in the online Appendix Table A2.

The factor loading related to whether the woman is allowed to go to the market alone is normalized to 1, for identification.[23] As shown in Table 3, the decision-making measurements have high discriminatory power individually, relative to the reference category (i.e., they have a factor loading that is larger than 1). A higher factor loading indicates that a small difference in the autonomy trait is associated with a larger change in the probability of saying "yes" to these questions relative to other measurements.

---

[23] We normalise on this factor loading since we expect autonomy to have a non-zero effect on this measurement.

The "reliability" measure calculated as the proportion of variance explained by the autonomy index in the total variation of the measures (m1-m9) *individually* are provided in Table 3.[24] The latent autonomy trait is able to explain more than 60% of the variations in the observed measure related to whether the woman has a role in the decisions concerning large household purchases, and visiting family and friends; the latent autonomy trait also explains over 40% of the variations in the woman's participation in decisions regarding her own health care. Unequal factor loadings estimated in this model reiterate the importance of allowing for different dimensions of autonomy to play different roles; thus, they illustrate why an index derived by simply averaging the measures would be problematic.

6.2   *Choice of estimation sample*

In order to facilitate the discussion of selecting the appropriate sample to address the possible issue of 'son preference', we provide some relevant summary statistics in Table 4.

We first discuss how best to mitigate the effect of 'son preference' biasing our estimations. As discussed in the Introduction, son preference is likely to lead to differential care and feeding practices, and hence to differential nutritional outcomes. That is, nutritional outcomes can depend significantly not only upon the sex of the child, but also upon the sex composition of existing children, and how this compares with parents' desired number of boys and girls.

---

[24]   In our model, this is given by $\hat{\lambda}_j^2 * \hat{\sigma}_a^2 / \left[\hat{\lambda}_j^2 * \hat{\sigma}_a^2 + v\hat{a}r(district\text{-}level\ unobservable) + \pi^2 / 3 \right]$ - see equation (2). A specific measurement with a larger 'reliability' measure is able to explain larger proportion of the variability in the observed pattern of answers to that specific question across the women relative to another measurement with a smaller reliability measure.

There are two ways in which son preference may cause our sample to be endogenously selected. First, son preference may lead to sex-selective abortion and hence may lead to a lower proportion of girls at birth. Second, son preference is likely to have an impact on birth intervals and fertility choices. Parents may use a stopping rule for their fertility choice that depends on the number of girls and boys they already have (Barcellos et. al. 2014). Additionally, the birth intervals between children also might depend on the sex of the previous child if the mother tries to conceive faster in the hope of having a boy after a girl (Jayachandran and Kuziemko, 2011). Both these practices would imply that the number and sex of children in the sample are not randomly determined but depend upon various other observed and unobserved factors that may have been omitted from the specification - thereby causing the OLS estimator to be biased and inconsistent.[25]

The data on nutrition were collected for children born within the last five years at the time of the interview and currently alive. In Table 4, we provide some descriptive statistics on the characteristics of the children observed in terms of age, birth order, and year-of-birth, to help us with the selection of the sample for the estimation.

To shed some light on possible sex selection through abortion of female foetuses, we first look at the number of children born to the mothers in our sample. 69% of mothers had only one child born during this time interval and 97% of mothers only contribute one or two observations to the sample (Panel [1]). Among all children, except for the firstborns, the sex imbalance is exacerbated (Panel [2]). We cannot reject the null of

---

[25] The survey collected information on what the ideal number of boys and girls the woman would like to have. We created a binary indicator for women who stated that they preferred a higher number of boys than girls. We do not report results with this variable included because of the possibility of this variable being highly correlated to the number of children already in the family and their sex composition.

equality of proportion of boys and girls among the firstborn children - implying that parents generally do not sex-select their first child.

The other issue (i.e., son preference affecting birth spacing, stopping rules, and care and feeding practices) is more complicated. If the firstborn is a girl, the family may try to conceive sooner in the hope of having a boy. This would reduce the amount of time that the child can receive undivided care and attention (especially, breast milk) (Jayachandran and Kuziemko, 2011). Therefore, nutritional status of the firstborn may depend upon the parents' attitude (i.e., their son preference) as well as upon the birth interval, and the sex of the second child.

Panel [3] of Table 4 describes how many firstborn children were observed with a second-born by the birth year of the firstborn. We find that 35% (2,252 out of 6,434) of firstborns have a second sibling in the sample. The older the firstborn, the higher the chances of observing a second child in the sample. Since this pattern is dictated by the birth intervals, selecting a sample of firstborns without a sibling, will not deal with the problem of endogeneity caused by son preference as discussed earlier. This can be illustrated with an example. If the first child is a girl, the mother may have the second child quickly in hope of having a boy. On the other hand, if the first child is a boy, the woman may delay the second pregnancy to allow the boy to receive full care and attention. Thus, if we use this criterion, i.e., firstborns without a sibling, *boys* may have a higher probability of inclusion into the sample (Panel [3]). We, therefore, need an additional criterion to restrict the sample of firstborns, either in terms of the birth year or in terms of the child's age.

In Panels [4] and [5], we provide the breakdown of the age of all firstborns and those born after 2004, respectively, as some may feel that a calendar-year-based criterion

is likely to suffer less from endogenous selection bias. We focus on the year 2004 as the interviews took place in 2005 and 2006. As we compare these two panels, we find the majority of the firstborns aged less than 18 months were born in 2005 or 2006. The chance of finding a younger sibling becomes higher as we increase the calendar time interval (say choose 2003 instead of 2004).[26]

An additional issue we will have to consider is whether there has been any child death in the family. If a child had died in a family because of severe malnutrition, then the sample of surviving children for whom we have valid nutritional information is endogenously selected. 6% of the mothers in the original sample had experienced a child death (Table 1). However, in the sample of firstborns aged less than 18 months, only 3 mothers had experienced a child death. We do not expect this to be a problem.

In summary, based on the discussions above, our preferred specification restricts our sample to those firstborns who are aged less than 18 months, i.e., who are young enough that they are not very likely to be affected by the birth (and hence sex) of the second child. We have elected to restrict our sample in this way rather than choosing the eldest children without a younger sibling because the choice of the "only child" as a sample group will lead to endogenous selection if the mother conceives sooner after a girl (Barcellos et al., 2014). We also provide estimates based on the other sample selections as discussed in this section.

---

[26] Barcellos et. al (2014) select a sample of last-born children less than 15 months from the first round of the same survey, arguing that this will ensure that "*the parents have not had a chance to respond to the gender of the last child by having more children (Barcellos, et. al (2014): pp 187).* Since our sample is drawn from a later round of the same survey, we are not able to assume that pre-natal diagnostic tools were not widely available during the period covered by our data. The results from the estimation of our model using this sample is available on request from the authors.

6.3   *Nutritional status*

We next summarize the estimates of the parameter of interest – the coefficient of our autonomy variable, by different cuts of the sample used in the estimations, in Table 5. As discussed in the Introduction, the HAZ score measures the long-term nutritional status of the child. An additional interaction term between the autonomy variable and a girl child was included in the model to assess whether female children benefit more than male children when the mother is more "autonomous", ceteris paribus.   However, the interaction term was insignificant in all the regression models reported in Table 5.

The most important finding is that maternal autonomy is a significant positive predictor of better HAZ, and a negative one of stunting irrespective of the sample used. We defer discussions on the magnitudes of these estimates until later in this section and summarise the main results here.

(i)   The Autonomy index coefficient is not significant in the model estimated using all children aged 0-59 months, regardless of whether the sample contains all children or just the firstborn only (Panel [1]). As discussed, however, the coefficients for this sample may be biased because the sex composition of children in this sample may suffer from endogeneity acting through 'son preference'.

(ii)   In terms of the firstborn sample, a one SD higher autonomy score is estimated to be associated with about 0.16 higher HAZ score, depending on how we cut the sample (Panels [2] and columns (1) and (2) of Panel [3]. When we focus only on the firstborns in terms of their age (our preferred sample), the longer the observation period (15 months vs 18 months), the higher the chances of another younger child in the family. However, these estimates are robust to whether we select the firstborns in terms of their age at the time of the interview (age<15 or age<18) or

in terms of the birth year is greater than 2004. Both these sample selections are used to reduce the probability of another younger sibling in the family (Table 4, Panel [3]).

(iii)   We next turn to the results presented in Panel [3] Columns (3) and (4), where we focus on the firstborns but without a sibling. The estimations carried out using this may suffer from 'endogenous' selection due to the reasons discussed earlier in this section. The estimated coefficient of the autonomy variable is less than half of what we find in the model with firstborns aged <18 months (Panel [2] for eg.). Interestingly, the interaction of the autonomy variable with the girl dummy in these 'lastborn' sample models was not significant.[27]

(iv)   The association between women's autonomy and child stunting is significant even when all children of all birth orders (under the age of 60 months) are included in the sample, although the coefficient is smaller (Panel [1] Column (2)). However, Among the firstborn children aged under 18 months (or <15 months or born after 2004), the predicted probability of stunting when we shift our autonomy index by +1 SD is generally significant and lower by about 0.03 points (Panel [2] Columns (2) and (4), and Panel [3] Column (2)). The model estimated using a logit specification using the sample of firstborns aged <18 months, produced an estimated average partial effect for this 'autonomy index of -0.034.

We, therefore, conclude that there is a positive association between the long-term nutritional status of the firstborn and maternal autonomy.

---

[27]   In contrast to our results, Barcellos, et.al. (2014) using an earlier round of the same survey, concluded that parents treated girls and boys differently in many of the dimensions of parental care they looked at, using asample of lastborns aged less than 15 months.

It is well known that the first two years of life are the most important "window of opportunity" to make a long-term impact on children's nutritional status (UNICEF, 2013), and their lifelong health and well-being. Thus, the finding that more autonomous mothers can contribute to better health for their children specifically during this key window of time is very crucial for policy purposes.

Interpretation of the magnitude of the coefficient of autonomy

We next turn to the interpretation of the estimated coefficients of autonomy in the HAZ score, and the probability of stunting. As seen in Figures 1 to 3, relative to the HAZ scores of children younger than 6 months of age, the HAZ scores of older children become worse as they grow older; the probability of being stunted increases as well. These findings are reiterated in Table 6 (Model results same as Table 5 Panel [2]) where we report estimates for the specification that uses a sample of firstborns aged under 18 months. A 6-11-month-old child is estimated to have a HAZ score of about 0.3 SD lower than that of a child aged less than 6 months, *ceteris paribus*. This deteriorates even more for a child who is between 12 and 17 months old. The observed average HAZ score and the proportion who are classified as stunted, for our sample of firstborns aged less than 18 months, are -1.15 (SD 1.72) and 0.31, respectively. The estimated coefficient of the autonomy index for this sample is 0.161 (for HAZ) and -0.032 (for Stunting) (Table 6). Hence, one SD higher (relative to the mean of 0) autonomy index is associated with a higher HAZ score of 0.09 (0.161 divided by 1.72) giving a new HAZ score of -1.06 and a new probability of stunting of 0.28. In terms of the WHO distribution of HAZ scores, this is equivalent to a shift of a child from the 13th to the 15th percentile position. Interestingly, the effect of a change in +1 SD of our autonomy index both in our HAZ and in stunted regressions, is about half the age effect for 6-11-month-old children and about 15% for 12-17-month-old children,

relative to those aged less than 6 months. An estimated 22 million children aged less than 18 months live in rural India (Census of India, 2011). Given the sample proportion (30%), this translates to an estimated 6.6 million firstborn children in this age group; among them, approximately 2.1 million children (30.5%) would be classified as stunted. A one SD higher autonomy is associated with 300,000 fewer cases of stunting among firstborn *children aged less than 18 months* (as evidenced by a decline from 30.5% of this population to 27.3%). As this group of children aged from under 5 months of age group to the 6-11 month age category, this level of increase in maternal autonomy would effectively halve the average deterioration in HAZ scores experienced.

7.   **Discussion and Conclusion**

This paper has attempted to address two important econometric challenges when exploring the link between maternal 'autonomy' and child nutrition: (i) the definition and measurement of 'maternal autonomy', and (ii) the estimation of this link using a sample of children born that might be 'endogenously' selected due to 'son preference' in India.

In order to address the first challenge, we start with the premise that maternal autonomy is a latent trait, which is influenced by cultural and traditional norms that are difficult to shift in the short term. The difficulty of measuring such a trait has for long, hampered our understanding of its role in shaping other indicators. We suggest the use of latent factor modelling to construct an index of autonomy allowing socioeconomic factors to play a part. This contrasts with the use of other measures in the literature such as those constructed by adding up binary responses, averaging binary responses, or using principal component analysis. This paper has argued that, unlike other measures used in the literature, our autonomy index is able to better capture the mother-level unobserved autonomy trait that is correlated with the covariates in the nutrition equation.

The second challenge was the possible endogeneity in the sample of children selected for analysis, due to the existence of 'son preference' in India. We overcome this challenge by carefully selecting the sample to address possible biases. Our preferred model estimates, therefore, restrict the sample to firstborns less than 18 months of age. The results are similar if we select the sample of firstborns less than 15 months of age or firstborns born after 2004.

We conclude that there is a positive association between the long-term nutritional status of the firstborn and maternal autonomy. The finding that more autonomous mothers have an important role specifically during this key window of time is very crucial for policy purposes.

While this paper establishes the links between maternal autonomy and the long-term nutritional status of children, it does not delve into the specific pathways which have been explored earlier.[28] Future research can utilise the index of autonomy created here to explore the impact and identify the effectiveness of various policies on women's autonomy. As this paper has argued, such policies would not only improve women's autonomy – a desirable outcome in itself – but also help to reduce persistently high levels of child undernutrition in India which acts via the effect on the mother's autonomy.

---

[28] See for eg, Durrant and Sathar (2000), and Dyson and Moore (1983)) for many pathways by which autonomy related factors influence child health outcomes.

References

Agarwala, R. and Lynch, S. M. 2006. "Refining the measurement of women's autonomy: An international application of a multi-dimensional construct". *Social Forces* 84 (4): 2077–2098.

Barcellos, S. H., Carvalho, L. S., and Lleras-Muney, A. 2014. "Child Gender and Parental Investments in India: Are Boys and Girls Treated Differently?" *American Economic Journal: Applied Economics*, 6 (1): 157-89.

Borooah, V. K. 2004. Gender bias among children in India in their diet and immunisation against disease. Social Science & Medicine. 58(9), 1719-31.

Caldwell, J. C. 1986. Routes to low mortality in poor countries. *Population Development Review,* 12, 171-220.

Carlson, J. E., & von Davier, M. 2013. Item response theory. ETS Research Report Series, 2013(2), i-69.

Carlson, G. J., Kordas, K. and Murray-Kolb LE. 2015. Associations between women's autonomy and child nutritional status: a review of the literature. *Maternal Child Nutrition.* Oct. 11(4), 452-82. doi: 10.1111/mcn.12113.

Census of India. 2011. Provisional Population Totals: Paper 1 of 2011 India Series 1. Office of the Registrar General and Census Commissioner, Government of India.

Chakraborty, T., and De, P. K. 2011. Mother's autonomy and child welfare: A new measure and some new evidence. IZA DP. 5438, January.

Chilinda, Z. B., Wahlqvist, M.L., Lee, MS. *et al.* 2021. Higher maternal autonomy is associated with reduced child stunting in Malawi. *Scientific Reports, Nature,* **11,** 3882. https://doi.org/10.1038/s41598-021-83346-2

Cleland, J. 2010. The benefits of educating women. *The Lancet*. 376 (9745), 933-934.

Dancer, D. and Rammohan, A. 2009. Maternal autonomy and child nutrition Evidence from rural Nepal. *Indian Growth and Development Review*, Vol. 2 No. 1, pp. 18-38.

Dreze, J. 2004. Democracy and the Right to Food. *Economic and Political Weekly*, April 24.

Durrant, V., and Sarthar, Z. (2000). Greater investments in children through women's empowerment: a key to demographic change in Pakistan? Policy Research Division Working Paper No. 137. New York, NY: Population Council.

Dyson, T., and Moore, M. 1983. On Kinship Structure, Female Autonomy, and Demographic Behavior in India. *Population and Development Review*. 9 (1), 35-60.

Frost, M. B., Forste. R, and Haas, D. W. 2005. Maternal education and child nutritional status in Bolivia: Finding the links. *Social Science and Medicine.* 60, 395-407.

Goldstein, H. 2003. Multilevel statistical models. 3rd Edition, Kendall's Library of Statistics 3, Arnold, London.

Heckman, J. J., Stixrud, J., and Urzua, S. 2006. The effects of cognitive and noncognitive abilities on labor market outcomes and social behaviour. *Journal of Labor Economics*. 24 (3). 411-482.

Hu, L., and Schlosser, A. 2015. Prenatal sex selection and girls' well-being: evidence from India. *Economic Journal*. 125 (587), 1227–1261.

Imai, K. S., Annim, S. K., Kulkarni, V. S., and Gaiha, R.. 2014. Women's Empowerment and Prevalence of Stunted and Underweight Children in Rural India. *World Development.* 62 (C), 88–105.

International Institute for Population Sciences (IIPS) and Macro International Inc. 2007a. National Family Health Surveys (NFHS-3), 2005-06: India: Volume I. Mumbai: IIPS. India.

International Institute for Population Sciences (IIPS) and Macro International. 2007b. National Family Health Survey (NFHS-3), 2005-06, India: Key Findings. Mumbai: IIPS, India.

International Institute for Population Sciences (IIPS) and ICF. 2017. National Family Health Survey (NFHS-4), 2015-16: Mumbai: IIPS, India.

International Institute for Population Sciences (IIPS) and ICF. 2021. National Family Health Survey (NFHS-5), 2019-21, Volume I. Mumbai: IIPS, India.

Iversen, V., and Palmer-Jones, R. 2014. TV, female empowerment and demographic change in rural India. International Initiative for Impact Evaluation. Replication Paper 2.

Jayachandran, S., and Kuziemko, I. 2011. Why do mothers breastfeed girls less than boys? Evidence and implications for child health in India, *The Quarterly Journal of Economics*, Oxford University Press, 126, 1485-1538.

Jejeebhoy, S. 2000. Women's autonomy in rural India: its dimensions, determinants and the influence of context, in Harriet, P., Gita Sen Editors. *Women's Empowerment and Demographic Processes: Moving beyond Cairo*. Oxford University Press, Oxford, UK.

Jensen, R., and Oster, E. 2009. The Power of TV: Cable Television and Women's Status in India. *The Quarterly Journal of Economics.* 124 (3): 1057-1094.

Jensen, R., and Oster, E. 2014. Response to Iversen and Palmer-Jones. www.3ieimpact.org/media/filer_public/2014/06/07/jensen_oster_response.pdf. Accessed on 22nd Feb 2015.

Mamidi, R. S., Shidhaye, P., Radhakrishna, K.V., Babu, K.V. , and Reddy, P. S. 2011. Pattern of Growth Faltering and Recovery in Under Five Children in India using WHO

growth Standards – A study on first and third National Family Health Surveys. *Indian paediatrics*, March 15, 1-6.

Mason, K. O. 1986. The status of women: conceptual and methodological issues in demographic studies. *Sociological Forum*, 1(2), 284-300.

Murthi, M., Guio, A-C., and Dreze, J. 1995. Mortality, fertility and gender-bias in India: A district level analysis. *Population and Development Review*, 21(4), 745-782.

Paul, P., and Saha, R. 2022. Is maternal autonomy associated with child nutritional status? Evidence from a cross-sectional study in India, accessed from https://doi.org/10.1371/journal.pone.0268126.

Ramachandran, P., and Gopalan, H. S. 2011. Assessment of nutritional status in indian preschool children using the WHO 2006 growth standards. *Indian Journal of Medical Research*, 134 (1), 47–53.

Safilios-Rothschild, C. 1982. Female power, autonomy and demographic change in the Third World in Anker, R., Buvinic, M., and Youssef, N. H. editors. Women's Role and Population Trends in the Third World. Croom Helm, London, UK.

Saxena, N.C. 2018. Hunger, under-nutrition and food security in India. In, Mehta A., Bhide S., Kumar A., Shah A. (eds) Poverty, Chronic Poverty and Poverty Dynamics. Springer, Singapore.

Sumner, A., Haddad, L., and Climent, L. G. 2009. Rethinking Intergenerational Transmissions(s): Does a Wellbeing Lens Help? The Case of Nutrition. IDS Bulletin, 40 (1), 22-30.

Train, K. 2009. Discrete Choice Methods with Simulation, Cambridge University Press, Cambridge, UK.

UNICEF. 2013. The right ingredients: the need to invest in child nutrition. Child Nutrition Report 2013. UNICEF, UK.

Victora, C. G., Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L., and Sachdev, S. H. 2008. Maternal and Child Undernutrition: Consequences for Adult Health and Human Capital. *The Lancet*. 26; 371(9609): 340–357.

World Health Organisation (WHO) Multicenter Growth Reference Study Group. 2006. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age-methods and development. Geneva: World Health Organisation.

Yamaguchi, K. 1989. A Formal Theory for Male-Preferring Stopping Rules of Childbearing: Sex Differences in Birth Order and in the Number of Siblings. *Demography*. 26 (3), 451-465.
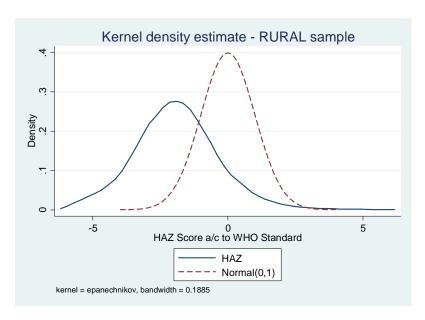
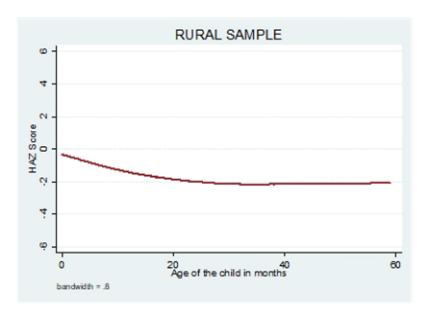**Figure 1: HAZ scores – Rural Children aged 0-59 months**

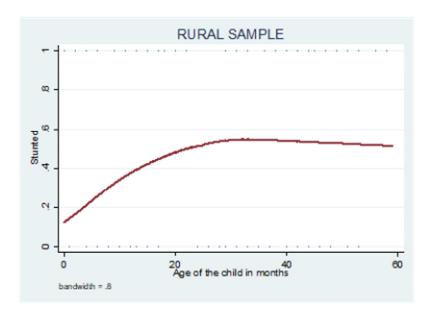**Figure 2: Smoothed Plots of HAZ by Age – rural sample**

31

Figure 3: Proportion of children who are classified as 'stunted' by age

<u>Notes to Figures 1-3</u>: All figures are based on authors' calculations from the sample used for the estimation of the model.

Table 1 – Descriptive Statistics (Mean (SD))

Panel [1]: variables only in the autonomy eq (3) - s	
Partner's age-woman's age (binary indicators)	
Age difference between the woman and her partner < 3 years	0.12
Age difference between the woman and her partner 3-5 years	0.47
Age difference between the woman and her partner 6-10 years	0.30
Age difference between the woman and her partner > 10 years	0.11
Panel [2]: variables only in the nutrition equation: Child covariates z	
Girl	0.48
Age in months	30.2 (17.0)
Part of a multiple birth	0.01
Birth Order 1	0.27
2	0.26
3	0.18
4	0.11
5 or more	0.18
Preceding birth interval	
< 18 months	0.08
18-24 months	0.15
25-36 months	0.51
>36 months	0.27
Panel [3]: nutrition equation dependent variables	
HAZ – Height for Age Z scores	-1.86 (1.66)
Stunted (HAZ<-2)	0.48
Panel [4]: measurements used in the construction of the autonomy index	
Woman is allowed to go to the:	
market alone (m1)	0.48
health facility alone (m2)	0.45
places outside the community alone (m3)	0.36
Woman has the final say alone on purchases for daily needs (m4)	0.29
Woman has the final say together: own health care (m5)	0.61
large household purchases (m6)	0.5
visiting family and friends (m7)	0.58
what to do with husband's money (m8)	0.62
Woman has money for her own use (m9)	0.36
Average Total Score (Std Dev)	4.24 (2.48)
Mean of the average scores	0.47
Median of the average scores	0.44
Number of mothers	17,749
Number of children of 17,749 mothers	23,878
Proportion of mothers with one child in this sample	0.59
Mother has experienced at least one child death	0.06

Notes: (i) Sample consists of women who had children who were less than 60 months old at the survey time and thus contributed to the 'nutrition' analyses. See text for further details; (ii) The nutritional status variable definitions are based on the World Health Organisation standards; (iii) All variables are binary except when a SD is indicated in parenthesis.

Table 2
Frequency distribution of the sum of the measurements (m1-m9) used
in the construction of the autonomy index

Sum	# of women	%	Cumulative %
0	1,454	8.2	8.2
1	1,729	9.7	17.9
2	1,589	9.0	26.9
3	1,976	11.1	38.0
4	2,800	15.8	53.8
5	2,355	13.3	67.1
6	1,784	10.1	77.1
7	2,103	11.9	89.0
8	1,564	8.8	97.8
9	395	2.2	100.0

Notes: (i) See Table 1 for the definitions of the measurements; (ii) Number of women in the rural sample=17,749; (iii) Sample average of the score is 4.2.

Table 3: Estimates of Equation (2) Parameters (Standard errors)
(Impact of Women's Autonomy on Probability of Positive Response to the Measurement Question)

MEASUREMENTS (binary indicators)	FACTOR LOADING	INTERCEPT
	[1]	[2]
woman is allowed to go to market alone – **intercept** (m1)	1	-1.407***
		(0.082)
woman is allowed to go to health facility alone (m2)	0.886***	-0.005
	(0.026)	(0.046)
woman is allowed to go to places outside community alone (m3)	0.894***	-0.484***
	(0.028)	(0.050)
final say alone on purchases for daily needs (m4)	0.745***	-0.653***
	(0.030)	(0.060)
final say together on own health care (m5)	2.171***	-0.682***
	(0.081)	(0.097)
final say together on large household purchases (m6)	2.877***	-2.420***
	(0.119)	(0.150)
final say together on visiting family and friends (m7)	2.959***	-1.815***
	(0.115)	(0.151)
final say together on what to do with husband's money (m8)	1.463***	0.170***
	(0.055)	(0.065)
woman has money for her own use (m9)	0.023	0.758***
	(0.020)	(0.085)
Estimated variance of woman level heterogeneity	0.815***	
	(0.023)	
Estimated variance of district level heterogeneity	0.748***	
	(0.015)	
'RELIABILITY' MEASURE[+] (percentage)		
woman is allowed to go to market alone	16.8	
woman is allowed to go to health facility alone	13.8	
woman is allowed to go to places outside the community alone	13.8	
final say alone on purchases for daily needs	10.2	
final say together on own healthcare	48.7	
final say together on large household purchases	62.6	
final say together on visiting family and friends	63.9	
final say together on what to do with the husband's money	30.1	
woman has money for her own use	0.0	
Maximised log-likelihood value	-90899	

(i) ***, **, * p-value<0.01, 0.05 and 0.10 respectively. (ii) The 'reliability' measure provides the percentage of variation attributed to the autonomy variable in the total variation observed in that **particular** measurement. A measurement with a larger "reliability" measure is able to explain a larger proportion of the variability in the observed pattern of women's answers to that question relative to another measurement with a smaller reliability measure. (iii) Rest of the results are provided in the online appendix Table A2.

Table 4 – Sample Characteristics

PANEL [1]: Number of children aged<60 months					
Number of children	1	2	3	4	Total (#)
% of mothers	68.5	28.6	2.82	0.08	17,749

PANEL [2]: Distribution of Birth Order – Column %							
	1	2	3	4	5	6	7 or more	Total
Girls	49.4	48.2	46.5	48.4	47.8	49.4	46.7	48.2
Boys	50.6	51.9	53.5	51.6	52.2	50.7	53.3	51.8
Total (number)	6,434	6,312	4,219	2,682	1,758	1,078	1,395	23,878
Total - row %	27.0	26.4	17.7	11.2	7.4	4.5	5.8	100

PANEL [3]: FIRSTBORNS with SECOND-BORN in the sample by year of birth of firstborn						
	2001	2002	2003	2004	2005	2006	Total (#)
Numbers	649	829	569	193	11	1	2,252
%	28.8	36.8	25.3	8.6	0.5	0.04	100.0

PANEL [4]: Age in Months of FIRSTBORNS				
	0-15	16-17	18-23	24+	Total
Numbers	1,696	241	657	3,840	6,434
%	26.4	3.8	10.2	60.0	100.0

PANEL [5]: Age in Months of FIRSTBORNS with birth-year>2004			
	0-15	16-17	18+	Total
Numbers	1,557	78	7	1,642
%	94.8	4.8	0.4	100.0

PANEL [6]: Firstborns without a younger sibling				
	0-15	16-17	18-23	24+	Total
Numbers	1,690	227	587	1,698	4,202
%	40.2	5.4	14.0	40.4	100.0

Table 5 – HAZ & 'Stunted' regressions - Coefficient Estimate (std error)

VARIABLES	HAZ	'STUNTING'	HAZ	'STUNTING'
Column number	(1)	(2)	(3)	(4)
PANEL [1]	ALL BIRTH-ORDER AGE 0-59 months		FIRSTBORNS AGE 0-59 months	
Autonomy	0.022	-0.011***	0.026	-0.008
	(0.015)	(0.004)	(0.025)	(0.008)
Constant	-1.880 ***	0.467***	-2.239***	0.623***
	(0.088)	(0.026)	(0.173)	(0.051)
R-squared	0.110	0.094	0.135	0.119
Number of Children	23,788	23,788	6,413	6,413
PANEL [2]	FIRSTBORNS AGE<15 months		FIRSTBORNS AGE<18 months	
Autonomy	0.146**	-0.029*	0.161***	-0.032**
	(0.058)	(0.015)	(0.051)	(0.014)
Constant	-1.218***	0.325***	-1.441***	0.382***
	(0.377)	(0.098)	(0.364)	(0.088)
R-squared	0.139	0.133	0.176	0.157
Number of Children	1,571	1,571	1,931	1,931
PANEL [3]	FIRSTBORNS BIRTH-YEAR>2004		FIRSTBORNS with no younger sibling AGE<18 months	
Autonomy	0.158***	-0.033**	0.059**	-0.016**
Constant	(0.059)	(0.015)	(0.032)	(0.009)
	-1.129***	0.300***	-1.326***	0.365***
	(0.375)	(0.101)	(0.205)	(0.064)
R-squared	0.151	0.132	0.194	0.158
Number of Children	1,640	1,640	4,185	4,185

Notes: (i)The full set of variables included in the regression is in Appendix Table A2; (ii) age dummies (0-5 (base), 6-11, 12-17, 18-23, 24+), as well as the birth order dummies, were included where appropriate; (iii) Bootstrapped standard errors (allows for clustering at the district level with 500 replications) in parentheses. (iv) The number of observations used in the estimations relative to those reported in Table 4, can differ due to the missing values in some of the included variables in the regressions.

Table 6 – Estimates of Equation (1): First-born rural children aged<18 months

	HAZ	'Stunted' [binary]
Maternal Autonomy –z score	0.161***	-0.032**
	(0.051)	(0.014)
Child Characteristics		
Age in months – binary – (base <6 months) 6-11	-0.318***	0.058**
	(0.100)	(0.025)
12-17	-1.032***	0.237***
	(0.099)	(0.027)
Girl	0.178**	-0.039**
	(0.071)	(0.019)
Part of multiple birth	-2.392***	0.630***
	(0.442)	(0.162)
R-squared	0.176	0.157
Sample average of the dependent variable (SD)	-1.15	0.31
	(1.72)	
Number of Children	17,749	11,187

Notes: (i) This is the same as Table 5, Panel [2] Columns 2 and 3. (ii) ***, **, * p-value<0.01, 0.05 and 0.10 respectively. (iii) All the estimates are in online Appendix Table A2; (iv) Bootstrapped standard errors (allows for clustering at the district level with 500 replications) in parentheses.

WEB BASED SUPPLEMENTARY MATERIAL

Rural sample of households

Table A1– Descriptive Statistics (mean (S.D))

	Rural [1]
PANEL 1: MEASUREMENTS USED IN THE CONSTRUCTION OF THE AUTONOMY INDEX	
Woman is allowed to go to the:	
market alone (m1)	0.48
health facility alone (m2)	0.45
places outside the community alone (m3)	0.36
Woman has the final say alone on purchases for daily needs (m4)	0.29
Woman has the final say together on: own health care (m5)	0.61
large household purchases (m6)	0.50
visiting family and friends (m7)	0.58
what to do with husband's money (m8)	0.62
Woman has money for her own use (m9)	0.36
Average of reported autonomy answers (Std Dev)	4.24 (2.48)
Mean of the average scores	0.47
Median of the average scores	0.44
PANEL 2: VARIABLES IN THE NUTRITION AND AUTONOMY EQUATIONS (1) AND (3) - Z and S	
Wealth index factor score/100000	-0.58 (0.78)
Family is a nuclear family	0.47
Mother's characteristics	
Current Age in years	27.03 (5.8)
Caste	
'general' caste (used as the base category in the analysis)	0.25
Schedule caste	0.18
Schedule tribe	0.20
OBC (Other Backward Caste)	0.33
Caste information is missing	0.05
Religion	
Hindu (used as the base category in the analysis)	0.74
Christian	0.10
Muslim	0.13
Other Religion	0.03
Education	
No education or primary not completed (used as base category)	0.57
Completed primary	0.36
Completed secondary	0.03
Completed higher education	0.03
Woman's Occupation	
No occupation (base category)	0.55
Professional, Technical, Managerial; Clerical, Sales, Services	0.04
Agricultural employee	0.33
Skilled and Unskilled Manual	0.08
Woman's working and earning status	
Not working (base group)	0.54
works all year for cash	0.11
works all year for non-cash (not paid, paid in kind)	0.13
seasonal or occasional work	0.22
Media Exposure	
Woman reads newspapers or watches TV or listens to the radio	0.51

Table A1– Descriptive Statistics (mean (S.D)) - continued

	Rural [1]
Partner's Education	
No education (used as the base category in the analysis)	0.46
Completed primary	0.45
Secondary or higher education	0.02
Education information missing or not known	0.07
Partner's Occupation	
Skilled and Unskilled Manual (base category) + a handful of 'unemployed'	0.38
Professional, Technical, Managerial	0.05
Clerical	0.03
Sales	0.09
Agricultural employee	0.40
Services	0.05
State/Union Territory	
Jammu and Kashmir	0.03
Himachal Pradesh	0.03
Punjab	0.03
Uttaranchal	0.03
Haryana	0.03
Rajasthan	0.05
Uttar Pradesh (used as the base state)	0.13
Bihar	0.05
Sikkim	0.02
Arunachal Pradesh	0.02
Nagaland	0.04
Manipur	0.04
Mizoram	0.02
Tripura	0.02
Meghalaya	0.02
Assam	0.04
West Bengal	0.05
Jharkhand	0.04
Orissa	0.05
Chhattisgarh	0.04
Madhya Pradesh	0.05
Gujarat	0.03
Maharashtra	0.03
Andhra Pradesh	0.03
Karnataka	0.04
Goa	0.02
Kerala	0.02
Tamil Nadu	0.03

	Rural
	[1]
PANEL 3: VARIABLES ONLY IN THE AUTONOMY EQUATION (3) - _S_	
Partner's age-woman's age (binary indicators)	
Age difference between the woman and her partner < 3 years (used as the base category in the analysis)	0.12
Age difference between the woman and her partner 3-5 years	0.47
Age difference between the woman and her partner 6-10 years	0.30
Age difference between the woman and her partner > 10 years	0.11
PANEL 4: VARIABLES ONLY IN THE NUTRITION EQUATION – _Z_	
CHILD COVARIATES	
Girl	0.48
Age in months	30.2 (17.0)
Part of a multiple birth	0.01
Birth Order 1	0.27
2	0.26
3	0.18
4	0.11
5 or more	0.18
Preceding birth interval	
< 18 months	0.08
18-24 months	0.15
25-36 months	0.51
>36 months	0.27
MOTHER SPECIFIC COVARIATES	
Child had died in the family	0.06
Whether the mother is anaemic i.e. haemoglobin<11gm/dl	0.40
Mothers height less than 145cm	0.10
Mother has low BMI i.e. BMI<18.5	0.14
BMI missing	0.14
PANEL 5: NUTRITION EQUATION DEPENDENT VARIABLES	
HAZ – Height for Age Z scores	-1.86 (1.66)
WHZ – Weight for Height Z scores	-0.99 (1.30)
WAZ – Weight for Age Z scores	-1.76 (1.23)
Binary Indicators	
Stunted (HAZ<-2)	0.48
Wasted (WHZ<-2)	0.19
Stunted but not wasted	0.39
Not stunted but wasted	0.11
Neither stunted nor wasted	0.41
Stunted and wasted	0.09
Number of mothers	17,749
Number of Children for 17,749 mothers	23,788
Proportion of Mothers with one child in the sample	0.59

Notes: (i) Sample is the women who had children who were less than 5 years old at the survey time and thus contributed to the 'nutrition' analyses. See text for further details; (ii) The nutritional status variable definitions are based on the World Health Organisation standards; (iii) The Rural sample excludes Delhi; (iv) All variables are binary except when a SD is indicated in parenthesis.

Appendix Table A2 – Estimates of Equation (3) Parameters (Standard errors)
(Determinants of Women's Autonomy Index)

	RURAL
Wealth index factor score/100000	-0.043***
	(0.017)
Family is a nuclear family	0.454***
	(0.021)
Woman's characteristics	
Age in years	0.028***
	(0.002)
Caste: base case is 'general'	
Schedule Caste	0.027
	(0.026)
Schedule Tribe	-0.009
	(0.032)
Other Backward Caste	-0.080***
	(0.024)
Caste missing	-0.004
	(0.047)
Religion: base case is 'Hindu'	
Christian	0.086*
	(0.049)
Muslim	-0.132***
	(0.030)
Other	-0.042
	(0.046)
Education: base is no education	
Completed primary or incomplete secondary	0.125***
	(0.021)
Completed secondary education	0.277***
	(0.049)
Higher education	0.348***
	(0.057)
Media Exposure	
Listens to either radio or watches television or reads newspapers at least once a week	0.045**
	(0.019)
Woman's Occupation – base: no occupation	
Professional, Technical, Managerial; Clerical, Sales, Services	0.068
	(0.162)
Agricultural employee	-0.126
	(0.157)
Skilled and Unskilled Manual	-0.102
	(0.159)
Woman's working status in the last 12 months – base: not working	
works all year for cash	0.261*
	(0.159)
works all year for non-cash (not paid, paid in kind)	0.214
	(0.158)
seasonal or occasional work	0.244
	(0.158)

	RURAL
Partner's Characteristics	
Education: base is no education	
Completed primary or incomplete secondary	-0.051***
	(0.019)
Completed secondary education	-0.093
	(0.058)
Higher education	-0.080**
	(0.040)
Occupation – Base: Manual	
Professional, Technical, Managerial	0.102**
	(0.041)
Clerical	-0.025
	(0.048)
Sales	0.005
	(0.029)
Agricultural employee	-0.031
	(0.019)
Services	0.087**
	(0.039)
Age difference between the partners	
Base: less than 2 years	
Husband older by 2-5 years	0.008
	(0.025)
Husband older by 6-10 years	0.053*
	(0.027)
Husband older by more than 10 years	0.074**
	(0.034)
State/Union Territory (base: Uttar Pradesh)	
Jammu and Kashmir	-0.352***
	(0.065)
Himachal Pradesh	0.238***
	(0.063)
Punjab	0.397***
	(0.070)
Uttaranchal	-0.015
	(0.059)
Haryana	0.440***
	(0.063)
Delhi	+++
Rajasthan	-0.266***
	(0.051)
Bihar	-0.029
	(0.046)
Sikkim	0.813***
	(0.093)
Arunachal Pradesh	0.717***
	(0.084)
Nagaland	1.042***
	(0.080)
Manipur	1.079***
	(0.076)
Mizoram	1.315***
	(0.127)
Tripura	0.052
	(0.070)
Meghalaya	1.132***
	(0.097)

Table A2 - Continued

	RURAL
Assam	0.999***
	(0.071)
West Bengal	-0.116**
	(0.048)
Jharkhand	0.280***
	(0.056)
Orissa	0.358***
	(0.051)
Chhattisgarh	0.173***
	(0.053)
Madhya Pradesh	-0.101**
	(0.048)
Gujarat	-0.129**
	(0.057)
Maharashtra	0.415***
	(0.061)
Andhra Pradesh	0.043
	(0.061)
Karnataka	-0.208***
	(0.053)
Goa	0.483***
	(0.085)
Kerala	0.634***
	(0.071)
Tamil Nadu	0.427***
	(0.066)
Number of Mothers	17,749

Notes: (i) ***, **, * p-value<0.01, 0.05 and 0.10 respectively. (ii) All are binary indicators except the Wealth score variable and the woman's age variable. (iii) +++ There were not enough women in the rural sample living in Delhi and these women were dropped from the rural analyses. (iv) The main Table 3 contains the estimates of equation (2) parameters related to intercepts and factor loadings.

Appendix Table A3 – Estimates of Equation (1) Parameters (Standard errors)
First-born rural children aged<18 months

	Mean (SD)	HAZ	'Stunted' [binary]
Maternal Autonomy –z score	-0.38 (0.99)	0.161***	-0.032**
		(0.051)	(0.014)
Child Characteristics			
Age in months – binary – (base <6 months)			
6-11	0.37	-0.318***	0.058**
		(0.100)	(0.025)
12-17	0.37	-1.032***	0.237***
		(0.099)	(0.027)
Girl	0.48	0.178**	-0.039**
		(0.071)	(0.019)
Twin	0.00	-2.392***	0.630***
		(0.442)	(0.162)
Family Characteristics			
Wealth index factor score/100000	-0.36 (0.82)	0.210***	-0.067***
		(0.072)	(0.020)
Family is a nuclear family	0.21	-0.082	0.015
		(0.106)	(0.026)
Mother's characteristics			
Age in years	21.47 (3.69)	0.042***	-0.010***
		(0.013)	(0.003)
Whether the mother is anemic i.e. hemoglobin<11gm/dl	0.57	-0.006	-0.005
		(0.080)	(0.021)
Mothers height less than 145cm	0.11	-0.630***	0.132***
		(0.121)	(0.036)
Mother has low bmi i.e. bmi<18.5	0.37	-0.340***	0.098***
		(0.080)	(0.022)
Caste: (**base case is 'general**)			
Schedule Caste	0.17	-0.120	0.041
		(0.122)	(0.034)
Schedule Tribe	0.18	0.024	-0.020
		(0.148)	(0.037)
Other Backward Caste	0.32	-0.119	0.067**
		(0.099)	(0.029)
Religion: (base case is 'Hindu')			
Christian	0.08	-0.078	0.062
		(0.219)	(0.048)
Muslim	0.10	0.224	-0.079**
		(0.146)	(0.039)
Other	0.07	0.018	0.014
		(0.188)	(0.048)
Education: **base is no education**			
Completed primary or incomplete secondary	0.49	0.114	-0.065**
		(0.090)	(0.027)
Completed secondary education	0.07	0.032	-0.047
		(0.182)	(0.045)
Higher education	0.06	0.258	-0.028
		(0.193)	(0.051)
Media Exposure: Listens to either radio or watches tv or reads newspapers at least once a Week	0.62	-0.058	0.018
		(0.088)	(0.025)

Appendix Table A3 – Continued

	Mean (SD)	HAZ	'Stunted' [binary]
Woman's Occupation – base: no occupation			
Professional, Technical, Managerial; Clerical, Sales, Services	0.03	-0.663	0.294**
		(0.933)	(0.118)
Agricultural employee	0.22	-0.525	0.314***
		(0.919)	(0.115)
Skilled and Unskilled Manual	0.05S	-1.020	0.422***
		(0.948)	(0.125)
Woman's working status in the last 12 months – base: not working			
works all year for cash	0.07	0.738	-0.321***
		(0.955)	(0.120)
works all year for non-cash (not paid, paid in kind)	0.09	0.755	-0.364***
		(0.912)	(0.114)
seasonal or occasional work	0.15	0.506	-0.298**
		(0.941)	(0.118)
Partner's Characteristics			
Education: base is no education			
Completed primary or incomplete secondary	0.55	0.082	-0.019
		(0.096)	(0.028)
Completed secondary education	0.03	0.421**	-0.088
		(0.204)	(0.058)
Higher education	0.11	0.153	-0.016
		(0.170)	(0.045)
Occupation – Base: Manual			
Professional, Technical, Managerial	0.07	-0.067	-0.005
		(0.177)	(0.044)
Clerical	0.03	0.188	-0.059
		(0.198)	(0.054)
Sales	0.10	-0.198	0.014
		(0.143)	(0.035)
Agricultural employee	0.36	-0.098	0.023
		(0.091)	(0.025)
Services	0.05	0.122	-0.029
		(0.178)	(0.045)
State/Union Territory (base: Uttar Pradesh)			
Jammu and Kashmir	0.02	0.317	-0.046
		(0.276)	(0.076)
Himachal Pradesh	0.03	0.148	-0.028
		(0.259)	(0.066)
Punjab	0.04	-0.125	0.037
		(0.265)	(0.068)
Uttaranchal	0.03	-0.461*	0.089
		(0.257)	(0.068)
Haryana	0.03	-0.236	0.023
		(0.233)	(0.066)
Rajasthan	0.05	0.219	-0.063
		(0.210)	(0.060)
Bihar	0.04	0.317*	-0.141**
		(0.184)	(0.061)
Sikkim	0.02	0.561	-0.049
		(0.386)	(0.075)
Arunachal Pradesh	0.02	0.092	0.041
		(0.397)	(0.106)
Nagaland	0.02	0.268	-0.153**
		(0.367)	(0.076)
Manipur	0.04	0.540**	-0.056
		(0.239)	(0.059)

	Mean (SD)	HAZ	'Stunted' [binary]
Mizoram	0.01	-0.078 (0.400)	0.076 (0.118)
Tripura	0.03	0.200 (0.257)	-0.096 (0.072)
Meghalaya	0.01	-0.011 (0.439)	0.005 (0.106)
Assam	0.05	0.032 (0.229)	-0.006 (0.064)
West Bengal	0.05	0.293 (0.213)	-0.025 (0.060)
Jharkhand	0.03	0.251 (0.307)	-0.050 (0.077)
Orissa	0.05	0.190 (0.210)	-0.073 (0.055)
Chhattisgarh	0.03	-0.330 (0.221)	0.093 (0.069)
Madhya Pradesh	0.04	0.387* (0.225)	-0.119* (0.062)
Gujarat	0.03	-0.041 (0.243)	0.022 (0.076)
Maharashtra	0.05	0.064 (0.239)	0.017 (0.059)
Andhra Pradesh	0.02	0.593* (0.305)	-0.239*** (0.066)
Karnataka	0.04	0.440* (0.243)	-0.132** (0.058)
Goa	0.02	0.115 (0.239)	-0.031 (0.081)
Kerala	0.04	0.002 (0.249)	-0.013 (0.063)
Tamil Nadu	0.03	0.240 (0.264)	-0.061 (0.065)
Intercept		-1.441*** (0.364)	0.382*** (0.088)
R-squared		0.176	0.157
Sample average of the dependent variable (SD)		-1.15 (1.72)	0.31
Number of Children	1,931	1,931	1,931

Notes: (i) ***, **, * p-value<0.01, 0.05 and 0.10 respectively. (ii) All are binary indicators except the Wealth score variable and the woman's age variable. (iii) +++ There were not enough women in the rural sample living in Delhi and these women were dropped from the rural analyses. (iv) Sample consists of firstborn children aged<18 months.