Why malnutrition in shining India persists*

Peter Svedberg**

Abstract. India has a higher prevalence of child malnutrition, as manifested in stunting and underweight, than any other large country and was home to about one-third of all malnourished children in the world in the early 2000s. There are, however, substantial inter-state differences in child malnutrition and also in the (generally meagre) progress made since the early 1990s. The persistence of widespread malnutrition may seem surprising considering the recent overall shining performance of the Indian economy. Between 1993 and 2006 net state domestic product per capita nearly doubled in the wake of 4.5% average annual growth. The main objective of this paper is to identify the reasons why rapid economic growth has failed to reduce malnutrition more substantially. The methods used are OLS, instrument-variable, fixed-effect and first-difference regression analyses on the basis of panel data at the level of states in India. The results suggest that the persistence of malnutrition is mainly explained by modest poverty reduction — despite high overall economic growth — due to minuscule factor productivity and income growth in the agricultural sector, still employing 54% of the Indian labour force. Widespread rural female illiteracy and restricted autonomy for women are other significant explanations.

Key words: child, maternal, malnutrition, poverty, female illiteracy, autonomy, India

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* "India is shining" was the ubiquitous slogan boasted by the incumbent National Democratic Alliance (NDA) in its multi-billion dollar media campaign in the run-up to the national elections in 2004. The message conveyed was that all sectors of the Indian economy had recorded unprecedented growth and progress during the five years the NDA had ruled India. The NDA lost the election and an often acclaimed reason is that millions of poor and malnourished Indians felt they had been left in the shade.

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1. Introduction

In the early 1990s, about half of the pre-school children in India were malnourished, as measured by being stunted or underweight for age. At the time, several other countries in South Asia and Sub-Saharan Africa had similar levels of child malnutrition. The prevalence of child stunting and underweight in India has declined since then, but at a slower pace than in most other developing countries. In years around 2000, the latest date for which estimates are available for sufficiently many countries to enable meaningful comparison, only a few, much smaller countries had a higher incidence of child malnutrition than India (WHO 2007a). As late as in 2005/06, 46% of all young Indian children were underweight for age and 38% were stunted.

The high and persistent incidence of child malnutrition may seem surprising considering that India has done remarkably well in economic terms since the policy reform process gained momentum in the early 1990s. Between 1993 and 2006, net state domestic product per capita (NSDP/C) grew by 4.5% per year on average, signifying nearly a doubling of real income. Despite this shining overall economic performance, the prevalence of child stunting and underweight dropped by 23 and 12% only over the 13 years (or by 8.7 and 5.4 percentage points). These rates of decline look modest in comparison to China, where child stunting fell from 33 to 10% between 1992 and 2005 and child underweight was practically eliminated. India's progress in reducing child underweight since the early 1990s has been only marginally better than in Sub-Saharan Africa, a region with high and persistent child malnutrition, but economically stagnant (Svedberg 2006).

The key question addressed in this paper is why high overall economic growth has failed to bring about a more rapid alleviation of child malnutrition in India. The main explanation advanced in the earlier literature is the subdued position of women (mothers). This hypothesis, the so-called Asian Enigma Syndrome (Ramalingaswami et al 1996), is widely adhered to, but firm quantitative evidence of the role of female subjugation relative to that of income poverty is scarce.[1] This paper will try to fill that void.

[1] Smith et al. (2003; 2005a) analyse the role of women autonomy for alleviating child malnutrition and find empirical support for the women subjugation hypothesis, especially in South Asia, but the relative role of income poverty is not explicitly studied.

The research tools applied are panel and first-difference regression analyses based on data at the level of Indian states. In addition to trying to quantify the relative impact of the fundamental causes of child malnutrition, income poverty and female education and autonomy, a further aim is to identify pathways through which these variables affect children's nutritional status. In that context, we will also examine how child and maternal malnutrition are inter-related.

Some limitation in the scope of the study should be mentioned upfront. The first is that gender differences in child malnutrition will be beyond the focus of the analysis.[2] Moreover, the study is confined to investigating causes of malnutrition. The consequences for the individual, higher burden of disease, elevated mortality risk, retarded cognitive development and impaired labour productivity later in life — or for society in the form of loss of human capital and slower economic growth — will not be addressed, but have recently been analysed elsewhere.[3]

The rest of the paper is organised as follows. The next section presents a brief overview of child nutritional status in India as a whole and by state. The theoretical framework and the econometric models to be estimated are presented in section 3. Variable definitions and measurements are outlined in section 4. Results from panel OLS, instrument-variable, fixed effect and first-difference regressions are presented in section 5. Section 6 reports results from regressions aimed at identifying the pathways thought which child malnutrition is caused. Section 7 aims at disentangling the extent to which the small reduction in child malnutrition is attributable to weak response to changes in determining variables and to small changes in these variables themselves. Qualifications and robustness tests are provided in section 8. Section 9 summarizes and section 10 discusses policy implications.

2. An overview of malnutrition in India and by state

[2] Differences in the formation of child malnutrition in rural and urban areas have recently been investigated by Smith et al (2005b) in a cross-country study. For recent studies of gender differences in India, see Pande (2003) and Tarozzi and Mahajan (2006).

[3] Behrman et al (2004); Alderman et al (2007); Grantham-McGregor et al (2007); Black et al (2008), Victoria et al (2008); Huddinott et al (2008; Lancet); Lópes-Casanova et al (2005); Deaton (2007), Walker et al (2007); Horton et al (2008).

The modest decline in child stunting and underweight between the years 1992/93, 1998/99 and 2005/06, when National Family and Health Surveys (NFHS) were carried out, is depicted in Figure 1. Between the first two surveys, child stunting was almost flat, while underweight dropped by 4 percentage points. Between 1998/99 and 2005/06 it was the other way around: child stunting declined by 7 percentage points, while underweight remained practically unaltered. These different developments provide an indication that child stunting and underweight may have partly different causes, a possibility to be examined.

[Figure 1 about here (insert China as well)]

India is far from being a homogenous country in terms of malnutrition. Child stunting and underweight have persistently been more prevalent in some of the land-locked northern and central states than in the rest of India (Figure 2). The rates at which the incidence of child stunting and underweight have changed also vary notably across the states. In six large Indian states, child underweight actually increased between the two most recent surveys. The subsequent statistical analysis aims at explaining this dismal development.

[Figure 2 about here]

Estimates of the incidence of child malnutrition across households according to "wealth" (possession of selected durable consumer goods) quintiles and maternal education in the whole of India are presented in Figures 3 and 4. The prevalence of child stunting and underweight in the household quintile with the lowest "wealth" score is more than twice that in the highest quintile. The ratio of the incidence of child malnutrition in households where mothers have no education to those with the highest is also above two. These observations provide an indication that income poverty and female education are likely to explain part of the variance in the prevalence of child (and mother) malnutrition across states in India (although they say nothing about relative impacts).

[Figures 3 and 4 about here]

It is notable, though, that stunting and underweight is prevalent (20-25%) also in the households in the highest wealth quintile and with mothers who have more than 10 years of education. This suggests that for children to be brought up in a relatively wealthy and well educated household is not sufficient for avoiding malnutrition. In turn, this indicates that factors other than household income and female education are contributing to child malnutrition. The subsequent statistical analysis aims at identifying these other causes.

3. Research strategy and estimation models

3.1. The implicit theoretical model

The implicit maximising model for households underlying the subsequent empirical investigations of determinants of child malnutrition can be thought of as akin to the Becker type of model of why parents invest in education for their children. Parental provision of adequate food and health care for children can be seen as an investment in their survival and future earnings capacity and hence for providing for parents at old age. Healthy and well nourished children may also have an intrinsic value to parents. The constraints on being able to provide for children are economical (household income), (maternal) knowledge about adequate feeding, sanitation and health-care practises, and the provision of public services. A further constraint can exist if fathers and mothers have different preferences for how the intra-household resources should be allocated.
/More formal model warranted?/

3.2. The empirical models

The empirical analysis based on panel data for three years (surveys) will proceed in three steps. In the first step, the regressions aim at quantifying the relative strength of what are assumed to be the fundamental reasons for the variation in child stunting and underweight across the Indian states. The fundamental variables to be tested are poverty, female illiteracy and a proxy variable for female autonomy. The basic regression model to be estimated has the standard properties:

(1) $$Y_{it} = \beta_0 + [\boldsymbol{\beta}_{\mathbf{k}}][\mathbf{X}_{\mathbf{itk}}] + \alpha_i + \lambda_t + \mu_{it},$$

Y_{it} is the outcome variable, alternately the prevalence of child stunting or underweight in state i. $\mathbf{X}_{\mathbf{itk}}$ is the vector of explanatory variables and $\boldsymbol{\beta}_{\mathbf{k}}$ are the coefficients to be estimated**;** α_i is an entity (state) dummy variable, λ_t is a time dummy and μ_{it} is the random error term**.** In s first round of panel regressions (OLS), the explanatory variables

($\mathbf{X_{itk}}$) are assumed to be strictly exogenous (Cov($\mathbf{X_{itk}}$,μ_{it}) = 0) and to enter the regressions linearly and independently (qualified later). Subsequently, instrument variable panel regressions will be run with and without entity and time dummies. The regressions with both state and time fixed effects will hopefully eliminate omitted variable bias due to unobserved variables that do not change over time and unobserved variables that are constant across the Indian states.

In the second step, an attempt s made to identify pathways through which child stunting and underweight are affected. More specifically, we will examine how nutritional conditions are related to certain health and household characteristics, so called confounding variables ($\mathbf{CV_{it}}$). The regression model applied is:

(2) $$Y_{it} = \pi_0 + [\boldsymbol{\pi_j}][\mathbf{CV_{ijt}}] + \alpha_i + \lambda_t + \nu_{it}$$

The confounding variables included in these regressions are mothers' nutritional status, qualified child health care provision, the fertility rate, feeding practises and sanitation facilities. (The theoretical justifications for choosing these variables are presented in a later section.) Since there may be causation in both directions between the Y_{it} variables and some of the confounding $\mathbf{CV_{itk}}$ variables, we will not be able to claim that all the latter variables cause malnutrition (when significant). The more modest objective is to lay bare which health-care-related variables that are the most closely associated with child malnutrition. As has been emphasised in the epidemiological literature since long (Thomkins and Watson 1989), it is seldom possible to identify the proximal root cause of poor health in children because many diseases and malnutrition are convolutedly intertwined (Bhutta 2006).

The third step will be to examine to what extent overall economic growth in the Indian states is related to changes in the fundamental variables, poverty, female illiteracy and the gender composition of the population (the male/female population ratio).

4. Variable measurements

All variables used in the subsequent econometric analysis are measured at the level of states in India. There are several hoped-for advantages with units of observation at this level of aggregation rather than unit-record data at the individual household level.[4] First, the state data allows the construction of balanced data panels that permits panel and first difference analyses.[5] A second advantage with data at the level of states is that externalities can be captured more accurately. Children's nutritional status depends on several household-specific characteristics, such as income and mothers' education, but also on unobservable variables that reflect the broader environment in which the household lives and dwells. These could be cultural norms that dictate women's role in society, or the general level of poverty in the area that may have bearings on the incidence of transmittable diseases and the quality of health-care services.[6]

A third advantage with aggregated data (i.e. states) is that noise of various types tends to average out, hopefully leading to more efficient estimates. Individual household data usually contain large random measurement errors, which induce an attenuation bias (Wooldrige 2006). Moreover, data for individual households also pick up short-term fluctuations in variables that do not reflect more permanent conditions.

There are, however, some potential drawbacks with using data at the level of states. One is that the limited number of observations (at the most 48 in some of the panel regressions) reduces the degrees of freedom and hence the size of the models that can be tested. The Indian states may also be too large and internally diverse. Ideally, smaller areas would be preferred, e.g. the 593 districts (in the 2001 Census) that comprise the next layer of administrative unit in India. However, representative data on child stunting and underweight, as well as on most explanatory variables, are not available at this lower level of aggregation.[7]

The data on child nutrition status are from the three National Family Health Surveys (NFHS 1-3) carried out in 1992/93, 1998/99 and 2005/06. Most other data are from the large 50th, 55th and 61st National Sample Surveys (NSS) conducted in 1993/94,

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4 Studies from India based on household observations include those cited in note 2 above; also see Borooah (2004) and references cited therein, the World Bank (2004), Radhakrishna and Ravi (2004) and Bharati et al (2008).

5 Other recent studies based on state data include Deaton and Drèze (2002), Besley and Burgess' (2004) study of labour market performance in India and Deaton's (2008) investigation of the causes behind the distribution of adult heights in India.

6 In the DHSs, data on some observable community characteristics are usually collected in rural areas, but so far not in urban settings.

7 The World Bank (2004) provides charts with the incidence of child underweight at a lower level than states in India, but acknowledges that these are not representative.

1999/00 and 2004/05, but also various other official sources including the Reserve Bank of India (RBI). The bulk of the Indian state data are obtained in overlapping years (1993, 1999 and 2005), which enable us to construct balanced data panels. A statistical supplement to this paper gives details of the data used, more complete references and discussions of data shortcomings (work in progress).

4.1. Dependent variables

Child malnutrition will be measured alternately by the prevalence of stunting and underweight among 0-3 year old children. Child stunting (underweight) is defined as a height (weight) for age below 2 standard deviations from the median height (weight) of the norm children. The age-specific estimates of stunting and underweight are derived on the basis of the WHO/NCHS norms.[8] Stunting (retarded skeletal growth) is conventionally regarded as the most sensitive marker of long-term deprivation of micro-nutrients and frequent and prolonged illness. Underweight (low mass of fat and muscle tissue) reflects calorie deficiency and more acute illness (Waterlow 1992; Shrimpton et al 2001; Lancet 2008). Wasting (low weight for height) was also tried in a first round of regressions, but few significant results were obtained as there is very little variation in this measure across states and over time.

The focus on children (and their mothers later on) is dictated by the seldom contested perception that they are the nutritionally most vulnerable groups. This is also reflected in the fact that anthropometric data for other population segments are not frequently collected. Estimates of child stunting and underweight are available for all Indian states, but most of the analysis here has to be confined to the 16 largest ones since

[8] In 2006, the WHO changed the norms for "normal" height and weight for specific age and sex. In the case of India, this implied that the share of stunted children aged 0-3 years in 2005/06 jumped from 38.4 to 45.2%, while the share of underweight dropped from 45.9 to 41.8%. Since there are no estimates of stunting and underweight by state with the new norms for previous survey years, we use the old ones in order to accomplish inter-temporal comparability. It is notable, though, that the choice of norms affects the estimated levels of stunting and underweight, but have little impact on the inter-state differences or the rates of change over time, which are the concerns here. The work with establishing new norms also entailed a renewed investigation of whether the standard international norms for child genetic potential growth apply to Indian young children as well, which the study confirmed (Bhandari et al 2002).

data for many explanatory variables are lacking for the 17 mini-states and Union Territories (jointly with 4% of the Indian population).[9]

4.2. Fundamental explanatory variables

Poverty. At the level of states in India, the share of the population that can afford an adequate diet is determined mainly by average household per capita income, the inter-household distribution of incomes and relative (food) prices — the three main building blocks behind the poverty estimates. Food comprises about half of total consumption expenditures of the average Indian household and nearly three-fourths in the lowest income quartile (Sen and Himanshu 2004). Low income also constrains households' ability to feed children food with a high and balanced micro-nutrient content as such food items, i.e. animal products, fruits and vegetables, are invariably more expensive than staple grains. Poverty further reduces households' ability to demand for qualified child and maternal health care. India is special in the sense that three-quarters of all health expenditures are private, out of the pocket. This proportion is higher than in almost all the other 192 countries for which the WHO (2007b) provides estimates. Income poverty also constrains household demand for adequate housing, sanitation and water supply.

Female illiteracy. Mother illiteracy will be used as the measure of maternal ability to care well for children. There are at least four reasons for expecting maternal illiteracy to impair the nutritional status of their children. One is that illiterate mothers are in a disadvantaged position to acquire and apply knowledge about appropriate health-care and feeding practices. A second is that uneducated women are likely to be less able to care well for themselves in terms of nutrition and health and therefore less apt to care for their own children. A third is that uneducated women marry earlier and have higher fertility (Abadian 1996; Smith et al 2003; Smith et al 2005a). A fourth reason is, as we will see, that illiterate women abstain from exercising their right to vote in state election more often than their literate peers and this affects the public provision of child health care.

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[9] The prevalence of poverty in the smallest states and the UTs are simply assumed to be the same as in neighbouring larger states (GOI 2007). In 2001, three of the largest Indian states (Bihar, Madhya Pradesh and Uttar Pradesh) were split up into two separate states. In order to accomplish comparability with earlier

Mother's autonomy. In India, as in most countries, mothers are the chief caretakers of children, feeding them and seeking health care when they are sick. Mother's possibilities of undertaking these responsibilities — given their ability — can be constrained by gender-biased cultural values. The less autonomy or clout women have within the household and in society, the less likely it is that their own and their children's wellbeing is prioritised in the intra-household allocation of resources (Abadian 1996; Smith et al 2003). Ancient cultural norms that subjugate women in India and other south Asian countries have been advanced as the main reason why malnutrition in this region is much more prevalent than in poorer Sub-Saharan Africa (Ramalingaswami et al 1996). This study will investigate whether differences in gender-related cultural values within India contribute to explaining — with due controls for other influences — the inter-state variation in child malnutrition.

The male/female (M/F) population ratio will be used as the proxy variable for female autonomy. This measure of "missing women" is mainly determined by differences in sex-specific death rates for different age cohorts and the sex ratio at birth (Sen 1992). A higher than normal M/F ratio in a population reflects excess death rates of females in general in the wake of discriminatory treatment in health care and nutrition within households, but also sex-selective abortions (Jha et al 2006).

5. Results

5.1. OLS and instrument variable panel regressions

The results from the first round of OLS panel regressions are presented in Table 1. In the regressions for child stunting, all three fundamental explanatory variables turn out highly significant: poverty, female illiteracy and the M/F ratio. In the regressions for child underweight, poverty and female illiteracy are significant, but not the proxy variable for women's autonomy (the M/F ratio). All the standard errors are heteroskedasticity robust. Moreover, the three fundamental variables are only weakly correlated internally, signifying no problems with interpretation due to multicolinearity.

[Table 1 about here]

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state division, all data from 2005/06 for the "new" states have been merged (population weighted average) into the three "old" states.

The second time dummy is negative and significant (at the 0.05 level) in the regressions for stunting (but not for underweight), suggesting that stunting has declined over and above what is explained by changes in poverty, female illiteracy and the M/F ratio between the early 1990s and 2005/06. This indicates that there may be an omitted variable bias in the regressions for stunting, but not for underweight.

The OLS panel regressions reported in Table 1 are based on the assumption that the right-hand side variables are strictly exogenous. This may not be the case. One question is whether malnutrition in children affects mothers' literacy. Mothers who have failed to gain literacy at school age could be prevented from learning how to read and write later in life if they have many malnourished and sickly children demanding all their time. Normally, however, female literacy is obtained at an age that predates childbearing, providing a natural lag, signifying that reverse causality from malnutrition in children to maternal illiteracy is a rather infrequent possibility. The risk that the OLS results have been seriously distorted by simultaneity bias on this account hence seems small. There could be a "third" factor that explains both child malnutrition and maternal illiteracy, e.g. the conservative cultural norms that discriminate against women in India. These norms have hopefully been internalised by entering the M/F ratio variable in the regressions.

The risk of endogeneity bias seems larger when it comes to poverty. A possible link exists from the confluence of child malnutrition and many children in households (high fertility) to reduced female labour supply and lower household income (Smith and Haddad 2002). From a theoretical perspective, however, the nutritional consequences for children of mothers working outside the home are ambiguous. Working mothers may contribute to household income, which is expected to reduce child malnutrition. On the other hand, outside work implies less time for child feeding and health care, with possible adverse nutritional outcomes. At least one study has found the net effect on child nutritional status in India to be ambiguous (Radhakrishna and Ravi 2004; IFPRI studies).

We have nevertheless chosen to instrument poverty, although identifying a variable that constitutes a convincing instrument for poverty is difficult. The share of the labour force engaged in agriculture will be the variable tried here. In all India, labour productivity and incomes in the agricultural sector is about one-fifth of that in industry and services (Bosweorth et al 2007; Lal 2008). It is hence not too farfetched to expect a link from high concentration of labour to agriculture to high prevalence of poverty. Notable is that the of labour share in agriculture (LSA) in all-India has only declined from slightly above 60% in the early 1990s to 54% in the mid 2000s (NSS).

As expected, in the first-stage regression of poverty on LSA (and female illiteracy and M/F), the LSA variable comes out highly significant (0.01)**.** Moreover, in this regression the F-statistic is 11.1, slightly above the 10.0 that is the rule-of-thumb value used to identify a valid instrument (Stock and Yogo 2005; Stock and Watson 2007). We can hence tentatively rule out that LSA is a weak instrument for poverty./Alternative instrument?/

The results from the IV regressions for child stunting and underweight are reported in Table 1. Poverty (OLS) and instrumented poverty (LSA) are highly significant in the regressions for both stunting and underweight. It is notable, though, that the estimated coefficients are about twice as high in the IV regressions in both cases. Female illiteracy turns out insignificant in the IV regressions, while significant in the OLS regressions. It is not straightforward to provide a convincing factual explanation for this discrepancy. /Have to think this over/ The M/F variable remains highly significant in the regressions for stunting, while it is (weakly) significant in the IV regressions for underweight, but not in the OLS regressions.

5.2. First-difference and fixed-effect regressions

The large inter-state differences in the fundamental determinants of child malnutrition, poverty and female illiteracy and autonomy (M/F), are the outcomes of processes that have evolved over many decades — if not centuries (Banerjee and Iyer 2005). From a policy perspective, an important question is whether recent improvements in these variables have led to reduction in child malnutrition. In the previous OLS and panel regressions for stunting (Table 1), the second time dummy came out significant. This suggests that between 1993 and 2006, child stunting (while not underweight) declined over and above what changes in the independent variables could explain. In this sub-section, we will examine changes over time in more detail. The two additional alternative methods for testing changes over time (in the absence of yearly time series) are first-difference and fixed-effect regressions. Since there are no simple rules for discriminating between these two methods (Wooldridge 2006) we will apply both.

The fixed-effect panel regressions will be based on model 1 above. The first-difference regressions for child stunting/underweight on changes in poverty, female illiteracy and in the M/F ratio across the Indian states are based on the following model:

(3) $\Delta Y_i = \theta_0 + [\boldsymbol{\theta}_{\mathbf{ik}}][\Delta \mathbf{X}_{\mathbf{ik}}] + \varepsilon_i,$

where the Δ stands for first-difference change in respective variable.

The results for first-difference regressions (changes between 1992/93 and 2005/06) are reported in Table 2. In the regressions for child stunting, changes in poverty, female illiteracy and the female/male population ratio are all significant with the expected signs. The size of the regression coefficient for female illiteracy (around 0.80) suggests a large quantitative impact: a 1 percentage point reduction in female illiteracy is followed by a 0.80 percentage point decline in child stunting. The equivalent coefficient for poverty is smaller (0.50), but also highly significant. The M/F ratio is also significant, but the size of the regression coefficient defies an easy interpretation. The results for stunting reported in Table 2 square reasonably well with those obtained in the previous cross-sectional OLS panel regressions and also the IV regressions (Table 1).

[Table 2 about here]

In contrast, first-difference regressions for child underweight on changes in the fundamental variables yield only weak significance for female illiteracy, but at such low level that the F-statistic is insignificant. This result is not totally surprising considering that the decline in child underweight in all-India and in many states was minuscule between the early 1990s and mid 2000s. There is, however, the possibility that some important variable may have been omitted from the regressions. A chief suspect is underweight in mothers in accordance with the "Asian enigma hypothesis", which we shall investigate in a subsequent section.

The (state) fixed-effect results are considerably weaker. In the regressions for stunting, poverty is insignificant. Female illiteracy is highly significant when no time dummies are included in the regression, but once these are entered, significance disappears. The M/F ratio is significant when time dummies are included, but not when these are left out. In the regressions for underweight, the female illiteracy variable turns out significant, but only when time dummies are excluded. The overall weak results in the regressions for underweight are likely due to the minuscule changes in this variable over the measured period.

6. PATHWAYS

In the earlier discussion of the motivations for selecting the fundamental explanatory variables, several pathways through which these variables are hypothesised to affect child malnutrition were sketched. Most of these pathways were examined in preparatory work and results from two of these exercises will be presented here.

6.1. Inter-generational perpetuation of malnutrition

Hypotheses. A commonly adhered to hypothesis is that when mothers are malnourished, there is an elevated risk that their children will become malnourished as well — inter-generational perpetuation of malnutrition (Ramalingaswami et al 1996). There are at least three plausible reasons for expecting this. One is that underweight in pregnant women increases the likelihood of low birth weight (LBW<2.5 kg), which in turn is a strong predictor of underweight in infancy and early childhood (ACC/SCN 2000; Osmani and Sen 2003; Lancet 2008). The second reason is that malnutrition in lactating mothers reduces the micro-nutrient content in their breast milk, affecting infant growth adversely (Allen 2005). The third reason is that malnourished mothers are presumably weaker and more sickly and hence less able to care well for their off-springs (Lancet 2008).

The first link in the pathway to be tested is the determinants of malnutrition in mothers, as measured by a body mass index (BMI) below 18.5. Maternal BMI failure is hypothesised to be determined by the same fundamental variables as child stunting and underweight, i.e. poverty, female illiteracy and autonomy. The second link that we intended to test is that between mother underweight and LBW. Unfortunately, there are no representative estimates of the prevalence of LBW in the Indian states (Mistra 2002). The 30% estimate for all-India routinely provided by UNICEF and other international organisations builds on births in selected medical institutions (ACC/SCN 2000). We can hence not test this link. The next link tested is therefore the one between stunting and underweight among children and mothers with a BMI<18.5, with controls for child health care provision, size of households, feeding practices and sanitation facilities.

The case for including health-care provision rests on findings in the epidemiological literature; mounting evidence shows frequent and prolonged untreated illness to be one of the most important factors behind child malnutrition (Black et al 2008; Victoria et al 2008). Moreover, recent epidemiological research finds that micro-nutrient deficiency aggravates infectious disease, which in turn leads to mal-absorption of several micro-nutrients, stifling child growth in a vicious circle (Bhutta 2006).

The total fertility rate (TFR) is included in the regressions as a control on the assumption that many children in households mean that mothers have less resources and time to care for each child. High fertility also implies shorter birth spacing and time for mothers to recuperate (Dewey et al 2007). Moreover, high fertility goes hand in hand with mothers being very young and inexperienced when giving the first birth (NFHS-3 2007).[10] The feeding practice variable is included as there is almost universal agreement among experts that from the age of six months infants should be fed supplementary solid food in order to ensure full genetic potential skeletal growth. Adequate sanitation is important mainly for reducing water-born diseases such as diarrhoea — a contributing cause of malnutrition (and also the second largest killer of post-natal infants and young children in poor countries).

Data and variable measures. The two latest NFHSs provide comparable estimates of the share of mothers with a BMI<18.5, while no such estimates were obtained in the first NFHS (1992/93). Neither were comparable data for feeding practices collected in this survey. We hence have to restrict the panel for the 16 states to two points in time. Average household size is measured by the total fertility rate and feeding practises by the share of 6-9 month olds who in addition to breast milk are regularly fed solid or semi-solid food. Sanitation is proxied by the availability of a flush toilet or a covered latrine in the home. Data on all these variables are from the NFHSs. [11]

[10] Data from the 2005/06 NFHS show the incidence of underweight to be positively correlated to the (higher) birth order of the children (NFHS-3, table10.1). There is most probably causation in both directions between child malnutrition and the fertility rate, as child stunting/underweight raise the infant mortality rate and hence fertility through the replacement effect.

[11] The definition of safe water has unfortunately changed drastically between the three NFHSs, which means that this variable cannot be included in the regressions.

There is no summary statistic on the share of children that is provided with qualified health care in the Indian states. Therefore, a child-health-care index (CHCI) was constructed that includes both preventive and curative health-care services. The index is defined as the average of the shares of (1) births in medical facilities, (2) births assisted by health professionals, (3) children being fully vaccinated and (4) children brought to a health facility when suffering diarrhoea. The four variables are internally highly correlated, which indicates that in unison, they should measure well the general reach and coverage of qualified health-care provision for children. There is large variation across the Indian states in child health care provision, as measured by this index, reflecting differences in demand and supply.

Results. In OLS panel regressions for child stunting on the confounding variables, mother's BMI status is insignificant in combinations with other variables (Table 3). Stunting is the most strongly associated with the child health care index. The feeding practice variable is highly significant in the regression without a time dummy, but insignificant when this dummy is entered, and is hence not robust (Table 3). The time dummy itself is significant with a negative sign, indicating that stunting declined over and above what is "explained" by the confounding variables. In sharp contrast, in the regressions for child underweight, mother's nutritional status (BMI) is highly significant. Also the TFR is highly significant with the expected positive sign, while child health care, feeding practices and sanitation turn out insignificant. In this regression, the time dummy is also insignificant.

[Table 3 about here]

That child stunting is strongly associated with lack of qualified preventive and curative health care is consistent with the epidemiological findings that frequent and prolonged untreated illness impairs infant and child skeletal growth, which is practically irreversible.[12] That underweight is not associated with inadequate health care could be consistent with the observation that weight loss (fat and lean tissue) related to disease can be reversed once the child recuperates. That child underweight is strongly associated with (or caused by) maternal underweight is consistent with the well-established link from

[12] It is widely agreed in the epidemiological literature that stunting in infancy and during the first two or three years of life is the main determinant of short height later in life and that the potential for "catch-up" growth later is small (Shrimpton et al 2001).

underweight in pregnant women to low birth weight and subsequent underweight in infants and young children (ACC/SCN 2000). That the TFR is a significantly associated with child underweight is probably because in households with many children, mothers have less time for feeding and caring well for each of them. The hypothesis ventured in section 2, that child stunting and underweight have partly different determinants, is hence in agreement with the data.

6.2. Female voting and public child health care provision

Given the apparent importance of qualified child health care for alleviating malnutrition, especially stunting, we shall make an attempt in this section to examine in some more detail a presumed pathway from female literacy to child health care.

Hypotheses. Households' demand for qualified child health care is assumed to be determined by income poverty, female education and autonomy. The supply of public health-care infrastructure is assumed to be determined by government expenditures allocated to the health sector in the states. It is further assumed that women generally give higher priority to health care for children than their husbands (Abadian 1996; Smith et al 2003).[13] Moreover, mothers are expected to be able to spend relatively more of household resources on qualified health care for their children if they are literate and have autonomy. Finally, we assume that by voting in state elections, mothers may be able to affect state governments' expenditures for health care in general and for children in particular.[14]

There are hence four links in the pathway to be tested. The first is what determines the share of women who exercise their right to vote in state elections relative to men. The second link is that between state governments' allocation of resources to the health-care sector and women/men turnout in the elections. The third link is that between provision of child health care and state health expenditures (rupees per capita and year). The final link is that between child health care and child stunting and underweight, which

[13] It is notable that most micro-credit schemes in poor countries target women as the prime lenders.

[14] The supply of public health care facilities is largely determined by the budget allocations of state governments, which are responsible for health and education in the states, while the central government is a minor provider of founds.

was already reported in Table 3 (N=32), but a further test on a larger data set (N=48) and partly different confounding variables will be reported from below.

Data and variable measures. The data on voting turnout refer to the latest state election preceding the years in which the national nutritional surveys were carried out (1992/93, 1998/99 and 2005/06) as reported by the Election Commission of India. The state government health expenditures per capita (SGHE/C) in respective year will be measured in real 1993 rupees. The data on Net State Domestic Product per capita in real terms are from the Reserve Bank of India. The provision of qualified health care for children is measured by the CHCI (see above).

Results. The results from OLS panel regressions of the four links in the pathway are reported in Table 4. The panel covers the 16 largest states in India in three years. In the first regression (column 1), the female/male turnout ratio is the dependent variable with female illiteracy as the explanatory variable of main interest; total turnout, poverty, the M/F ratio and time dummies are entered as controls. Female illiteracy comes out highly significant along with total turnout and poverty, while the M/F ratio is insignificant.

[Table 4 about here]

In the second regression (column 2), state government real health expenditures per capita (SGHE/C) is the dependent variable, regressed on F/M turnout ratio in the elections and controls and time dummies. The F/M turnout is highly significant, while the total turnout is significant with a negative sign! In this regression, the NSDP/C comes out insignificant, although with the expected positive sign. In the third regression (column 3), with the CHCI as the dependent variable, the SGHE/C variable turns out significant with the expected sign. The control variable the total fertility rate is highly significant, but the sanitation variable is insignificant.

In colums 4 and 5, child stunting and underweight (alternately) are regressed on the CHCI with controls and time dummies. The CHCI turns out significant in both regressions, but more strongly so for stunting than for underweight.[15] In the regression for stunting, the TFR also comes out significant while not the sanitation variable. In the

[15] It should be noted the CHCI variable came out insignificant in the regression for child underweight reported in Table 3, based on a shorter panel, but including maternal underweight (highly significant) for which no data exist in 1992/93.

regressions for child underweight it is the other way around. Sanitation is highly significant, while the TFR is insignificant. These results indicate that the pathways through which child stunting and underweight are caused do differ.

That female illiteracy, but not the proxy for women's autonomy, determines the women/male turnout in state elections is perhaps surprising from an Asian-enigma perspective. That the voting turnout of women relative to men — but not the total turnout — has a positive effect SGHE/C underscores, however, that empoverment of women is important for child health. The result that SGHE/c seems to have an impact on the actual provision of health care for children was not entirely expected. In India as a whole, the share of health in total state expenditures is lower (3.9%) than in all but a handful of other countries (WHO 2007b) and about three-quarters of all health expenditures are private, out of the pocket. Considering also that state health expenditures fluctuate wildly from year to year and actually seems to be *the* residual item in the state budgets, the link to child health care provision is somewhat surprising.[16] Finally, the results in Table 4 are consistent with the epidemiological findings that qualified health care is important for reducing illness and hence for avoiding impaired skeletal growth (stunting) in infants and young children.

7. Little poverty reduction – little malnutrition reduction

The results from the OLS and instrument-variable panel regressions (Table 1) show poverty and female illiteracy to be highly significant determinants of child malnutrition as manifested in stunting and underweight. Also the first-difference regressions (Table 3) show decline in poverty and female illiteracy to reduce child stunting significantly, but not so for underweight (which we at least partly explain by the minuscule change in underweight over the period). That income poverty and female education matter for child nutritional status in India is fully in line with results obtained in most related studies, based on cross-country or unit-record observations in individual countries, which is reassuring.

[16] The residual property and the high year-to-year fluctuations in public health expenditures in the Indian states have been highlighted in a recent official report (NCMH 2005, p.71).

There is, however, compelling reason to go a few steps further in the strive to understand why child stunting and, especially, underweight in India have not declined more rapidly since the early 1990s. Considering an impressive overall growth of net state domestic product per capita in India of about 4.5% per annum, reductions of stunting and underweight by 12 and 5 percentage points over this period seem small. The estimated coefficients for both stunting and underweight with respect to poverty and illiteracy in the OLS panel regressions all in the range 0.31 to 0.39 and twice as large in the IV regressions (Table 1). In the first-difference regressions for stunting, a 1% point reduction in the incidence of poverty translates into a decline in the prevalence of child stunting by about 0.5 percentage point (Table 4). Whether the size of these coefficients should be deemed small or large is difficult to say since no previous comparable study of child malnutrition has used poverty as the explanatory income variable. In the methodologically akin cross-country investigations, the income measure used is per capita GDP, and an income-malnutrition elasticity of around -0.50 is a standard result.[17]

What we can say with considerable confidence is that the growth of NSDP per capita in all-India by 4.5% per annum between 1993/94 and 2004/05 (RBI 2007) was followed by relatively little poverty reduction. Between the same years, the officially estimated incidence of poverty dropped by 8.5 percentage points only, or by 23.6% in relative terms. In relation to an accumulated increase in the NSDP/C by 61.5%, this suggests a rough aggregate poverty-income elasticity of the order -0.38. In a study based on data from 1958 to 1991, Datt and Ravallion (1996; 2002) found the poverty-income elasticity in India to be between -0.75 and -1.09 depending on the assumptions made. Although a more detailed comparison between the pre- and post-1991 period is called for, the reduction of poverty in response to economic growth in the Indian economy seems to have slowed down considerably.[18]

Moreover, there is no correlation whatsoever between poverty reduction and cumulative growth of net state domestic product per capita (NSDP/C) across the Indian

[17] Smith and Haddad (2002); Haddad et al (2003); Svedberg (2004).

[18] The recent trepid poverty decline in response to accelerating growth in all-India also seems meagre in international comparison. Available estimates of poverty-income elasticities, based on cross-country panel data, are in the -0.67 to -1.94 range, depending on estimation method and type of data used (Kraay 2006; Loayza and Raddatz 2006). Also see Deaton and Drèze (2002)

states over the period 1993/94 to 2004/05 (Figure 6). This is so irrespective of whether the sample is restricted to the 16 large states included in previous regressions, or all states for which data are available (25). All 25 states experienced some growth of NSDP/C and some poverty reduction, but the expected negative significant correlation fails to materialise (the regression line is positive, but insignificant). This is in sharp contrast to cross-state observations for India, which reveal a very strong correlation between levels of poverty and NSDP/C. This observation provides a further indication that the link between poverty reduction and overall economic growth in India has changed since the early 1990s.

[Figure 6 about here]

Although a full-fledged analysis of the reasons for the meagre decline in poverty in all-India (and the lack of correlation between income growth and poverty reduction across the Indian states) is beyond the scope of the present paper, one can identify four plausible contributing factors. One is that the share of consumption expenditures, as broadly measured in the national accounts, fell from 66% to 56% between 1990 and 2006 (ADB 2007). A second reason is that consumption expenditures as measured in the NSS household surveys — the basis for the poverty estimates — are only some 60-70% of consumption as measured in the national accounts, and seems to have grown more slowly (Datt and Ravallion 2002).

A third reason is that the distribution of NSS household consumption expenditures has become more uneven over time: the Gini coefficient for household expenditures increased by 3.5 points between 1993/94 and 2004/05. This is mainly because annual growth of real per-capita consumption expenditures in the lowest income quintile was a meagre 0.85% between the same years, while above 2% in the highest quintile (ADB 2007).

The slow growth of consumption expenditures among the poorest, in turn, is at least partly an outcome of the fact that income growth in India has been very uneven across sectors, with agriculture as the lagging sector. During the 1993-2004 period, annual growth of output per worker in the agricultural sector averaged 0.5% while in the industry and service sectors, growth was 0.9% and 2.1%, respectively (Bosworth and

Collins 2008).[19] The fact that more than half of the Indian labour force is still employed in the relatively stagnant agricultural sector is hence consistent with little reduction of poverty — and of child malnutrition.[20]

The growth of household income has been especially low in the most populous states with the initially highest levels of malnutrition, Bihar, Madhya Pradesh and Uttar Pradesh. This is another contributing factor behind the tardy reduction of child malnutrition as measured by underweight in all-India. These three states were home to more than half the underweight children in India in 1993. As can be seen from Figure 6, the three states had very little accumulated growth of NSDP/C and minuscule poverty reduction over the next 13 years — and little reduction of child underweight. The slow decline of child underweight in all-India is hence partly explained by the unfavourable overall economic performance and persistent poverty in the most populous states. In the cross-state regressions, in which all states carry the same weight, this size-of-state issue is hidden.

We also examined how the declines in female illiteracy and in the male/female population ratio relate to economic growth across the Indian states. In short, the reduction of female illiteracy between the early 1990s and mid 2000s was found to be significantly related to growth of NSDP/C, albeit at a rather low level of significance (0.05). The minuscule change in the M/F population ratio over the same period was unrelated to economic growth.

8. Qualifications and robustness tests

In previous sections, controls for endogeneity, heterskedasticity and robustness were made. There are a few other measurement and methodological issues to be addressed.

8.1. Multicolinearity

[19] In recent years it has become increasingly clear that the sector composition of growth matters considerably for poverty alleviation and that slow productivity growth in labour-intensive sectors in general and in agriculture in particular, is the major reason for the failure to reduce poverty more forcefully in the developing countries in general (Loayza and Raddatz 2006).

[20] In the 2000 NSS labour survey 58% of the labour force was in agriculture and 54% in the 2005 survey. In absolute numbers, the agricultural labour force in India increased by 5 million, from 202 to 207 million between these years (ADB 2007).

The main reason why a distinction has been made between fundamental and confounding variables is that they are expected to be highly correlated. Including confounding and fundamental variables in the same regressions for child stunting or underweight could hence cause problems with multicolinearity. To test this hypothesis, the confounding variables were regressed on the fundamental variables. The results are presented in Table 5.

As expected, the confounding variables are significantly correlated with many of the fundamental variables, but partly different ones. In panel OLS regressions for maternal BMI failure, poverty and female illiteracy turn out highly significant with the expected signs. The M/F proxy is insignificant, however, indicating that women autonomy (as measured here) is not affecting their nutritional status.

The CHCI is significantly and negatively associated with poverty (reflecting affordability) and mother's literacy and autonomy (reflecting maternal knowledge and priorities within households). The total fertility rate is strongly correlated to female illiteracy, while unrelated to poverty and the M/F ratio, a perhaps surprising result. In the regressions for feeding practices, the M/F ratio and female illiteracy are significant but poverty is not. This is the only regression in which the time dummy is (strongly) significant, with a positive sign, indicating unexplained improvements in feeding practices over time in India at large.[21] Sanitation facility (flush toilet) is highly correlated to female illiteracy with the expected sign, but not to any of the other fundamental variables. Finally, it is notable that all five confounding variables are significantly correlated to female illiteracy — with the expected signs.

8.2. Data shortcomings

India probably has better, more disaggregated and more comprehensive data on most variables that have been used in this study than any other low- and middle-income country. Still, there are shortcomings. One is that in the first NFHS (1992/93), estimates of the prevalence of stunting are missing for five of the 16 large states included in our regressions. With an aim to have a balanced data panel and maximum degrees of

[21] A strong association between the TFR and maternal education has been found in several studies, although an unambiguous line of causation is difficult to establish (Doepke 2004).

freedom, as well as not "wasting" data on other variables, we have interpolated the 5 missing data points on stunting, using a regression technique borrowed from the WHO (de Onis et al 200?). The method relies on estimating the correlation between stunting and underweight on the basis of the 11 states with complete data on both variables in 1992/93. The ensuing regression equation (highly significant) is then used to estimate stunting from the available data on underweight in the five states.[22] As a check of the reliability this method, we re-ran all regressions for stunting omitting the five missing observations (five states in 1992/93). The ensuing results, based on 43 observations, did not differ in any significant manner from those obtained earlier.

A second data shortcoming is that some of the variables used in the panel regressions may not be strictly comparable over time. A large number of scholars have pointed out measurement anomalies in estimated household consumption expenditures in the 1999/00 NSS survey. These anomalies may have compromised the comparability of the poverty estimates for this year and the other two survey years. This potential incomparability, in turn, may have distorted the panel regressions reported in Tables 1 and 2. Several attempts have been made, though, to correct the official poverty estimates from 1999/00 so as to make them more comparable with the estimates from 1993/94 (and 2005/06). [23] Deaton's (2003) scrutiny of the base data and his re-estimation of poverty in 1999/00 is perhaps the most trustworthy such undertaking. To control for the bias in the official poverty estimates, re-ran all previous cross-state regressions based on Deaton's alternative poverty estimates for 1999/00. Quite reassuringly, not a single result was turned around. In fact, the differences were negligible and the regressions based on Deaton's poverty estimates actually turned out marginally stronger than when based on the official ones. This could be interpreted as a vindication of the frequent claim that the official ones do underestimate poverty in 1999/00. There has been no questioning of the inter-temporal comparability of the poverty estimates from 1993/94 and 2004/05 when

[22] Similar methods are frequently used by the international organisations to fill in missing data points, e.g. by the World Bank when estimating GDP per capita in countries with incomplete or obsolete data. The Bank's International Comparison Program includes benchmark estimates for less than half the about 200 countries contained in World Development Indictors.

[23] There is no agreement on the size of the bias. Sen and Himanshu (2004) claim that the official poverty estimates from 1999/00 are far too low and that the decline in poverty over the 1990s to be much smaller than the official estimates suggest. Datt and Ravallion (2002) find the official estimates to be only slightly

based on a uniform recall period, which we used in the first-difference regression (Table 2).

A third potential data problem is that for some variables, alternative estimates are available. There are at least three independent statistical sources providing estimates of female literacy: the NFHSs, the NSS and the Censuses. If these provide diverging estimates, the use of one particular data set could be ambiguous and induce non-robust results. When choosing data on female (il)literacy to be used in the present study, estimates from the three (independent) sources were compared, for India as a whole, and for the individual states. The comparisons revealed a very close correspondence both in terms of levels and in changes over time, indicating that no major measurement bias is likely to be found in the (il)literacy estimates. The decision to use the estimates from three NSSs was dictated mainly by the fact that these surveys were conducted in the same years as the NFHSs and they cover the same age group over time (females 7+ years). These three NSS surveys are quintile, implying that they are especially large (thick).[24]

A further potential problem is that data unavailability has led to the omission of some variables that theoretical considerations suggest should be included in the analysis. The most obvious is the prevalence of LBW, for which no representative estimates are available for the Indian states. The sanitation variable "safe water" was also omitted because the definition has changed drastically over the NFHSs. Relative food prices have not been entered as an independent explanatory variable in the child malnutrition regressions. Food price differences, across states and urban/rural areas, as well as over time, have been taken into account indirectly since the state-, urban/rural- and time-specific poverty lines used for the estimation of poverty incorporate such differences.

8.3. Blunt proxy variables

Some of the proxy variables applied in this study could be poor measures of what they intend to capture. The M/F population ratio, for instance, may not be the most adequate measure of women's autonomy in households and society. One problem is that the M/F ratio could have been compromised by gender-specific emigration and/or inter-state

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off the mark, while Deaton's (2003) find the official estimates to be some 3-4 percentage points too low. (For additional contributions to this debate, see Deaton and Kozel 2005, Pogli et al 2005; Reddy 2007.)

[24] In the NFHSs, the age group covered has changed over time /Check again/

migration. Kerala, for instance, is the only state where the M/F ratio is below unity (around 0.96). This is at least partly a consequence of the fact that large numbers of men in Kerala migrate to the Gulf states. It is notable, though, that in other Indian states, emigration and non-seasonal inter-state migration are minuscule and has been so over the period of concern (Lucas 1998; Srivastava and Sasikumar 2003).

An alternative proxy for female autonomy used in related literature is female labour market participation. This variable may be poor proxy for autonomy since it can have an independent impact on child malnutrition. It was nevertheless tried as an alternative to M/F, but no significant results emerged. A contributing reason may be that the female participation rate is not well defined and poorly measured in the Indian states. Official labour market statistics set the rate at about 25% and with little variation over states or time. It may also be that our proxy for feeding practices is too blunt, but it is the only one available in all three NFHS.[25]

8.4. Specification bias

In the models tested, all explanatory variables were entered linearly and independently in the regressions. Linearity means that the marginal effect of a change in an explanatory variable is assumed to be constant, both across different levels of the variables and across different states. To check the validity of this assumption, plot inspections of all regressions were made. Only in some regressions in which the total fertility rate is included, a non-linear specification seemed justified. Re-estimations showed, however, that the improvements in fit were negligible.

The independency assumption underlying the regression model applied was tested by introducing the interaction variable poverty*female illiteracy in the regressions. The regressions in which poverty and female illiteracy were entered jointly, but separately, provided better fits as measured by R-square. However, in the regressions where the inter-action variable replaced these two variables, it was significant at a very high level. It

[25] In the most recent NFHS (from 2005/06), several measures of child feeding practices are provided, such as newborns breastfed within one hour of birth, children aged 0-5 months exclusively breastfed, and children aged 6-9 months receiving supplementary solid food. In the earlier NFHSs, most of these data were not collected in a comparable manner.

hence seems that whether poverty and female illiteracy are entered separately or as an interaction variable matter little for the results.

9. Summary of findings

The main objective of this study has been to explain why the reduction in child malnutrition has been relatively small despite the impressive overall performance of the Indian economy since the early 1990s. Although the results are only indicative, we have found that while poverty reduction has a significant impact on the alleviation of child malnutrition in India However, poverty decline has been modest despite high aggregate growth in the economy. This, in turn, is at least partly a consequence of slow growth of household real consumption expenditures among the poorest quintiles that are predominately employed in the agricultural sector. In this sector, factor (labour) productivity growth has been much slower than in the rest of the Indian economy and even declined since the late 1990s (Lal 2008).

Female illiteracy was found to be a strong determinant of child malnutrition, which is in line with results in earlier related literature. In all-India, female illiteracy has declined notably since the early 1990s, from 55% to 39% in 2005. Masked behind these averages, however, is the fact that female illiteracy fell less in the rural areas of the most populous states, with the initially highest prevalence of child malnutrition. In these states, Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh, rural female illiteracy was still well above 50% in 2005 and the rural population accounts for 75-87% of the total in these states.[26] Overall improvements in female literacy has helped bring down child malnutrition according to the results reported here, but in rural India, female illiteracy is still more than twice as high as in urban settings (46 vs 20% in 2005).

The third fundamental explanatory variable for child malnutrition in this study, the M/F population ratio, used as a proxy for women's autonomy, was found to have a significant impact on child stunting in the panel and first-difference regressions, but not on underweight. In all-India, the M/F ratio has changed only marginally over time, from

[26] In the 2001 census, the three (pre-secession) states had a joint population of 374 million, or 36.4% of the total in India. The population in Uttar Pradesh, at 175 million, exceeded by far the entire population in Pakistan in 2001 (141 million) and in Bangladesh (133 million). No single country in Africa or Latin

107.9 in the 1991 census to 107.1 in the 2001 census, and is estimated at 106.8 in 2006 (GOI 2006b). A recent nationally representative estimate of the M/F ratio at birth found it to be 111.2, reflecting mainly gender selective abortions (Jha et al 2006). This signals that the gender bias in India is not about to erode in the near future.

In addition to estimating the relative strength of fundamental variables behind child malnutrition, we have examined two pathways through which children's nutritional status are assumed to be affected. The first is the link from mother to child nutritional status. Child underweight (but not stunting) was found to be highly correlated to underweight among mothers. This is in line with the world-wide observation that malnutrition in expecting mothers is a strong predictor of LBW and subsequent underweight in infants and young children (ACC/SCN 2000). Unfortunately, we were not able to test the LBW link directly due to the unavailability of data on birth weights. Underweight in mothers (BMI<18.5) themselves was found to be significantly correlated to poverty and own illiteracy (but not the M/F ratio), the same fundamental variables behind child underweight.

The second pathway focused on the link from female illiteracy, women's turnout in state election and state government expenditures on health care. The variable women/men turnout ratio was found to be strongly associated with women literacy, but also with poverty and total turnout (female and male). A high women/men turnout ratio was identified as a highly significant determinant of state health expenditures. In this regression, the total turnout was significant, but carried a negative sign. The other control variable, NSDP/C, turned out insignificant. In the regression aimed at finding out whether qualified child health care, as proxied by the CHCI, depends on SGHE/C, this was confirmed. Finally, it was found that child stunting (and less so underweight) is strongly associated with the provision of health care as measured by the CHCI.

In the regressions for confounding variables on the fundamental variables, qualified health care provision (CHCI) was found to be strongly correlated to poverty and mother's autonomy as proxied by the M/F ratio (Table 5). It hence seems that autonomous mothers are more capable of ensuring that their children are vaccinated and

America has a larger population and only three countries in the world have: China (1,272 million), USA (285 million) and Indonesia (209 million).

receive professional care when sick. This can be expected to result in lower frequency of prolonged ill health and less retarded skeletal growth (stunting). More autonomous mothers are also likely to be able to feed their offspring more varied and micro-nutrient dense (but comparatively expensive) food, which is a necessary (but not sufficient) precondition for normal (genetic potential) growth in infants and young children.[27]

The "Asian enigma hypotheses" have only partially been supported by the findings in this study. In the OLS and IV panel regressions the proxy for women's autonomy, the M/F ratio, came out significant for stunting, but not in the regression for underweight (Table 1). In the first difference regressions, the autonomy variable turned out insignificant and/or not robust in all regressions (Table 3). The latter result is not totally surprising since the changes in child underweight have been very small over time. In the OLS panel regressions for underweight on confounding variables, however, maternal weight failure (BMI<18.5) was highly significant, corroborating another "enigma" hypothesis, i.e. that malnutrition tends to be transmitted over generations (Table 4).

10. Policy implications

In the policy-focused literature on child malnutrition, a distinction is usually made between long-term and short-term interventions. In this paper, we have focused mainly on factors that are expected to improve child nutritional status in the long term: poverty reduction and increases in female literacy and autonomy. It is now widely agreed, not only among economists, but also nutritionists, as well as analysts from the international organisations, that substantial poverty reduction is a necessary and important long-term prerequisite for accomplishing more rapid alleviation of child malnutrition.[28] It is notable that the first MDG is to halve poverty *and* "hunger" before the year 2015; the merging of these two objectives in the same goal reflects a generally held perception that they are closely related. In the present paper we have reported results that confirm this in the case of India.

[27] In a recent study from Mexico, 5-10% of the children were found to be both stunted and overweight, indicating micro-nutrient deficiency and overindulgence of calorie-rich staple food (Fernald and Neufeld 2006).

If poverty is to be reduced more forcefully in India than in the recent past, future economic growth has to encompass households in the lowest income quintiles to a larger extent. In the macro-economics literature on India, there seems to be almost consensus on the required strategy, at least in broad terms. The prime focus should be on increasing labour productivity (and hence incomes) in agriculture, which still (2005) employs 54% of the Indian labour force. This share has dropped by 6 percentage points only from 1993 and India is probably one of very few countries in which employment in the agricultural sector is still growing in absolute numbers. The productivity and income gaps between the agricultural and the industry and service sectors have grown rapidly since the early 1990s and are estimated to be around five-fold in recent years (Bosworth et al 2008). However, as labour productivity in agriculture increases, surplus labour has to be absorbed in other rapidly growing labour-intensive sectors. The small-scale (rural) manufacturing sector should have good potential, given the abundance of low-skilled labour in India, but has so far not been expanding very rapidly.[29]

As we have seen, female illiteracy is a major drag on the alleviation of child malnutrition through a multitude of channels (Table 5). That female illiteracy is still close to 50% in rural India suggests ample scope for improvement that our results suggest would have a significant impact on child malnutrition. In this perspective, it is encouraging that female secondary school enrolment in rural areas is on the increase in many states (but with some notable exceptions). More education for males may also be helpful for eroding the conservative values underlying the discrimination of women, as reflected in the high and persistent M/F population ratios.

In most of the policy-oriented epidemiology-cum-nutrition literature, the focus is on targeted interventions to alleviate child malnutrition in the short and medium terms. There is a wealth of evaluations demonstrating high returns to such interventions in strictly controlled experiments in small select communities (Allen and Gillespie 2001; Behrman et al 2004; Horton et al 2008; Lancet appendix 2008). There is a dearth of reliable evaluations of large, scaled-up interventions in developing countries aimed at

[28] See, for instance, the two series of articles on “Child development in developing countries” and “Maternal and child undernutrition”, published in The Lancet in early 2008. Also see World Bank 2004.

entire (sub)-populations. The available studies find, however, that most such interventions have been poorly targeted to the intended groups, e.g. malnourished children (Coady et al 2004; Lancet appendix 2008).

Some of the results derived in the present paper suggest that targeted interventions to children should have promising effects on the reduction of child malnutrition in India in the not-so-long term. Increased maternal education on feeding practises and on the importance of qualified health care provision when children are sick are two examples. Much of this has been tried in India for many decades.

In India, the largest scaled-up program by far, is the Indian Child Distribution System (ICDS), which on paper covers two-thirds of all villages in India. The program has recently been evaluated by independent researchers, by at least three official Indian government commissions, and by the World Bank.[30] All found the ICDS in general to be underfinanced, ill targeted and inefficiently managed, and hence to have little or no impact on children.

The federal Indian government has limited juridical and financial power over the health-care sector in the states, but provides the main funding for the ICDS and a number of other programs aimed at improving child and maternal welfare. More generous federal government financial support for this program is underway since 2004/05 (GOI 2006). This is a promising start, but as the evaluations show, what is also required is an efficiency-enhancing overhaul of the program, which has yet to materialise. As noted in a recent official evaluation: "After 30 years of rich experience in the programmatic perspective, a paradigm shift is required to reform the ICDS in respect of overall programme management for a faster and sustained achievement of child and women nutritional goals" (GOI 2007c). There is no lack of suggestions for how to enhance the efficiency of the ICDS (e.g. Levinsson et al 2005) and there are local success stories (Tarozzi 2005) that may be possible to emulate in other states.

Another option is to replace (or supplement) the ICDS and other defunct existing programs with some form of conditional cash transfer scheme of the type that Mexico

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[29] For more detailed quantitative analyses along these lines, see Datt and Ravallion 2002; Foster and Rosenzweig 2004; Loayza and Raddatz 2006; Bosworth et al 2007; Kraay 2007; Honorati and Mengistae 2007; Mitra and Ural 2007; World Bank 2008; Lal 2008; Panagarjya 2008; Subramanian 2008.

[30] Lonchin et al 2006; Kochar 2005; GOI 2005, 2006, 2007c; Granolati 2006; World Bank 2004, 2006.

(Progresa/opportunidad) and Brazil (Bolsa famiglia) have initiated. These are among the few large-scale child programs in developing countries that have been efficient and effective according to a number of evaluations.[31] It may be that conditional cash-transfer programs work well in Latin American countries because child malnutrition is heavily concentrated geographically and to the poorest households (Svedberg 2007). In India, where malnutrition is widespread (cf. figures 3 and 4), targeting could be more problematic and costly (Adato and Hoddinott 2007). Nevertheless, cash programs ought to be considered, but have so far not been widely discussed in India. The recent focus seems to have been on expanding and rejuvenating the hitherto dismal (Gahia 1996) National Rural Employment Guarantee Scheme.

In sum, the shining overall economic performance of the Indian economy since the early 1990s has undoubtedly left large population segments in the shade, as reflected in slow declines of poverty and child malnutrition. The most promising route ahead is a combination of an overall long-term economic growth strategy that is more inclusive of the poor population groups paired with improved targeted interventions for the alleviation of child malnutrition in the shorter term. Whatever strategies and programs that are opted for, however, the prospects for success depend on financial funding, commitment and operational efficiency — and hence on political priorities.

[31] Coady et al 2004; Behrman et al 2004; Soares et al 2007; Black et al 2008; Horton et al 2008.

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Table 1. OLS and instrument variable panel regressions of child stunting and underweight on fundamental variables

	Dependent variables							
	Child stunting				Child underweight			
	OLS regressions		IV regressions[a)]		OLS regressions		IV regressions[a)]	
Poverty (MRP)	0.33 *4.28****	0.32 *4.83****	0.74 *3.11***	0.77 *3.20***	0.39 *4.75****	0.39 *4.42****	0.79 *3.02***	0.77 *2.95***
Female illiteracy	0.22 *3.49****	0.17 *2.98***	0.03 *0.28*	-0.01 *0.11*	0.24 *3.66****	0.25 *3.52****	0.06 *0.46*	0.10 *0.76*
M/F ratio	70.6 *4.37****	73.9 *4.94****	97.1 *4.45****	101.8 *4.48****	17.3 *0.86*	15.9 *0.78*	42.7 *1.96#*	39.4 *1.84#*
Time dummies	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
R^2 F-stat N	0.75 65.8*** 48	0.79 41.8*** 48	0.56 46.6*** 48	0.57 26.8*** 48	0.66 40.5*** 48	0.67 24.6*** 48	0.48 23.6*** 48	0.51 19.6*** 48

Absolute t-statistics in italics (robust standard errors)

***/**/*/# indicate statistical significance at the 0.001, 0.01, 0.05 and 0.10 levels

a) Instrumented variable: poverty (mrp)

Instruments: filit, mf, lsa (labour share in agriculture) and, when applicable, time dummies.

Stata data file: fixedeffect.dta/

Table 2. First difference and fixed effect panel regressions of child stunting and underweight on fundamental variables

	Dependent variables					
	Child stunting			Child underweight		
	First-diff	**Fixed effect**		**First-diff**	**Fixed effect**	
Poverty[e)]	0.51 3.02**	0.24 *1.10*	0.13 *0.70*	-0.05 0.16	0.15 *0.93*	-0.14 *0.61*
Female illiteracy	0.81 3.76**	0.43 *4.15****	0.08 *0.33*	0.55 1.84#	0.32 *2.53**	0.02 *0.09*
M/F ratio	135.0 2.59*	128.7 *1.49*	150.5 *2.03**	40.5 0.32	-36.8 *0.33*	22.7 *0.20*
Time dummies	-	*No*	*Yes*	-	*No*	*Yes*
R^2 F-stat N	0.60 6.94** 16	0.88 61.0*** 48	0.90 47.9*** 48	0.09 1.40 16	0.84 17.6*** 48	0.86 14.7*** 48

Absolute t-statistics in italics (robust standard errors)

***/**/*/# indicate statistical significance at the 0.001, 0.01, 0.05 and 0.10 levels

a) The poverty estimate in the fixed effect regressions are based on Mixed Recall Period: (MRP) and the first difference on Uniform Recall Period (URP).

Stata data files. fixedeffects.dta and firstdifference.dta.

Table 3. OLS panel regressions of pathways from maternal underweight to child stunting and underweight (T = 2)

Independent variables	Dependent variables			
	Child stunting		Child underweight	
Mother BMI<18.5	-0.05 *0.30*	-0.05 *0.42*	0.69 *8.62****	0.69 *8.64****
Child Health Care Index (CHCI)	-0.23 *2.04**	-0.25 *3.20***	0.01 *0.34*	0.02 *0.62*
Total Fertility Rate (TFR)	1.19 *0.56*	2.15 *1.21*	5.61 *4.90****	5.29 *4.56****
Solid supplementary food at age 6-9 months	-0.17 *3.76****	-0.06 *0.94*	0.02 *0.45*	-0.02 *0.32*
Sanitation facility (flush toilet in house)	-0.08 *1.45*	-0.07 *1.35*	-0.03 *0.56*	-0.03 *0.61*
Time dummy	-	-5.12 *2.20**	-	1.71 *1.13*
R^2 F-statistic N	0.74 37.0*** 32	0.80 27.4*** 32	0.87 60.0*** 32	0.88 58.2*** 32

Absolute t-statistics in italics (robust standard errors)

***/**/*/# indicate statistical significance at the 0.001, 0.01, 0.05 and 0.10 levels

Stata data file: pathwayone.dta

Table 4. OLS panel regressions of pathways from female illiteracy to child stunting and underweight (T = 3)

	Dependent variables:				
	Female/male turnout in elections	**State health expenditures per capita**	**Child health care index**	**Child stunting**	**Child underweight**
Independent variable	Female illiteracy	Female/male turnout in elections	State health expenditures per capita	Child health care index	Child health care index
	-0.002 *6.59****	543.9 *3.10***	0.08 *2.02**	-0.26 *4.51****	-0.19 *2.30**
Control variables	Poverty*** M/F* Tot turn***	Tot turnout* NSDP/C	TFR*** Sanit	TFR* Sanit	TFR Sanit***
Time dum	Yes (insign)	Yes (insign)	Yes (insign)	Yes(sign#)	Yes (insign)
R^2 F-statistic N	0.80 25.2*** 48	0.51 8.9*** 48	0.69 30.2*** 48	0.79 37.4*** 48	0.63 23.9*** 48

Absolute t-statistics in italics (robust standard errors)

***/**/*/# indicate statistical significance at the 0.001, 0.01, 0.05 and 0.10 levels

Stata file: pathwaytwo.dta

Table 5. OLS panel regressions for confounding variables on fundamental variables (t = 2)

	Dependent variables:				
Independent variables	**Mother's BMI<18.5**	**CHCI**	**Total fert rate**	**Solid food (6-9 m)**	**Sanitation facility**
Poverty (MRP)	0.34 *3.56****	-0.66 *3.20***	0.01 *1.00*	-0.24 *1.07*	-0.20 *0.88*
Female illiteracy	0.29 *2.92***	-0.47 *2.06**	0.03 *2.66***	-0.44 *2.11**	-1.19 *6.71****
M/F population ratio	-17.1 *0.73*	-102.3 *2.65***	3.13 *1.60*	-166.5 *4.66****	43.9 *1.13*
Time dummy	1.10 *0.53*	-4.24 *1.10*	0.12 *0.69*	12.1 *3.43***	-2.03 *0.50*
R^2 F-statistic N	0.59 9.53*** 32	0.63 24.8*** 32	0.59 6.37*** 32	0.79 36.1*** 32	0.75 23.7*** 32

Absolute t-statistics in italics (robust standard errors)

***/**/*/# indicate statistical significance at the 0.001, 0.01, 0.05 and 0.10 levels

Stata data file: pathway three.dta

Figure 1. Change in child stunting and underwieght and mothers' with a BMI<18.5 between the three NFHSs in India

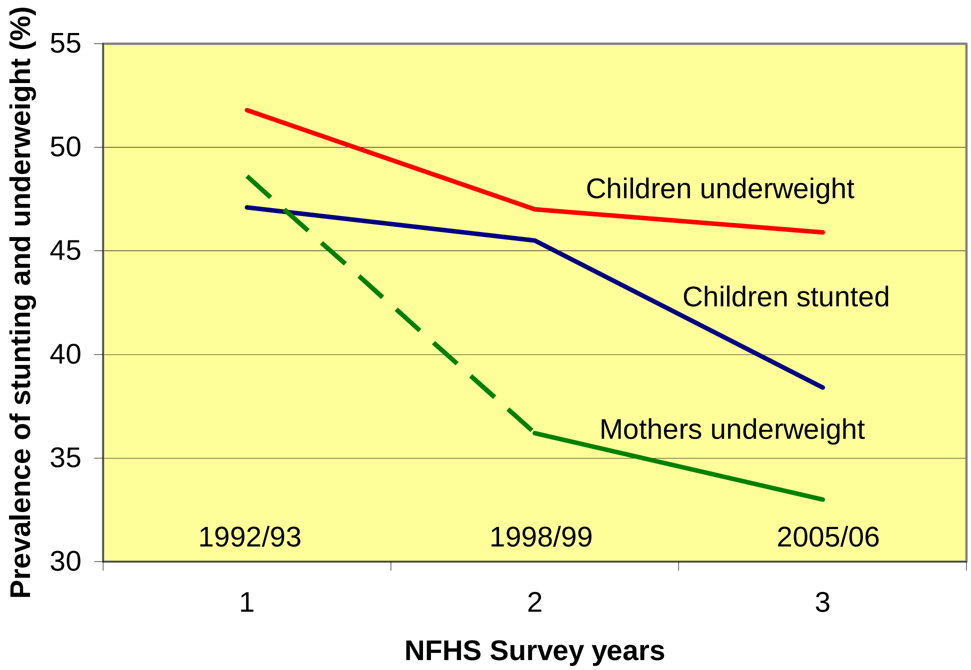

Figure 2. Indian states where prevalence of child underweight increased between two latest surveys

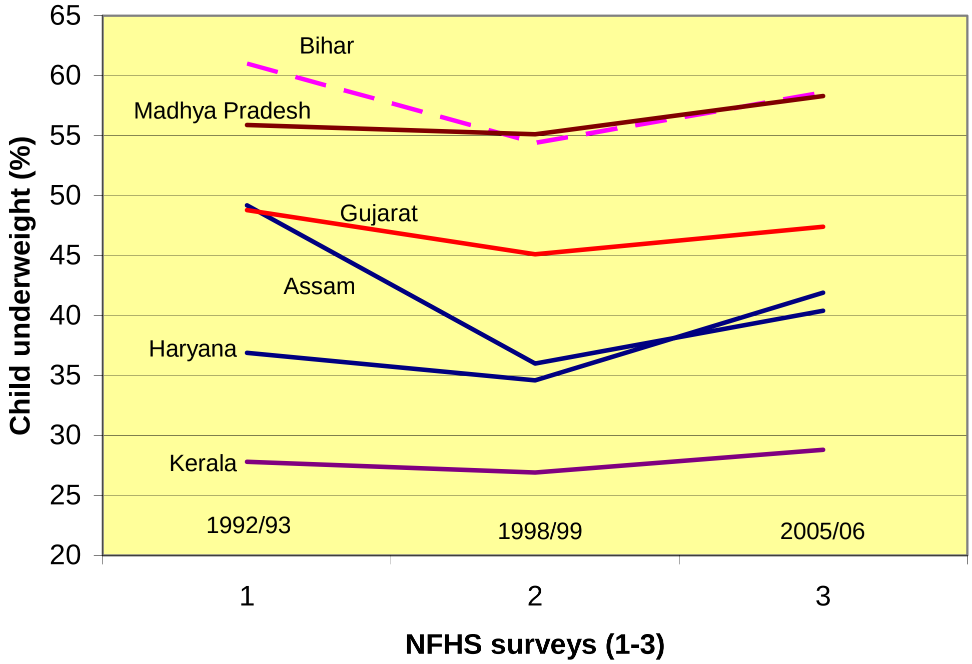

Figure 3. Prevalence of child stunting (blue) and underweight (red) in India by wealth quintile and average, 1998/99

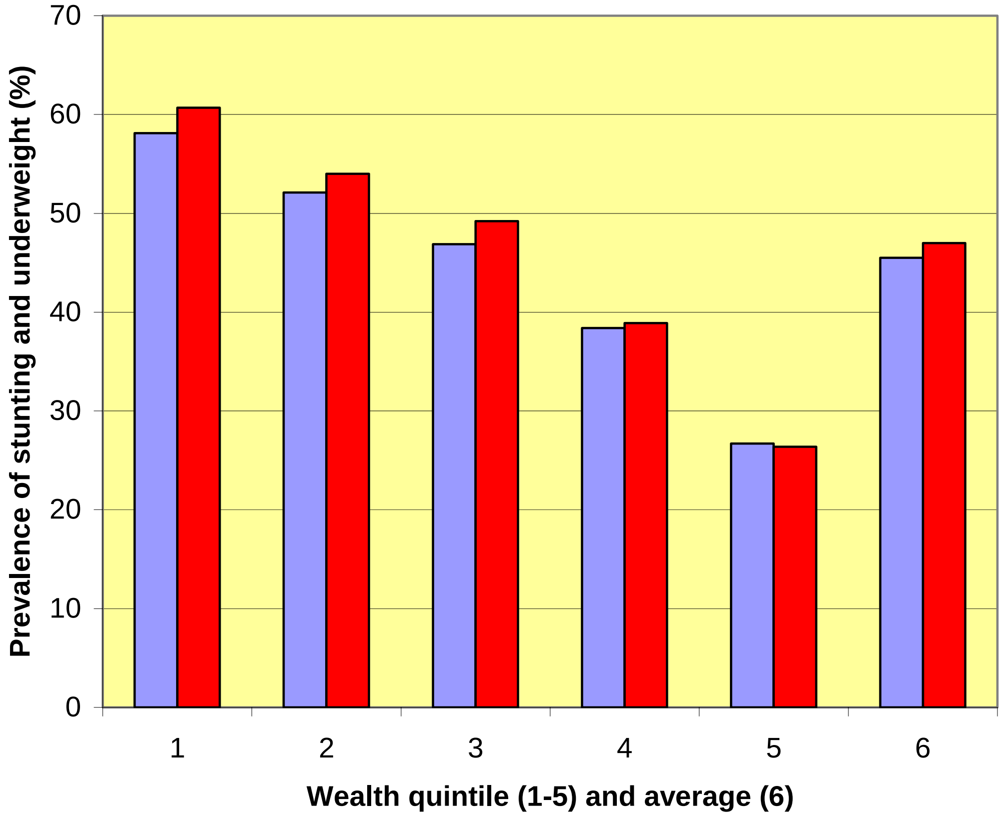

Figure 4. Prevalence of child stunting and underweight in India according to mothers' level of education, 2005/06

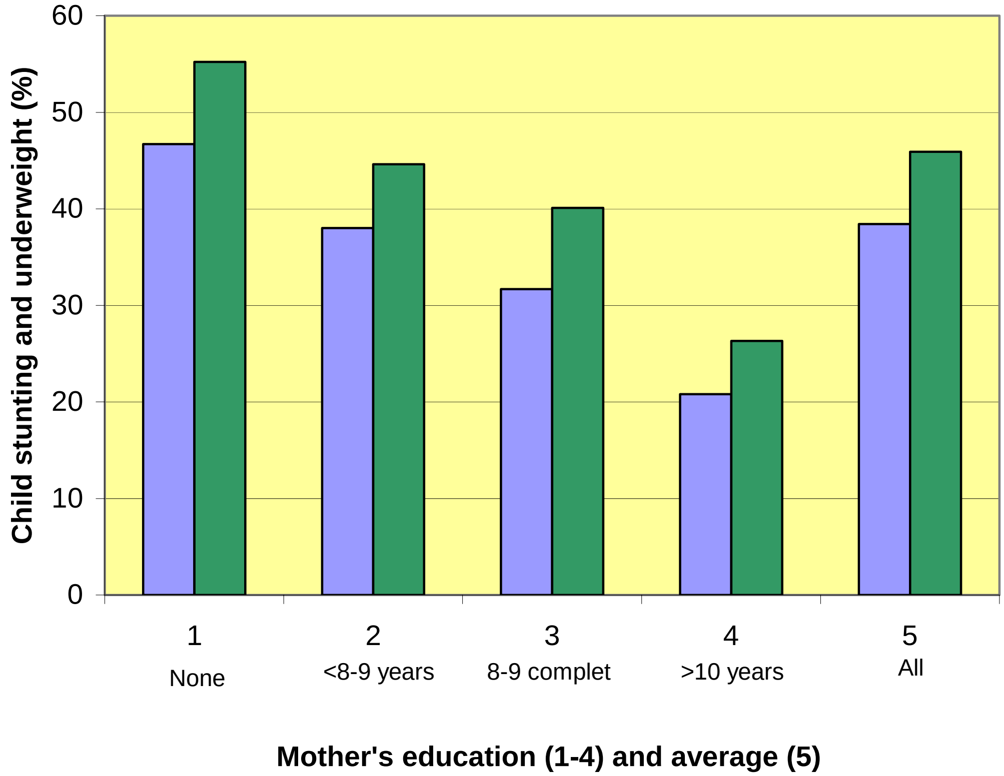

Figure 5. Partial correlation between poverty and labour share in agriculture (LSA) across 16 largest Indian states (panel data from 1993, 1999 and 2005)

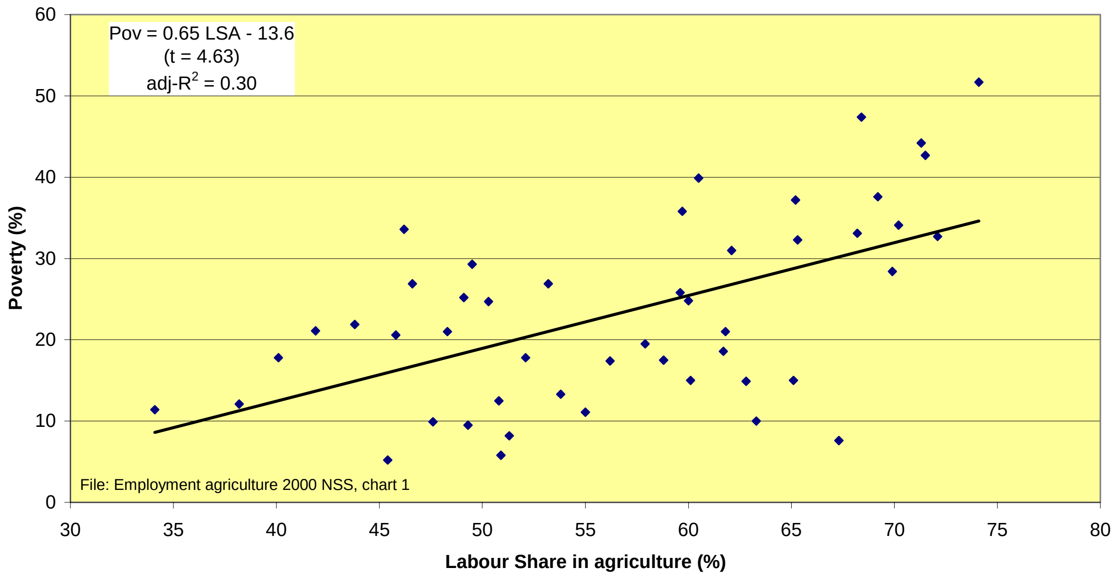

Figure 6. Correlation between reduction in poverty and growth of net state domestic product per capita across 25 Indian states between 1993/94 and 2004/05