The Indian Public Distribution System as Provider of Food Security: Evidence from Child Anthropometry in Andhra Pradesh

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Abstract

We study whether a sudden increase of the price of rice supplied by the Indian Public Distribution System in Andhra Pradesh, a large Indian state, had a negative impact on child weight. After the price increase, the Indian National Family Health Survey started measuring weight in a sample of children in Andhra Pradesh. The data collection continued for several months, so that children measured later in the survey lived for a longer period of time in a less favorable price regime. We study whether this implied a worsening of their nutritional status as measured by weight, but we do not find evidence supporting this hypothesis.

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1 Introduction

Food subsidization has a very long tradition in India. For most of the last three decades it has accounted for more than two percent of total government expenditure, and its cost peaked in 1993-94 at 55 billion Rupees (roughly 1.8 billion 1993 US$), almost 50 percent of total expenditure allocated to poverty alleviation programs, and approximately 0.8 percent of Gross Domestic Product (Radhakrishna et. al., 1997). The bulk of these sums sustains the Public Distribution System (PDS hereafter), which is one of the oldest and largest poverty alleviation programs in the world. The program mainly supplies rice, wheat, edible oils, sugar, and kerosene at subsidized prices through a network of retail outlets known as 'fair price shops'.[1]

The main proclaimed task of the PDS is to provide food security to poor households, but there is a widespread consensus across researchers that corruption, inefficiencies, and limited scope are preventing the system from reaching its goal. The existing literature, though, has so far only provided a descriptive characterization of the program, analyzing the program's coverage of the Indian population across different socioeconomic groups and geographical areas, and providing estimates of the implicit subsidies offered by the system.[2] Notwithstanding the size of the program and its importance in policy debates in India, an evaluation of the relationship between purchases from the system and the nutritional status of the beneficiaries is instead still missing. One goal of this paper is to contribute to fill this gap, studying the relation between PDS and children's nutritional status assessed through anthropometric measurements.

The evaluation is complicated by the fact that take-off rates and program placement are not random, and then a simple analysis of the relationship between purchases from the PDS and any outcome of interest would be plagued by selection bias. The literature on program evaluation sometimes eludes the selection problem making use of natural experiments, in which policy changes translate into arguably exogenous variations in the level of the examined treatment.[3] In the present context we use a sudden drop in the level of subsidy offered by the system in Andhra Pradesh, a large Indian State, as a natural experiment.

At the end of January 1992 the State Government of Andhra Pradesh almost doubled the price of subsidized rice, which had been kept for years at levels much below the market price. A few months later, the National Family Health Survey was on the field in Andhra Pradesh collecting data on health, fertility and other family issues. The NFHS interviewers also recorded weight and age of all less then four-years old children in the selected households. Since weight tends to react quickly to changes in the nutritional status, and since the NFHS kept collecting data in Andhra Pradesh for several months,

[1] In some areas the system also provides a few other staples, but their overall relevance is negligible.

[2] See, among others, Dev and Suryanarayana (1991), Howes and Jha (1992), Venugopal (1992), Ahluwalia (1993), Parikh (1994), Radhakrishna et al. (1997), Mooij (1999), and the collected essays in Krishnaji and Krishnan (2000).

[3] See Meyer (1995). Besley and Case (2000) warn that the exogeneity of the policy changes should be closely scrutinized.

children measured later in the survey have been living for a longer period of time in a less favorable PDS regime. In what follows we will provide strong evidence of the poor nutritional status of children in Andhra Pradesh, a phenomenon typically associated with low household wealth. If the subsidy offered by the system contributes significantly to households' resources, we can therefore expect worse anthropometric outcomes in children measured later in the survey, given their age and sex.

Admittedly, confining the analysis to Andhra Pradesh limits the generality of our results. On the other hand, besides providing an exogenous variation in the level of benefits offered by the system, our choice allows us to focus on one of the very few states in which the implicit subsidies offered by the PDS is thought to be relatively large. The management of the PDS is largely devolved to the local State Governments, and this has caused wide disparities in the reach and scope of the program across different Indian states.[4] In most states, the system provides such a negligible support that the task of identifying an effect on nutrition would be practically hopeless. It should be noted that the fact that our analysis considers only the rice scheme, rather than the totality of items sold in fair price shops in Andhra Pradesh, turns out not to be a serious limitation. In fact, we will show that the sale of subsidized rice is by far the most important component of the PDS in Andhra Pradesh.

The paper is organized as follows. The next section presents a brief description of the PDS in India, and in Andhra Pradesh in particular. Section 3 describes the data used in the paper, and lay out in detail the identification strategy we will use. Section 4 provides evidence about the poor nutritional status of children in Andhra Pradesh, while Section 5 shows that the PDS in this state offers significant support to poor households. In Section 6 we present a preliminary exploration of out identification strategy, using nonparametric estimation. Parametric and semiparametric estimators are instead introduced in Section 7, to address problems that the nonparametric approach could not solve. Section 8 concludes.

2 The Indian Public Distribution System and the Rice Scheme in Andhra Pradesh

The PDS, which dates back to before Indian independence, was originally conceived as an instrument for protecting consumers from food shortages, and producers from price fluctuations. It was initially localized only in a few urban centers, but in the 1980s its reach widened, and it gradually assumed the features of a poverty alleviation program, with the specific proclaimed task of providing food security to vulnerable households.

Rice and wheat are by far the two most important staples provided by the PDS. The central Government, through a series of specific institutions and committees, decides the *procurement price*

[4] For an overview of the cross-state differences, see in particular Dev and Suryanarayana (1991), Howes and Jha (1992), Ahluwalia (1993), Radhakrishna et al. (1997).

(the price paid to producers and millers for the quantities they have to supply to the central pool), the amounts that each state must procure, and those that each state is entitled to lift from the pool. Each state, instead, independently decides actual procurement mechanisms, and it has the option to offer *higher* procurement prices and/or allowing a *lower* retail price. For a very long time each state was also allowed to decide on targeting policies, that is about the rules for the distribution to the beneficiaries. The fact that important aspects of the PDS management are left to the discretion of the states has led to important differences in the way the system works across states. In most cases the quantities of staples made available by the system are negligible, the subsidy very small, and until recently most states did not implement any effective targeting scheme, so that richer households were allowed to benefit from the system as much as, or more than, the poor.

To face the growing dissatisfaction with the system, in June 1997 the Indian government replaced the PDS with the Targeted Public Distribution System (TPDS). In this new system rice and wheat are offered at low prices only to households whose income, land-holding and other assets are below specified thresholds. This new system, though, have been introduced in a period subsequent to the time frame considered in this paper, and therefore will have no bearings on our results.

Even before the introduction of the TPDS, a targeted and relatively important distribution system was already present in Andhra Pradesh. In 1983, Andhra Pradesh implemented what became known as the *2 Rupees per Kilogram* program.[5] A special ration card was distributed to the beneficiaries, and entitlement was based on a means test. To be eligible it was necessary to have an annual family income below Rs 6000 or land ownership below certain thresholds.[6] The means test, though, has never been strictly enforced. The ration card entitled every member of the family to buy 5 kilograms of rice per month, with a ceiling of 25 kilograms per family per month. At the end of January 1992, after a political turnover, the rice scheme became less generous. The subsidized price almost doubled to 3.5 Rs per kilogram and the ceiling per family was reduced to 20 kilograms per family.[7] This is the change that we exploit to identify how the implicit subsidy offered by the system affects child anthropometry.

[5] The promised implementation of the program was one of the reasons of the electoral victory of the Telugu Desam Party, a newborn political party that won the State election held in January 1983 (see Krishna Rao, 1993).

[6] Up to 1.5 acres of irrigated land under assured source of irrigation, or 2.5 acres of wet land irrigated by tanks or wells, or 3 acres of dry land under commercial crop, or 5 acres of dry land.

[7] The more generous regime was reestablished in 1994, but in August 1996, due to budgetary tightness, the price per kilogram was raised again to 3.5 Rs, the per capita monthly allowance reduced at 4 kg, and the maximum per household reported to 20 kg per month. These parameters remained the same even after June 1997 when the Targeted Public Distribution System was introduced in all India.

3 Data Sources and the Identification Strategy

Information on child anthropometry in Andhra Pradesh come from the 1992-93 Indian National Family Health Survey (NFHS hereafter).[8] The main purpose of the survey is to collect information related to health, fertility and other family issues for ever married women aged 13-49 years. The Indian NFHS is one of the Demographic and Health Surveys (DHS), a series of surveys carried out in many developing countries to collect information on a wide range of health, fertility, and family issues. The surveys, which adopt a stratified and clustered design,[9] are divided into three sections: a village questionnaire, a household questionnaire, and an individual questionnaire. The village questionnaire contains information about various amenities available in the village (for example schools and health facilities). The household questionnaire is used to list all usual residents of the sample household, plus all individuals that slept in the household the night before the interview, in order to identify women eligible to be individually interviewed. These women (including visitors) are then given the individual questionnaire. This is divided into seven sections: respondent's background (including education), reproduction, contraception, health of children, fertility preferences, husband's background and woman's work, height and weight of children under age four. Actually, in the first states where the Indian NFHS was carried out, height was not recorded, due to lack of appropriate measuring boards. These states were Andhra Pradesh, Himachal Pradesh, Madhya Pradesh, Tamil Nadu, and West Bengal. It is then clear that weight-for-age is the only anthropometric measure we can use.

In Andhra Pradesh, 4276 women were interviewed, and weight was recorded for 1575 up to four years old children. The interviewers were on the field from April to July 1992, while the price of PDS rice was increased at the end of January 1992. To understand the reasoning underlying our identification strategy it is useful to look at Figure 1, which gives a visual description of the timing of the program and of the survey. The first row highlights the period during which the survey was run in Andhra Pradesh (from April to July 1992), while the second row shows the months during which all the children in the sample were born (from May 1988 to June 1992). The following lines provide information on the changes in the Andhra Pradesh rice scheme over time, making clear that the system became much less

[8] At the time of writing data from a second round of the survey (carried out in 1998-99) are already available. In principle it would be possible to use these data to perform an evaluation similar to the one we propose here, since another change in the subsidized price of rice took place in August 1996. We choose not to do it since the time interval between the regime change and the period during which the 98-99 survey was carried out is so long that most measured children were born *after* the regime change. Moreover, the few that were born *before* the price change were more than two years old when the survey started, so that it is very unlikely that an effect due to a few months' difference in the exposure to a different price regime is still detectable at the time of the survey.

[9] In Andhra Pradesh, NFHS is self weighting. Clusters are selected with probability proportional to size, and then a constant number of households is selected from every selected cluster. This implies that each household has, before cluster selection, the same probability of being in the sample, so that every household ends up with the same inflation factor (see Deaton, 1997, Ch. 1).

generous at the end of January 1992. The sample, then, contains anthropometric measures for children with the same age and sex but with different exposure to what one might call the "high price regime", so that we can build an identification strategy based on the difference between growth charts related to children with different exposure to the less generous regime. In fact, keeping age and sex constant, children measured *later* will have experienced *more* months of *higher* prices. So, for example, a child measured in April 1992 and recorded to be 6 months old has lived three months in the low price regime (which ended at the end of January 1992), and three in the high price regime (February, March, and April). For a 6 months old child measured in June 1992, instead, the *pre* and *post* price change periods are respectively 1 and 5 months long. Since many of these children have poor growth performances and live in families relying on support from the PDS, we can expect to find a negative relation between the number of months with high prices and anthropometric performance, keeping age and sex constant.

Since our identification strategy heavily relies on the child's age, our results can be undermined if age is reported with error. Such errors are common in surveys carried out in developing countries, due to low literacy rates of the respondent, and to the frequent unavailability of official birth records. It is then often observed that the respondents have a tendency to report age "rounded" to the nearest "preferred" digit (which for children's age might be, for example, 6 months, one year, and so on). Figure 2 shows the sample distribution of age for the measured children in Andhra Pradesh. From the graph no regular pattern or evident "focal ages" emerge; in particular note that there is no clustering around focal ages like one, two, or three years. It appears then that age misreporting is not an important problem in this sample. This is possibly due to the fact that the NFHS field staff was instructed to carefully double-check the mother's reply, whenever possible.

Since height was not recorded for children in our sample, we cannot rely on weight-for-height, which for most purposes is considered to be the best measure to assess children's nutritional status, and also has the advantage of not relying on accurate age reporting.[10] Therefore we will have to rely on weight-for-age, which does not distinguish between tall and *wasted* (thin) children and short ones with adequate body weight. Still, weight-for-age does react quickly to changes in the nutritional status, so that it can be seen as an appropriate outcome of interest in the present context, where we want to examine whether changes in the economic environment caused changes in anthropometric performances measured only a few months after the former changes took place.

When assessing the nutritional status of children in Andhra Pradesh, we will use, as reference, the latest revision of the pediatric growth charts for well-fed American children (NCHS, 2000). The use of the previous version of NCHS growth charts (NCHS, 1977) has been adopted for years by the World Health Organization as international standards for cross country anthropometric comparisons.[11]

[10] See, for example, Gorstein et al. (1994). On the use and interpretation of different anthropometric indicators see also WHO Working Group (1986), Gopalan (1992), Keller (1991).

[11] See Waterflow et al. (1977) and WHO (1983). The revised reference charts are available at the Center for Disease Control and Prevention website. For the description of the charts, and the reasons why it was deemed necessary to revise

The NFHS does not contain data on purchases from the PDS. Then, to evaluate the relevance of the rice scheme in Andhra Pradesh, we make use of the 50^{th} Round of the Indian National Sample Survey (NSS), a large household expenditure survey carried out between July 1993 and June 1994. The 50^{th} Round also contains detailed information on the purchases of 8552 households from Andhra Pradesh during the 30 days preceding the interview. For items available in fair price shops, the respondent was asked to report separately purchases from the PDS and from the open market. Since both quantities and value of monthly purchases are recorded, the ratios between the latter and the former can be used to estimate unit values, which are necessary to estimate the actual implicit unit subsidy offered by the PDS.

Admittedly, the 50^{th} NSS Round does not cover the whole period considered in this paper, but it is the only expenditure survey carried out in the early nineties containing information on consumption from the PDS. Also, the time frame analyzed by the 50^{th} round is close enough to the time span we focus on to give useful information on the importance of the PDS during the period.

4 Evidence on the Nutritional Status of Children in Andhra Pradesh

The identification strategy we propose in this paper builds on the assumption that, given age and sex, children who lived for a longer period of time in a less generous PDS regime will have worse anthropometric outcomes, if the system was actually being relevant in providing food security. Clearly, this identification strategy would be extremely unlikely to give any interesting result if children in Andhra Pradesh were actually already well nourished. But in this section we provide strong evidence that this is not the case.

In order to assess nutritional status, it is necessary to have an appropriate reference to build comparisons. The NCHS growth charts for American children have been used for many years as reference for international use, especially after the World Health Organization endorsed their use for such task.[12] It should be noted that the use of a population as a *reference* does not necessarily imply its acceptance as a *standard*, that is as an ideal target to achieve. Actually, some researchers suggest that *local* references should be used instead, in order to take into account genetic differences across populations.[13] Still, there is evidence that genetic differences are not relevant enough to justify significant differences in

the 1977 NCHS charts, see Kuczmarski et. al. (2000).

[12] See Waterflow et al. (1977) and WHO (1983).

[13] Some researchers even concluded that *individual-specific* references would be more appropriate, arguing that individuals possess a high degree of metabolic adaptability to changes in nutrition, and that the use of a reference population would tend to understate the role of such adaptability. On this issue, and many others related to the relation between malnutrition and poverty, see the essays in Osmani (1993).

growth charts.[14] In particular Agarwal et al. (1991) showed that the charts endorsed by WHO describe adequately the growth process of well-fed Indian children. We therefore follow the standard procedure, and use the latest revision of the NCHS growth charts as reference, to transform weight-for-age measurement into z-scores. These are computed subtracting from the individual measurement the mean weight of children of the same age and sex in the reference population, and dividing the difference by the sex and age-specific standard deviation of the measure in the reference population. If weight is approximately normally distributed for every age and sex, then, a z-score equal to -1.64 would indicate that the measured child's weight lies below ninety-five percent of the children of same age and sex in the reference population.[15]

Figure 3 shows how z-scores for weight-for-age change with age, for children living in Andhra Pradesh. We produced the graphs using nonparametric locally weighted regressions (Fan, 1992), which allow us to study the relation between z-scores and age without assuming a specific functional form for the curves. We prefer locally weighted regressions to the traditional Nadaraya-Watson estimators since the former tend to reduce the bias arising in the estimates when the regressors are unevenly spaced, a bias which can be particularly large near the boundaries of the regression. While using the Nadaraya-Watson approach the conditional expectation is computed estimating nonparametrically the conditional distribution of y given x, a locally weighted regression estimates the conditional expectation through a *parametric* "local" weighted regression. The regression is "local" in the sense that only observations in a neighborhood of x are included in the regression, and it is weighted since a kernel centered around x is used to attach larger weights to points closer to x.[16]

The top two figures compare the curves related to males and females in the urban (left) and the rural (right) sector. The graphs at the bottom compare instead curves for the same sex across different sectors. These graphs are not dissimilar from the standard pattern of z-scores for weight in low-income countries.[17] The curves start below zero, steadily decline till the age of twelve-eighteen months, and then stabilize. Note that for most ages the lines remain well below minus two. In most cases the regression indicates that the weight performance of the average child in Andhra Pradesh remains below the first percentile of the corresponding distribution in the American population.

Even if one thinks that American growth charts should not be taken as an ideal standard for these children, it is hard to believe that such low z-scores are due only to genetic differences or, as

[14] See Graitcer and Gentry (1981), Habicht et al. (1974).

[15] In practice, the age and sex-specific distribution of weight is not normally distributed. If one wants to retain the interpretation of the z-scores in terms of percentiles of the reference population, z-scores should be computed using mean and standard deviation of the distribution of a Box-Cox transformation of weight-for-age in the reference population, since by construction such transformation will be approximately normal (see Box and Cox, 1964, or Davidson and McKinnon, 1993, Ch. 14). This approach, known as LMS technique, has been introduced by Cole (1988), and has been adopted by the NCHS in the revised 2000 growth charts that we use (see Kuczmarski et. al., 2000).

[16] For a clear treatment of the Nadaraya-Watson estimator see Pagan and Ullah (1999, Ch. 3). Deaton (1997, Ch. 3) provides an intuitive treatment of locally weighted regressions.

[17] See Martorell and Habicht (1986).

someone might worry, to widespread obesity among American children, rather than mostly to widespread malnutrition of children in Andhra Pradesh. The argument that genetics might be part of the story is further weakened noting that growth charts in the rural sector tend to be systematically *below* the curves in the urban sector for the same sex, especially for females. This clearly does not depend upon genetic factors, and it should rather be explained noting that in Andhra Pradesh, as in all India, rural areas are typically poorer than urban areas.[18]

One might also be worried that low weight might be simply explained by low height. Since height was not recorded for children in Andhra Pradesh, we cannot disprove directly this claim which, however, even if true, would still leave one with evidence of low height performances. Still, something can be learned using data from states for which both weight and height were recorded. Figure 4 shows that z-scores patterns for weight-for-age in these states were very similar to those in Andhra Pradesh. That this is not simply due to low height is made clear by Figure 5, where we plot locally weighted regressions of z-scores of *weight-for-height* (in centimeters) for the same states. All curves start above zero, but decline steadily and stabilize well below minus one. Since height is highly correlated with age, this implies that weight-for-height tends to worsen with age, before reaching a steady level. Overall, this clearly shows that low height can only partially explain the very low z-scores in weight-for-age in these states. Since the pattern of the latter in these states is very similar to the pattern in Andhra Pradesh, there is no compelling reason to think that low height is the sole determinant of low weight in the latter state.

As an aside, it is interesting to note that the graphs show no systematic difference between the curves for males and females. In Andhra Pradesh female discrimination is not as severe as in many areas of northern India, but it is present nonetheless.[19] Even if nutrition is only one of the main determinant of anthropometric performance (the other major one being infections) this result is consistent with several previous studies that show how difficult it is to find evidence of gender discrimination using information about intra-household allocation of resources.[20]

It should be stressed that even if in this section we made use of z-scores to provide convincing evidence of the poor nutritional status of children in Andhra Pradesh, all the results presented in the rest of the paper are not computed using z-scores, but rather weight-for-age itself. So all our results do not depend in any way on the choice of the reference growth charts.

[18] See, for example, Deaton and Tarozzi (2000).

[19] See, for example, Murthi, Guio, and Drèze (1996) and references therein.

[20] For a short review see Deaton (1997, pp. 223-241).

5 Evidence on the Relevance of the Rice Scheme in Andhra Pradesh

Our identification strategy hinges on the fact that the implicit subsidy offered by the PDS provides a significant support to poor households in Andhra Pradesh. In this section we show that this is actually the case. For this purpose we will use data from the 50^{th} round of the Indian NSS, a large household expenditure survey which was carried out from July 1993 to June 1994. The time frame covered by this survey does not coincide with the period our natural experiment centers on, but it is close enough to provide relevant information on the magnitude of the subsidy relative to household total budgets. Note that the 50^{th} Round of the NSS covers a period during which the PDS regime was already less generous. The price of PDS rice was 3.5 Rupees per kilogram, and ration cards granted monthly entitlements equal to 5 kilogram of rice per person, with a maximum of 20 kilograms per household.

Table 1 contains summary statistics about consumption of rice in Andhra Pradesh, separately for the rural and urban sector. To emphasize differences in PDS usage across different expenditure groups, we show statistics computed separately for the lowest and highest sector-specific per capita expenditure deciles, as well as statistics for the whole sample. In both sectors almost everyone consumes rice. In the rural sector, 62 percent of households consume PDS rice, and the percentage is almost 80 percent for the poorest decile, and just below 40 percent for the richest decile. In the urban sector consumption from the system is less widespread, but the pattern is qualitatively similar, even if more pronounced: 73.5 percent of households in the poorest decile purchase from the PDS, and only 6.1 percent of those in the highest decile do. Overall, an estimated 34 percent of urban households consume from the system. Note that these results, as well as all those displayed in the rest of the table, show that in Andhra Pradesh a certain degree of targeting towards the poor has been achieved. The poorest households, on average, purchase more, and more often, from the system, even if some purchases can be observed also among the richest. Rows 3 and 4 show that consumption of subsidized rice is higher in the rural sector, where the poorest 10 percent relies on the PDS for almost half of total rice consumption. For these households the PDS rice accounts for 7.7 percent of total household expenditure. The rice scheme is instead much less important for the richest urban dwellers. Even if in Andhra Pradesh rice is not the only item sold in "fair price shops" (the other major items being sugar and kerosene), rows 6 and 7 make clear that the rice scheme is the bulk of the PDS, especially so for the most vulnerable sections of the population. Among the poorest households in rural ares, PDS rice accounted for about 80 percent of the purchases from the system, while in urban areas the proportion was only slightly lower. For richer households the proportion decreases to around 50 percent. This can be explained noting that better off households buy relatively larger quantities of sugar and kerosene, and relatively less rice, which is more often bought in the open market, where the quality is generally higher. Also, according to the targeting scheme in Andhra Pradesh, households that are not entitled to purchase subsidized rice can still buy sugar and kerosene from the PDS.

Since the relevance of the rice scheme rests on the gap between the subsidized price and the open market price, a better assessment of the program can be achieved looking at the total implicit subsidy offered by the system. Since the NSS does not directly collect data on prices, we have to use value and quantities of purchases to compute unit values, which we can use as proxies for prices. For every household h, we estimate the total subsidy enjoyed purchasing a given item i from the PDS as $q_i^h \left(u_{Mi}^h - u_{Pi}^h\right)$, where q_i^h is the total quantity purchased by the household from the PDS, and u_{Mi}^h and u_{Pi}^h are the unit values of purchases from the market and from the PDS respectively.[21] The total subsidy computed in this way is a coarse estimate of how many more Rupees the household should spend to buy on the open market the staples purchased from the PDS (keeping everything else constant[22]).

When a household buys from one source only, the unit value related to the unused source has to be imputed. Since in Andhra Pradesh (as in most of India) there is a large geographical variation of prices, especially between rural and urban areas, we use, as proxy for the missing price, the median unit value of purchases from the same source in the sector and region where the relevant household resides.[23]

In rows 8 to 11 of Table 1 we see that, once again, the rice scheme provides most of the implicit subsidy offered by the system. This is especially true for poor households living in the rural sector, for which more than 80 percent of the total subsidy comes from purchases of rice. For the lowest expenditure decile, implicit subsidy per head amounts to approximately Rs 6.5 per month (this, at the time of the survey, was about the price of one kilogram of rice) and is close to 5 percent of total household budget. For a very poor household, this can be a considerable amount.

Row 3 in Table 1 shows that, even among the poorest households, consumption of rice from the PDS remains well below the 5 kilograms per month per person allowed by the system. This is only partly explained by the fact that each household is entitled to a maximum of 20 kilograms per month. Some households, in fact, purchase less than their full quota. This is shown in Figure 6, where we plot sector-specific locally weighted regressions of take-up rates over the logarithm of per capita total monthly expenditure. The take-up rate is computed for every household as the ratio between actual purchases from the PDS and total entitlement assuming that the household has a ration card.[24] Even the poorest households take up on average 75 percent of their entitlement, and this proportion decreases for higher expenditure levels. In the urban sector the downward slope is more pronounced, suggesting

[21] The subsidy should be computed as the difference between PDS price and the open market price of rice of the same quality. Since the quality of rice supplied by the PDS is generally not high, our procedure might overstate the size of the subsidy for richer households, which generally purchase high-quality rice from the open market.

[22] This, of course, does not pretend to be a satisfactory welfare analysis, which should take into account behavioral responses of the household to a price change, and also general equilibrium effects that would certainly arise if the PDS were absent. But this goes beyond the scope of this paper. For a general equilibrium model of food subsidization see Sah and Srinivasan (1988).

[23] The NSS divides Andhra Pradesh in four regions: Coastal, Inland Northern, South-Western, and Inland Southern.

[24] We remind that the ration card entitles the owner to a monthly quantity equal to $\min\{20, 5\,(\text{household size})\}$.

once again that targeting towards the poor was being more effective in urban areas. Low take up rates are likely to be due to the inability of fair price shops to meet card-holders' demands for subsidized rice. In fact, approximately 75 percent of households that purchased rice from the PDS, but who did not lift their full quota, purchased *also* from the open market. There is ample anecdotal evidence suggesting that the quantities available in fair price shops are often not sufficient to meet the total quota of card-holders in the area, and in many cases the shop stays open only for a few days a month, and its shelves are emptied very quickly, so that sometimes card-holders do not have the opportunity to purchase their quota. Indrakant (2000), using data collected in 1994-95 in five villages in Andhra Pradesh with diverse socioeconomic characteristics, shows that in several cases households that were entitled to a ration card did not have one. Instead, contrary to what seems to happen in other Indian states, in the selected villages complains about low quality of PDS supplies were not frequent.

Since child anthropometry is the outcome we focus on here, it is useful to have an estimate of the impact that the reduction in the subsidy might have had on children's caloric intake. Since the NSS sample frame was the Indian Census, while NFHS collected information on child anthropometry only from ever married women aged 13-49 years, in this section we will restrict our analysis to that part of the NSS sample including households with at least one ever married woman in the relevant age interval, and with at least one child aged less than four years.[25] In this way, the sample reduces from 8552 to 2368 households. We proceed estimating, for every household, the relative increase in total monthly calorie availability that would be made possible by reverting back to the pre-1992 rice scheme, assuming that the quantity of rice purchased from PDS remains unchanged.[26] We also assume that the household allocates to food a proportion of the increased implicit subsidy equal to its food budget share. Finally, we assume that the increased calorie availability is split proportionally among all household members.

We compute actual calorie availability in the household making use of the detailed information on household consumption recorded in the NSS, which reports consumption data for more than two hundred different items. Specifically, we estimate total calorie consumption multiplying the quantities consumed of every item by the corresponding estimated average calorie content from Gopalan, Sastri, and Balasubramanian (1971), whose estimates specifically refer to Indian foods. Following Deaton and Subramanian (1996), for some food categories (like cooked meals, prepared sweets, salted refreshments etc.), we imputed the calorie content multiplying total consumption *in Rupees* by the "average price of a calorie" for all other food, augmented by a 50 percent premium for processing margins. For every

[25] In should be noted that building the subsample in this way there might be cases where the child's mother is not, in fact, an ever-married woman aged 13-49. For example, suppose that an unmarried woman has a 3 years old child, and lives with her sister, which is married but childless. In this case the child would not be included in a survey structured as the NFHS, but it will be included in our subsample. These are very special cases, though, and they should not bias the results.

[26] Note, though, that the maximum monthly allowance per household was 25 kilograms, higher than the 20 kg allowed in 1993-94. The fact that we do not take this difference into account will therefore slightly understate the importance of the regime change for larger families.

household we estimate the average price of a calorie dividing total expenditure in food items (those for which we are not using this imputation procedure) by total calorie content of the items. We compute household-specific food budget shares straightforwardly dividing total expenditure on food by total household expenditure.

An approximate estimate of the increase in calorie availability per child that would be made possible reducing the price of PDS rice from Rs 3.5 back to Rs 2 per kilogram is therefore given by the following:

$$\Delta\widehat{C}_{c,h}/\widehat{C}_{c,h} = \frac{w_{F,h}\,(1.5)\,Q_h}{p_h C_h} \tag{1}$$

where $1.5Q_h$ is the total amount (in Rupees per month) that the household would save if the same quantity of PDS rice were purchased at a price 1.5 Rupees per kilogram lower, $w_{F,h}$ is the budget share of food, p_h is the average price of a calorie for household h, computed dividing total expenditure in food by total household calories, and C_h is total calorie availability in the household, estimated using the procedure outlined above. In Figure 7 we plot the nonparametric regression of the expression defined in 1 over the logarithm of monthly expenditure per head. The picture shows that for the poorest 25 percent of the households a reduction of the price of PDS rice from Rs 3.5 to Rs 2 per kilogram would increase calorie availability per child by about 2 percentage points. The estimated nutritional benefit decreases rapidly, and it becomes negligible for households in the highest quartile of the distribution of the regressor. Overall, the estimated benefit is not large, but it should be kept in mind that we assumed that only a small part of the increased subsidy would actually end up being directed towards children' nutrition, so that the *potential* nutritional benefit will be much larger.

6 A Preliminary Program Evaluation using Nonparametric Tools

In this section we turn to the actual implementation of our identification strategy, so that in the rest of the paper we will use only the NFHS database described previously. While the rice scheme was changed at the end of January 1992, the NFHS was on the field from April to July of the same year, interviewing the women in the sample, and recording weight for less than four years old children. Only 36 children were measured in July, so that most children, when their weight was been recorded, had been exposed to high prices for a period ranging from three months (for those measured in April) to five months (for those measured in June).

Our identification strategy is based on the idea that children of the same age and sex who have been measured later in the survey have been living for a longer time span in the high price regime, so that one might expect their weight to be relatively lower.

A first and simple implementation of this identification strategy can be done estimating nonparametrically separate growth charts for children who have been exposed for three, four, or five months to the less generous PDS regime. Since infants up to three months old were not born yet when the rice scheme changed, we have to exclude them from our analysis. Similarly, children aged four months cannot, of course, have experienced more than four months of high prices, so I can compare them only with those that spent three months in the high price regime. A five-months old child, instead, spent his/her whole life in the high price regime if measured in June, only four months if measured in May, and three months if the interview took place in April. An identical pattern will hold for older children.

Figure 8 shows growth charts for males and females separately, smoothed using locally weighted regressions. If the change in the PDS regime actually affected the growth pattern, we would expect, for example, the growth chart for females exposed to five months of high prices to lie *below* the chart for females exposed for three or four months only. The pictures show no such apparent systematic pattern. One can summarize the information contained in these graphs computing average distances between two sets of curves, with age-specific weights proportional to the total number of children of the corresponding age. Let n^s_{am} denote the number of a months old children of sex s in the sample who have been in the high price regime for m months. Let w^s_{iam} denote the weight (in kilograms) of the i^{th} child in such category. Then the average distance between the growth charts related to children of sex s exposed to m and m' months of high prices is

$$D\left(s,m,m'\right)=\sum_{a=\underline{a}}^{47}\frac{n^s_{am}+n^s_{am'}}{\sum_{a=\underline{a}}^{47}\left(n^s_{am}+n^s_{am'}\right)}\left[\frac{1}{n^s_{am}}\sum_{i=1}^{n^s_{am}}w^s_{iam}-\frac{1}{n^s_{am'}}\sum_{j=1}^{n^s_{am'}}w^s_{jam'}\right]$$

where $\underline{a}$ is equal to four if $(m,m')=(3,4)$ and five otherwise. Table 2 shows the results, together with bootstrapped standard errors. If weight performances were systematically worse for children who lived for a longer period of time in the high price regime, one would expect the table to contain positive figures, since every weighted difference $D\left(s,m,m'\right)$ is estimated with $m<m'$. Instead, all entries are close to zero, three of them are actually *negative*, and none of them is different from zero at standard significance levels.[27] These tests, therefore, confirm the lack of systematic disparities between pairs of growth charts that was suggested by a simple visual inspection.

7 Parametric and Semiparametric Analysis of the Program

There are several reasons why one might look suspiciously at the results described in the previous section, which show no systematic difference in growth charts for children who have been living in the high price regime for a different number of months. First, the curves pool together all children irrespective of the socioeconomic status of the households they live in, and one cannot expect to detect an effect of changes in PDS rules on the growth performance of children living in relatively affluent

[27] Note that one should not expect $D\left(s,4,5\right)=D\left(s,3,5\right)-D\left(s,3,4\right)$, since each term is a weighted difference, and the weights used with each pair of curves depends upon which pair is being considered.

families, both because insufficient calorie availability is less likely to be an issue, and because richer households, as we showed, do not rely significantly on the Public Distribution System. Second, the NFHS sample was *not* randomly assigned to the different months during which the survey was carried out in Andhra Pradesh. This implies that our identification strategy would be invalidated by any systematic difference across the households interviewed in different months. Since different areas have been covered in different months, the possibility of such disparities cannot be ruled out.

To deal with these issues one has to include more covariates in the analysis, and since the size of our sample is relatively small, nonparametric methods become inadequate, due to the curse of dimensionality. For this reason, in what follows we extend our analysis making use of parametric and semiparametric tools.

To control for systematic differences across family units interviewed in different months, we make use of household and child-specific controls reported in the survey. These include completed years of education of child's mother and father, age and sex of household head, number of less than fourteen years old and number of more than sixty years old household members, household size, birth order, and dummies equal to one in the following cases: the household lives in the rural sector, the household head is Hindu, the household belongs to a scheduled caste or tribe, the child is twin, the mother was less than 20 or more than 40 years old when the child was born, the mother had antenatal visit, the child was premature, the birthweight was above average, the birthweight was below average, the child had polio, diptheria, or rickets.

Clearly, it would be important to control for systematic differences in the standard of living of the households, but the NFHS did not collect information on income or consumption. The survey does contain, though, data on asset ownership, and we use principal component methods to build an asset index to be used as proxy for the economic status of the household, as in Filmer and Pritchett (2001).[28] Principal component analysis is a statistical procedure whose objective is to describe a set of k variables (which here represent asset ownership) in terms of k unobservable *dimensions* or *factors*, whose meaning should be suggested by the context.[29] Each factor (or *principal component*) is obtained as a linear combination of the standardized original variables, through an iterative procedure. Since there are as many components as variables, the idea is to explain all the variance of the k original variables in terms of k orthogonal dimensions. In general, most of the variance is explained by a very few dimensions, and in most cases the *first* principal component is by far the more important one, so that the main task of the analyst is to give an interpretation of what this dimension is measuring. In the present context, where the original variables measure asset ownership, it is natural to think that

[28] The authors adopt this approach using NFHS data to evaluate the relation between schooling and economic status in Indian households.

[29] Principal component analysis is a particular form of *factor analysis*, in which the number of factors is allowed to be smaller than the number of variables explained. For details see the excellent treatment in Lindeman, Merenda and Gold (1980, Ch. 5 and 8).

the first principal component can be used as a proxy for the household's wealth. It should be stressed, however, that the *interpretation* of each component rests upon the judgement of the researcher, and it is not implied by the statistical procedure.

Filmer and Pritchett (2001), using NFHS data, show that the asset index gives reasonable results when used as a proxy of long-run economic status, and they also argue that such index might be a better measure than current consumption or income to evaluate household wealth. Here, the fact that the asset index is actually related to the economic status of the household is confirmed by a simple regression of z-scores of weight-for-age on the index, which results in a slope equal to 0.17, and a t-value equal to 17.8. The mean z-score of children living in families whose asset index is in the lower 25 percent of the distribution is -3, while the corresponding figure for children living in the upper 25 percent is -2, which becomes -1.4 for children born in households in the top five percent.

Table 3 contains the list of the assets that we use to construct the index. There are a total of 21 assets, related to land holdings, ownership of durable goods, and dwelling characteristics. We estimate the coefficients of the first principal component using observations from all Indian states surveyed from April to July 1992, which is the time frame relevant here.[30] Besides Andhra Pradesh, these states include Tamil Nadu, West Bengal, and Madhya Pradesh.

Each household-specific first principal component (our asset index) can be written as

$$a_h = \sum_{i=1}^{k} w_i z_{ih}$$

where w_i is the coefficient assigned to the $i-$th asset, and $z_{ih} = \sigma_i^{-1}\left(X_{ih} - \bar{X}_i\right)$ is the standardized value of such asset for household h (so $\bar{X}_i$ and σ_i are respectively mean and standard deviation of asset i in the sample). Therefore, a unit increase in the value of asset i implies a change in the asset index equal to $w_i\sigma_i^{-1}$. When the asset variable is a dummy, $w_i\sigma_i^{-1}$ simply indicates how the index changes when the household owns the relevant asset. We report the coefficients w_i in the first column of Table 3, while in the second column we report the sample means, and in the third we list the coefficients divided by the corresponding standard deviation.

Measuring program exposure, as we do, using the month during which the interview took place also brings forth another issue. Even assuming that there are no systematic differences in the characteristics of households interviewed in different months, one might worry about possible *seasonality* in growth performances due to inability to smooth consumption. This might be a realistic concern for India, which is still a largely poor and agricultural country. We solve this problem using a difference in differences approach, comparing the effect of a later measurement in Andhra Pradesh with that in other states surveyed during the same time frame, but where no relevant change in the PDS regime took place. Under the assumption that any seasonality in weight growth does not differ systematically

[30] Using the sample from all India, or from Andhra Pradesh only, the results are extremely similar. Both the correlation coefficient and the Spearman rank coefficient among each pair of asset indexes remain above 0.99.

across states, a nonzero difference in differences would provide support to the hypothesis that the change in the rice scheme that took place in Andhra Pradesh had an effect on child anthropometry. We implement this strategy using data from Tamil Nadu, West Bengal, and Madhya Pradesh, which together with Andhra Pradesh were surveyed by the NFHS from April to July 1992.[31] Following the NFHS terminology, we will generally refer to them as *phase I* states.

Since our identification strategy is based on the comparison of children with the same age but with different exposure to the high price regime, we will exclude from the sample infants which were less than four months old at the time of measurement, since all of these were born *after* the change in the Public Distribution System irrespective of the month of interview.[32]

7.1 The basic model

Since here we abandon a purely nonparametric approach, we have to make assumptions about how weight and age are functionally related. Figure 9 shows that among less than four years old children, the relation between the logarithm of weight and the logarithm of age is approximately linear, so that a double log functional form should be appropriate. In any case, we will show that relaxing this assumption using a semiparametric estimator that allows the functional form to be left unspecified, the results do not change significantly.

Using a double-log functional form, and assuming that all controls enter additively and separably in the regression, the simplest version of our model therefore becomes

$$\log(weight_i) = \phi \log(age_i) + \alpha_0 m_i + \mathbf{X}_i' \boldsymbol{\beta} + u_i \tag{2}$$

where $\mathbf{X}_i$ is a vector of child-specific controls and m_i is the number of months that the child has spent with high prices, so that α_0 is the parameter of interest.[33]

The choice of the functional form is not without implications when it comes to interpreting the results, since in (2) a unit change in m_i, or in any of the controls, implies a constant percentage change in expected weight, when all other regressors are being held constant. In particular, this means that one more month of high prices will imply the same percentage change across all age groups. In the present context, this implication of the model is reasonable, since weight tends to react quickly to changes in nutrition irrespective of age, so that one might expect to see comparable effects across all age groups, if the program is actually important in determining calorie availability for children.

[31] We will exclude from the analysis the very few observations related to women interviewed in August 1992 (which account for less than 2% of the relevant sample).

[32] We will also exclude children whose z-score was below -10, for which weight given age is so low to be probably due to misreporting (for example a two years old child weighting 5 kilograms). Choosing a different threshold, all results remained virtually identical.

[33] We include the constant in the vector of controls.

We estimate equation (2) using OLS, and we take into account the presence of clustering in the survey design when we estimate the standard errors.[34] We present the results in Table 4, separately for males and females. Columns 1-3 contain the results for males, while we present the corresponding estimated coefficients for females in columns 7-9. The other columns in the table refer to an alternative semiparametric estimator to which we return shortly below. For each sex we first present regressions with no controls (in Column 1 and 7). These regressions can be seen as the parametric equivalent of the nonparametric identification strategy proposed in the previous section, and they are therefore subject to all the critiques we already mentioned. In columns 2 and 8 we add a series of child and household-specific controls, to which in columns 3 and 9 we add the asset index described above. Clearly, in no case the main parameter of interest is significant at standard confidence levels. For males, the estimate is actually positive, which is contrary to what we expected. The sign of the remaining coefficients is mostly in line with the literature on child anthropometry. In particular, weight performance is positively affected by parental education, especially for females, while here the coefficients are not significant for boys. As expected, the asset index enters the regressions with a positive sign, but the hypothesis that its effect is zero is rejected only for males, where a unit increase in the index predicts approximately a one percent increase in weight-for-age. Birth order is generally associated to lower weight for boys, while for girls the coefficient is negative but insignificant. Not surprisingly, weight decreases if the child is a twin, or premature, or if the mother gave birth when very young (below 20) or more than forty years old, and a low birth weight has a large negative effect on weight at every age, for both boys and girls. Note that a low birth weight cannot be associated with the rice scheme change, because all children in the sample were already born before the change.

Since we do not want our results to be driven by the assumed log linear relation between weight and age, we repeat our estimates using Robinson's partially linear model (Robinson, 1988), a semiparametric estimator that allows to enter all controls linearly while leaving the functional form of the relation between weight and age unspecified. To ensure comparability among the results obtained using the two different procedures we use again both weight and age in logarithms, so that the basic model now becomes

$$\log(weight_i) = \Psi\left[\log(age_i)\right] + \alpha_0^R m_i + \mathbf{X}_i' \boldsymbol{\beta}^R + u_i^R \tag{3}$$

where the function Ψ is now left unspecified. The superscripts R indicates that the coefficients and the error in this model can differ from those in (2) above. Robinson's estimator uses the well known fact that in a linear regression of y on two sets of regressors, $\mathbf{X}_1$ and $\mathbf{X}_2$, the coefficients corresponding to $\mathbf{X}_2$ are numerically identical to those one obtains regressing the residuals of a regression of y on $\mathbf{X}_1$ on the residuals of a regression of $\mathbf{X}_2$ on $\mathbf{X}_1$.[35] For this argument to be valid, it is not necessary to assume

[34] Information about stratification in the survey was not available. This implies that the standard errors we present should be conservative estimates, since allowing for stratification usually reduces the variance of the estimates (see Deaton, 1997, Ch. 1).

[35] See, for example, Davidson and McKinnon (1993), Ch. 1.

that the relation between y and $\mathbf{X}_2$ is linear. In fact, if $y = f(\mathbf{X}_1) + \mathbf{X}_2'\gamma + u$, the set of coefficients γ can be estimated with a two step procedure, regressing $[y - E(y \mid \mathbf{X}_1)]$ on $[\mathbf{X}_2 - E(\mathbf{X}_2 \mid \mathbf{X}_1)]$ in the second step, while in the first step one estimates the conditional expectations nonparametrically.[36] In our context, $\mathbf{X}_1$ is univariate, so that the conditional expectations in the first-step can be easily estimated nonparametrically, making use of a locally weighted regression (Fan, 1992).

We present the results again in Table 4, to make the comparison with the previous purely parametric results easier. Again, the reported t-ratios take into account the clustered survey design, but they do not take into account the fact that, in the semiparametric estimator we use here, both the regressor and the dependent variable are estimated, rather than known. In large samples this is not relevant, since it can be shown that, if the semi-linear model is correctly specified, the asymptotic variance of the estimator is not affected by the first step. Since our sample is relatively small, as a robustness check we also compute bootstrapped standard errors, but the differences are negligible, and we do not report them in the table. The estimated coefficients for boys and girls are reported in columns 4 to 6 and 10 to 12 respectively. Clearly, all results are extremely close to the one computed using simple OLS and, in particular, the number of months spent in the high price regime is still small and insignificant.[37]

7.2 Difference-in-differences estimates

In all regressions we presented so far, the treatment variable is the number of months each child spent in the high price regime, and this variable is, by construction, perfectly collinear with the month during which the mother was interviewed by the NFHS. For this reason our estimates cannot distinguish between the effect of the program and any seasonality in growth rates that might be present among children living in poor households, where consumption smoothing can be made impossible by the presence of imperfect credit markets. Here we address this issue making use of a difference-in-differences approach, pooling together the sample from Andhra Pradesh and data from Tamil Nadu, Madhya Pradesh, and West Bengal, the other Indian states that the NFHS surveyed in the period from April to July 1992. In this way we can disentangle the effect of the program change from any seasonality in child anthropometry, as long as seasonality issues do not affect child growth differently across the different states considered here.

Let $D_i(s)$ denote a dummy equal to one when the i-th child in the sample lives in state s. Then,

[36] This can be easily seen by inspection after subtracting from each side of the original equation its expectation conditional on $\mathbf{X}_1$.

[37] We also repeated our estimates using only younger children (less than one, or less than two years old), or children living in relatively poor households (where the estimated asset index is below the median, or below the first quartile). Here we do not report these results, which are analogous to those shown in Table 4, and are available upon request from the author.

assuming again a log-linear relationship between weight and age, the model becomes

$$\log\left(weight_i\right) = \phi^d \log\left(age_i\right) + \alpha_0^d m_i + \alpha_1 m_i D_i\left(A\right) + \sum_{s=\{A,T,M\}} \gamma_s D_i\left(s\right) + \mathbf{X}_i'\boldsymbol{\beta}^d + u_i^d \tag{4}$$

where the indexes A, T, and M denote Andhra Pradesh, Tamil Nadu, and Madhya Pradesh respectively (so West Bengal is the omitted category here), and the superscript d makes clear that the coefficients (and residual) in (4) are not the same as in (2). Here, the effect of being measured one month later is equal to $\alpha_0^d + \alpha_1$ in Andhra Pradesh, and equal to α_0^d in the other states, so that α_1 (the difference-in-differences) is the parameter of interest. Again, we repeat our estimates relaxing the hypothesis of a linear relationship between the logarithm of weight and age, and using Robinson's partially linear estimator. We show the results in Table 5, for boys, and Table 6, for girls.

As in the previous section, there is no evidence of a significant effect of the change in the PDS price regime on child anthropometry. The sign of the relevant coefficient is still positive for boys, and negative for females, but in both cases we cannot reject the hypothesis that the effect is zero. The only new insight one has using the difference-in-differences approach is that children in Madhya Pradesh perform significantly worse than in West Bengal, which is here the omitted state category in the regressions. The sign and magnitude of the coefficients related to the controls present the same pattern observed when data from Andhra Pradesh only were used, and we do not comment further on them beyond noticing that, here too, and somehow surprisingly, parental education does not affect importantly children's anthropometric performance: for boys the coefficients are not significant, while for females only the father's years of completed education is significant, but very small.

We also repeat our estimates restricting the sample to households whose asset index is below the median, or below the first quartile, but the results do not change substantially, and we do not present the results here. The same happens if we only consider the youngest children (those less than a year, or less than two years old). The overall picture, then, is that our identification strategy cannot detect a significant impact of the change in PDS rules on child anthropometry.

8 Caveats and Conclusions

In this paper, we investigate whether a large and sudden reduction of the implicit subsidy offered by the Public Distribution System in Andhra Pradesh had detectable negative effects on children's weight-for-age. Our identification strategy uses the fact that the NFHS recorded children's weight during four months, form April to July 1992, while the increase in PDS rice happened at the end of January in the same year. Given their age, children measured later in the survey have been exposed to a shorted period of high prices. Since children in Andhra Pradesh are mostly malnourished, and since the PDS, in this state, provide a relatively large subsidy, one can therefore expect worse weight performances in children measured later in the survey. Using a range of different estimators, though, we cannot detect any significant effect of the change in the program on the outcome of interest, neither for boys, not for girls.

There are several possible explanations for this negative finding. First, and most obviously, it is possible that the subsidy offered by the system is not large enough to be detected by our estimates, given the relatively small sample size. In Section 1.5 we showed that, even among the poorest households, a return to the more generous former rice scheme might have implied a relative increase in calorie availability per child as small as two percent. Second, even if weight does tend to react quickly to changes in nutrition, it is possible that the differences in exposure considered here are not large enough to produce a detectable effect on children's weight. In fact, the difference in exposure is never larger than three months, for children measured in July versus April. Also, the fact that the change in the PDS took place only three months before the NFHS started collected data, implies that even poorer households might have been able to cope with the reduction in subsidy, making use of any accumulated savings. If this were the case, we would not be able to detect an effect on child anthropometry, even if the size of the subsidy were larger that what it actually is. A third reason behind our negative results might be the fact that age is reported at one month intervals, and this might cause attenuation bias in our estimates due to measurement error.[38] Note that this problem would be present even if age were reported without any error. To make things clear, suppose, for example, that a boy is recorded to be six months old in June. If he was born on December 27^{th}, 1991, and measured on June 27^{th}, 1992, he will have spent five months under the less generous rice scheme, which came into effect at the end of January 1992. But if he was born on December 1^{st}, 1991, and measured on June 1^{st}, 1992, the time spent with high prices will be much closer to four than to five months. Still, our procedure would not be able to distinguish between these two cases.

Even if these caveats do not make our results conclusive, they do cast further doubts on the ability of the Public Distribution System to offer food security to poor households, which is its primary proclaimed objective. Even in a state like Andhra Pradesh, where the system is working relatively well, we do not find evidence that this task is being achieved.

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Figure 1

Year	1988	1989	1990	1991	1992
Month	May Jun Jul Aug Sep Oct Nov Dec	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec	Jan Feb Mar Apr May Jun Jul
(1)					NFHS
(2)	Months of birth of children in NFHS sample				
(3)	Price of PDS Rice = 2 Rs/kg				3.5 Rs/kg
(4)	Per capita monthly quota = 5 kg				5 Rs/kg
(5)	Maximum monthly quota per household = 25 kg				20 Rs/kg
	Retail Price of Rice (average quality, rural and urban sector)[1]				
(6)	4.2	4.4	4.3	5.3	6

[1]Source: Bureau of Economic and Statistics, Government of Andhra Pradesh.

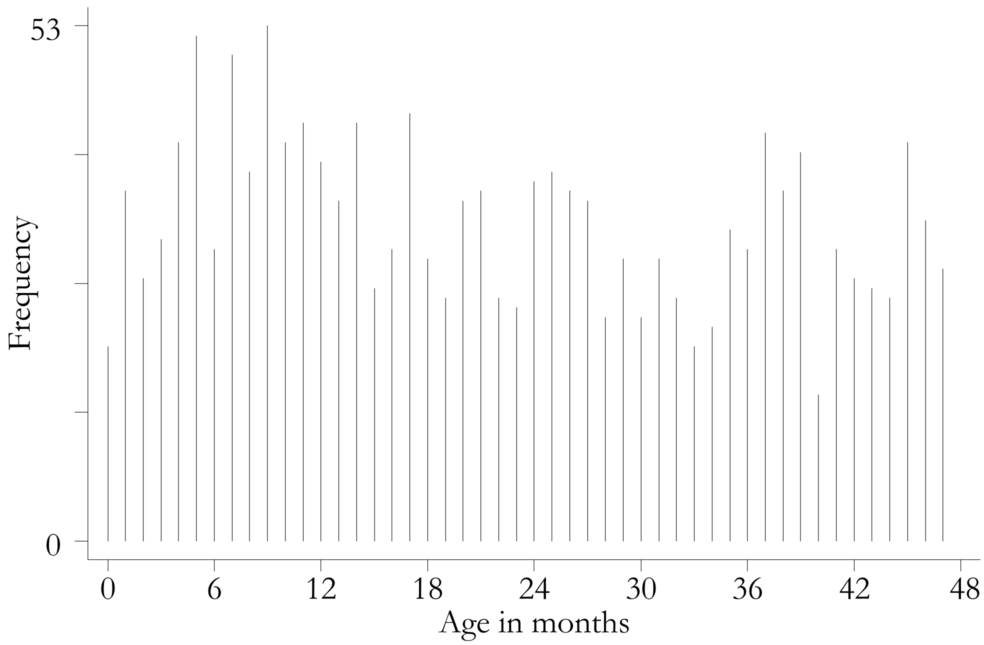


Figure 2 - Sample distribution of reported age of up to four years old children in Andhra Pradesh (males and females). Source: author's calculations from NFHS 1992-93.

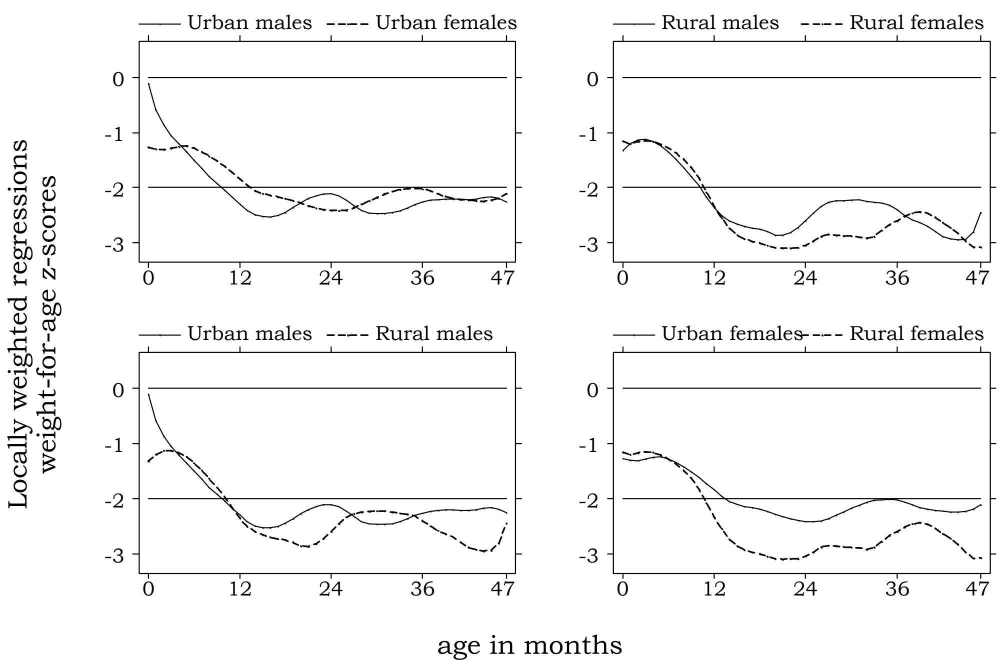


Figure 3 - Nonparametric regressions of z-scores on age. Andhra Pradesh only. Source: author's calculations from NFHS 1992-93. Each line is built using a locally weighted regression, with a biweight kernel. The bandwidth is equal to 8 in the urban sector, and equal to 5 in the rural sector. In the urban sector there are 187 males and 190 females. In the rural sector the sample contains 582 males and 559 females.

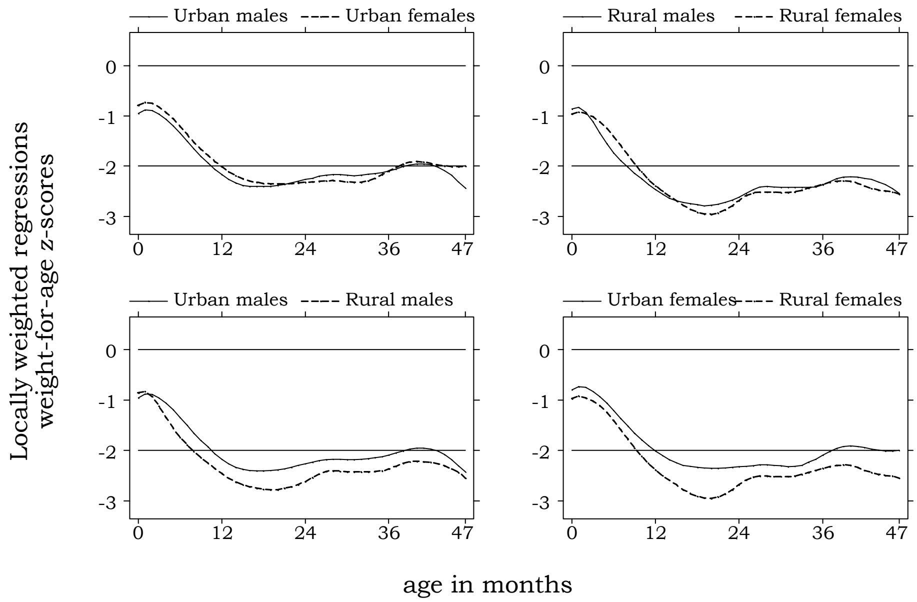


Figure 4 - Nonparametric regressions of z-scores on age. All India, except Andhra Pradesh, Himachal Pradesh, Madhya Pradesh, Tamil Nadu, and West Bengal. Source: author's calculations from NFHS 1992-93. Each line is built using a locally weighted regression, with a biweight kernel. The bandwidth is equal to 6 in the urban sector, and equal to 4 in the rural sector. In the urban sector there are 4213 males and 3848 females. In the rural sector the sample contains 10173 males and 9532 females.

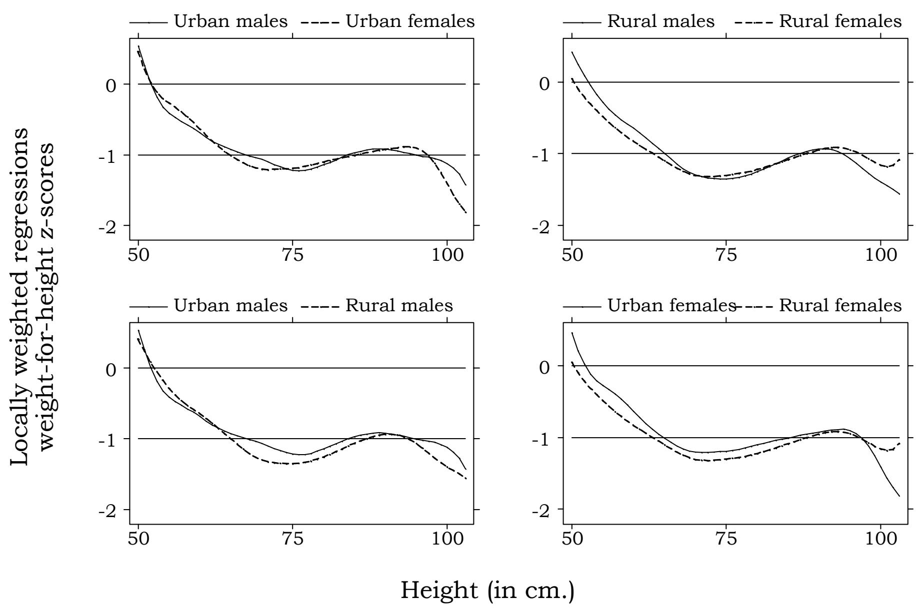


Figure 5 - Nonparametric regressions of z-scores on age. All India, except Andhra Pradesh, Himachal Pradesh, Madhya Pradesh, Tamil Nadu, and West Bengal. Source: author's calculations from NFHS 1992-93. Each line is built using a locally weighted regression, with a biweight kernel. The bandwidth is equal to 8 in the urban sector, and equal to 6 in the rural sector. In the urban sector there are 4132 males and 3850 females. In the rural sector the sample contains 10087 males and 9673 females.

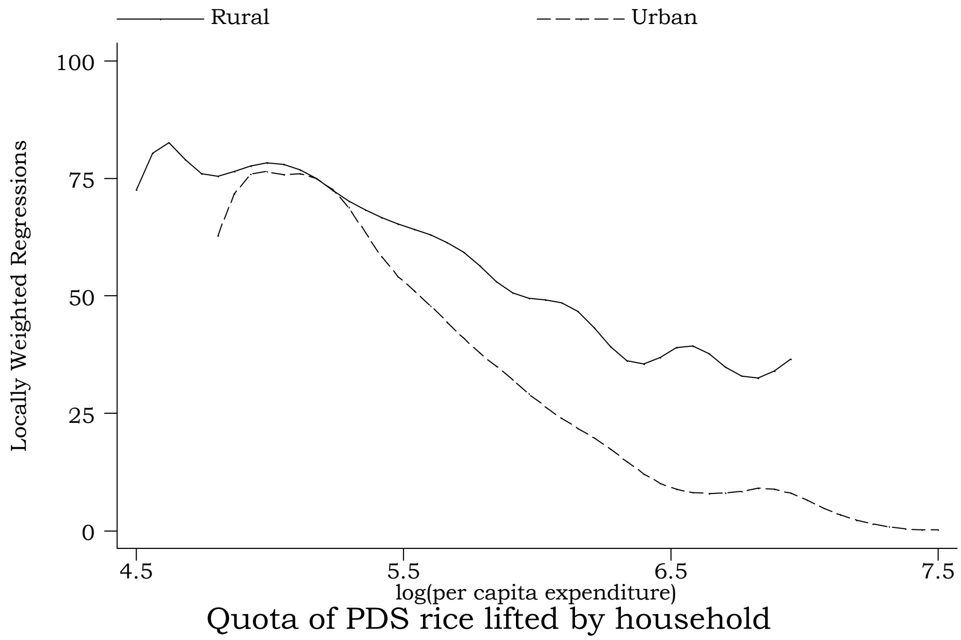


Figure 6 - Andhra Pradesh only. Source: author's computation from 50th NSS Round, 1993-94. The quota lifted is defined as min{20,5(household size)}. In both regressions the bandwidth is equal to 0.25. Both regressions are shown only for values of log(pce) above the lowest and below the highest centile of the corresponding sector-specific distribution.

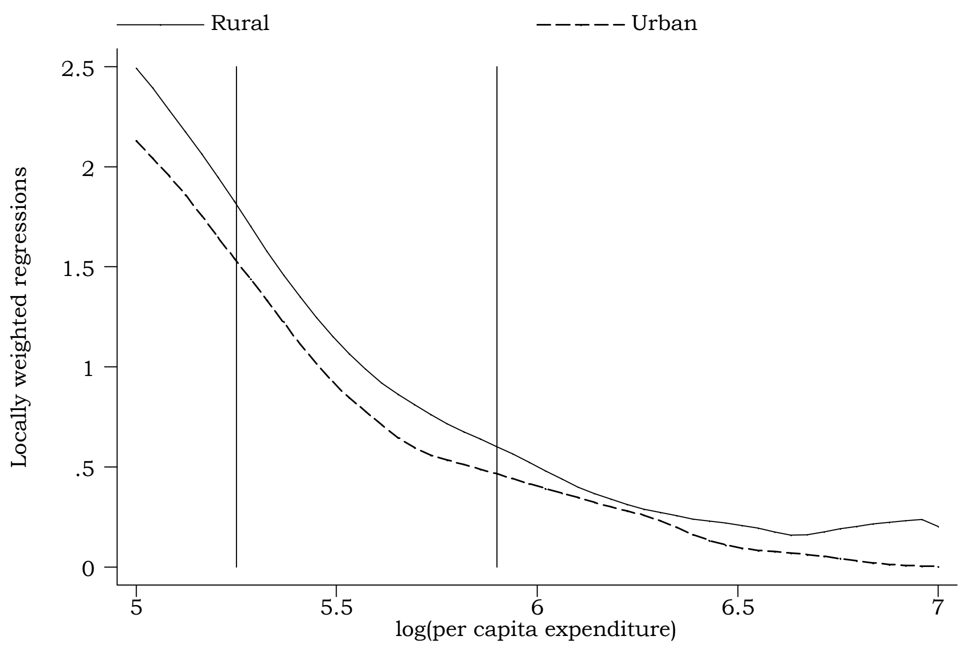
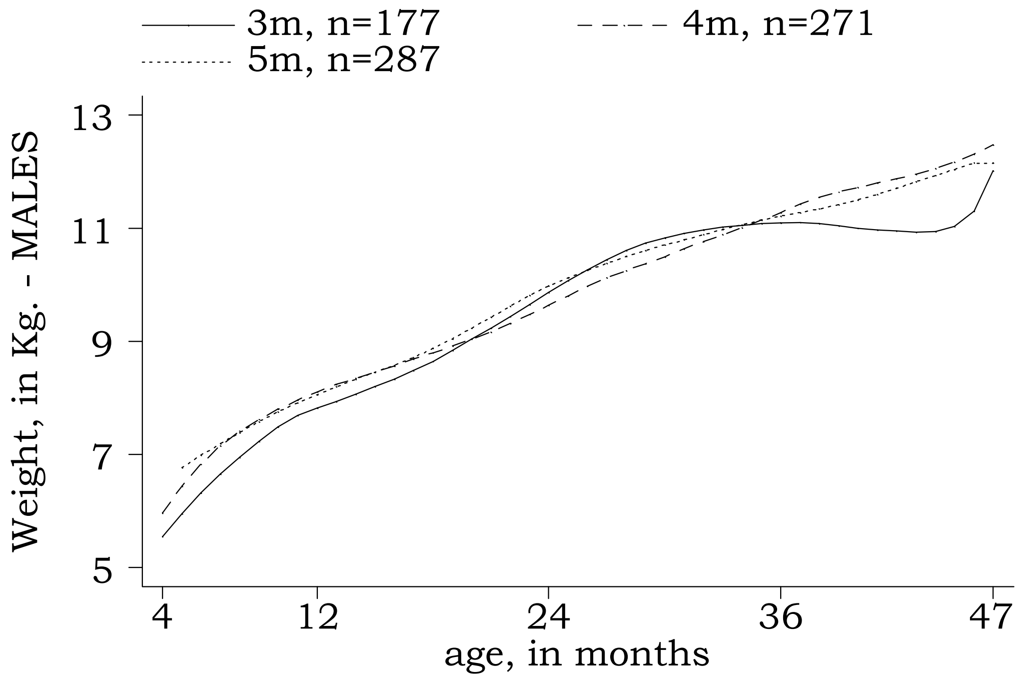


Figure 7 - Estimated relative increase in calorie availability per child. Andhra Pradesh only. Source: author's computation from 50th NSS Round, 1993-94. In both regressions the bandwidth is equal to 0.3. The two vertical lines delimit the interquartile range of the distribution of log(pce). The sample size is 1393 in the rural sector and 945 in the urban sector. For a precise description of the way we built the dependent variable see text.



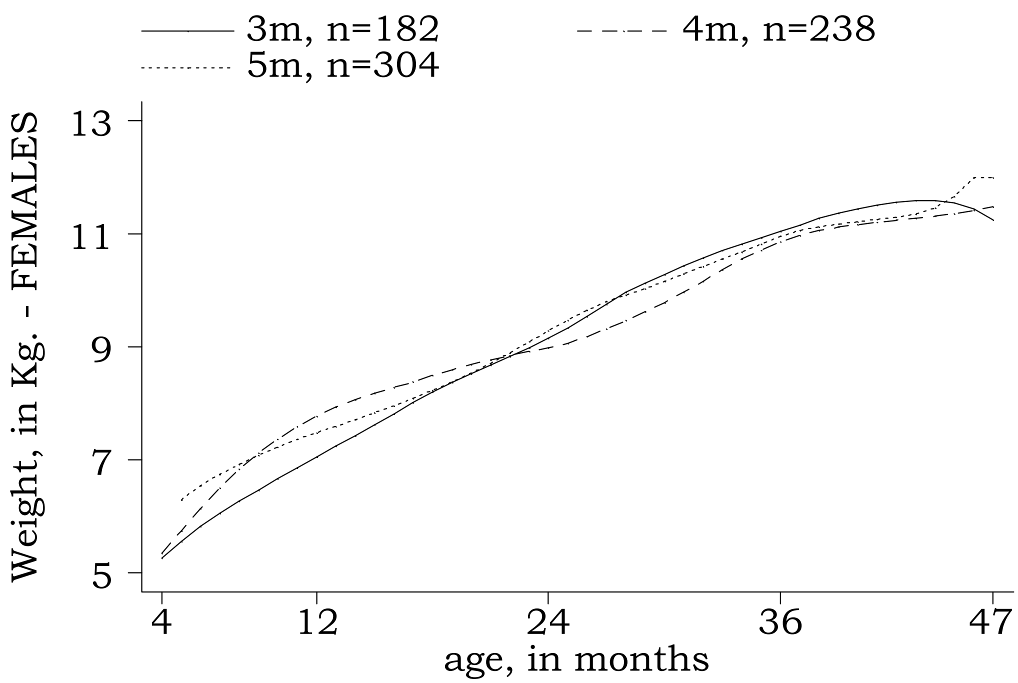


Figure 8 - Weight growth charts , by months of exposure to the high price regime. Andhra Pradesh only. Source: author's computation from NFHS, 1992-93. The curves are locally weighted regressions, with the bandwidth equal to 8.

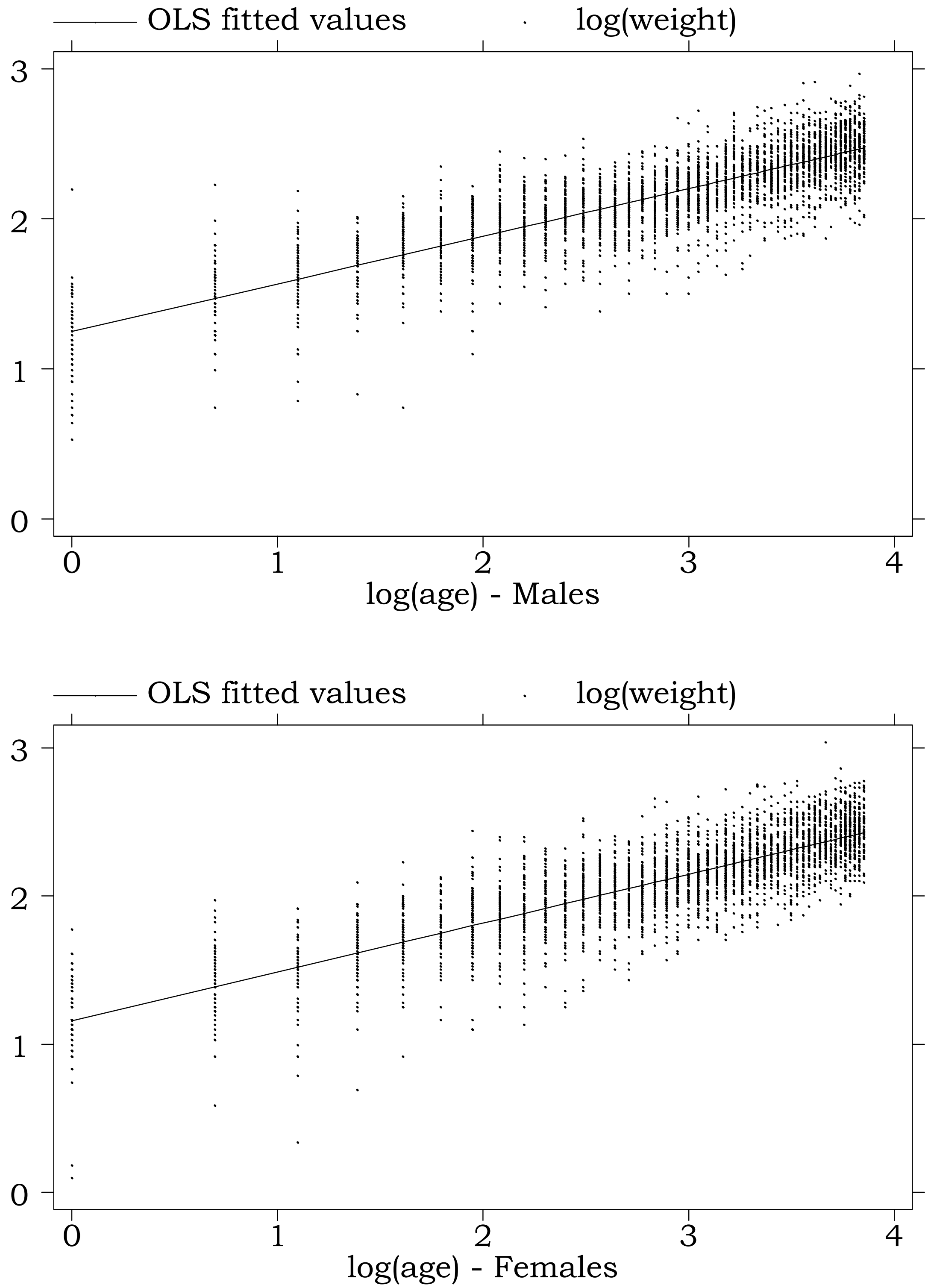


Figure 9 - Logarithmic Growth Charts: all *Phase I* states.
Source: author's computations from NFHS, 1992-93. Sample size: 3704 males, and 3645 females.

Table 1: Summary Statistics on Consumption of Rice in Andhra Pradesh, 1993-94

		Rural Sector (*n* =4908)			Urban Sector (*n* =3644)		
		1st decile	10th decile	All	1st decile	10th decile	All
	Percentage of households consuming:						
(1)	rice, purchased from PDS	77.8	37.4	62.0	73.5	6.1	34.0
(2)	rice, purchased from PDS or other sources[1]	94.6	99.3	98.1	95.2	95.6	95.9
(3)	Monthly per capita consumption of PDS rice (in kg)	2.6	1.8	2.5	2.4	0.4	1.5
(4)	Proportion of rice (in kg) purchased from PDS[2]	45.2	13.8	26.5	36.8	3.7	16.3
	Budget shares						
(5)	Rice, other sources[1]	20.1	13.1	20.6	20.8	7.9	17.4
(6)	Rice, from PDS	7.7	1.2	4.1	5.6	0.2	2.2
(7)	All items from PDS (rice, sugar, kerosene)[3]	9.7	2.1	5.7	8.0	1.2	4.2
	Per capita implicit subsidy[4] (in Rupees per month)						
(8)	Rice, from PDS	6.3	4.6	6.4	6.5	0.7	4.2
(9)	All items from PDS (rice, sugar, kerosene)	7.5	7.9	8.4	8.5	4.6	7.5
	Total subsidy as percentage of total budget[5]						
(10)	Rice, from PDS	5.2	0.8	2.9	4.3	0.1	1.7
(11)	All items from PDS (rice, sugar, kerosene)	6.3	1.3	3.7	5.7	0.5	2.7

Source: author's computations from NSS 50th Round (July 1993/June 1994). Deciles refer to the sector-specific distribution of per capita total expenditure. When the statistic displayed refers to a ratio, it is always computed as the average of household-specific ratios, and not as the ratio of two totals computed over all households. Notes: 1) Other sources includes cash purchases from the open market, domestic production, items received in exchange of goods and services, transfer receipts (such as gifts and loans) and free collection. 2) Since the denominator is the total quantity of rice consumed by the household, these figures are computed using only households consuming positive amounts of rice (from any source). 3) Other items sold in Fair Price Shops in Andhra Pradesh (wheat, edible oils, pulses, and other cereals) are on average negligible. 4) Total subsidy per household is the product between the quantity bought from Fair Price Shops and the difference between open market and subsidized price (both estimated using unit values). 5) Ratio between total implicit subsidy and household expenditure.

Table 2 - Average distances between growth charts

	s = Males	*s* = Females
D(*s*,3,4)	-0.19	-0.19
	(0.16)	(0.19)
D(*s*,3,5)	-0.01	-0.09
	(0.17)	(0.18)
D(*s*,4,5)	0.13	0.10
	(0.15)	(0.14)

Source: Author's computation from NFHS, 1992-93. Andhra Pradesh. *D(s,m,m')* is the weighted average distance (in kilograms) between the growth chart for children of sex s exposed to m months of high PDS prices and those exposed to m′ months. The distance at each age is weighted using the total number of observations used to estimate the difference itself. The figures in parenthesis are bootstrapped standard errors obtained with 100 replications. Bootstrap replications take into account the clustered survey design.

Table 3 - Components of asset index

	w_i	X_i	$w_i\sigma_i^{-1}$
Number of rooms in household's house	0.183	2.526	0.098
Separate room used as kitchen (0 no 1 yes)	0.165	0.493	0.33
Type of fuel used for cooking (0 wood/dung/coal - 1 other)	0.219	0.197	0.55
Land (acres)	0.011	2.642	0.001
Owns Sewing machine (0 no 1 yes)	0.202	0.109	0.647
Owns Clock/watch (0 no 1 yes)	0.23	0.486	0.46
Owns Sofa set (0 no 1 yes)	0.228	0.059	0.97
Owns Fan (0 no 1 yes)	0.299	0.292	0.657
Owns VCR/VCP (0 no 1 yes)	0.121	0.013	1.085
Source of drinking water (1 piped into residence 0 other)	0.255	0.117	0.795
Source of non-drinking water (1 piped into residence 0 other)	0.263	0.124	0.797
Type of toilet facility (1 flush toilet 0 other)	0.283	0.129	0.844
Has electricity (0 no 1 yes)	0.22	0.518	0.44
Has radio (0 no 1 yes)	0.195	0.392	0.399
Has television (0 no 1 yes)	0.297	0.165	0.8
Has refrigerator (0 no 1 yes)	0.214	0.036	1.153
Has bicycle (0 no 1 yes)	0.118	0.432	0.238
Has motorcycle (0 no 1 yes)	0.225	0.065	0.912
Has car (0 no 1 yes)	0.105	0.007	1.259
dwelling all high quality materials (0 no 1 yes)	0.266	0.19	0.678
dwelling all low quality materials (0 no 1 yes)	-0.244	0.61	-0.5

Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Source: Author's computation from NFHS, 1992-93. Obs. 5891. The figures are estimated using the sample weights provided in the survey, and counting every household once. When the relevant information on asset ownership is missing we imputed a value equal to the median in the same cluster.

Table 4 - Andhra Pradesh - dependent variable log(weight)

	Males, n = 736						Females, n = 723					
	log-linear			Robinson			log-linear			Robinson		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
log(age)	0.294	0.289	0.291				0.315	0.310	0.311			
	[30.67]	[29.40]	[29.44]				[28.94]	[28.42]	[28.52]			
No. months in high price regime	**0.004**	**0.005**	**0.002**	**0.002**	**0.003**	**0.000**	**-0.001**	**-0.009**	**-0.011**	**0.002**	**-0.007**	**-0.008**
	[0.59]	**[0.74]**	**[0.28]**	**[0.32]**	**[0.47]**	**[0.02]**	**[0.08]**	**[0.97]**	**[1.08]**	**[0.14]**	**[0.74]**	**[0.86]**
Asset index			0.013			0.013			0.005			0.005
			[3.44]			[3.30]			[1.55]			[1.55]
Mother's completed yrs of education		0.004	0.001	0.003	0.003	0.001		0.005	0.004		0.006	0.005
		[1.51]	[0.22]	[1.45]	[1.45]	[0.18]		[2.37]	[1.75]		[2.72]	[2.05]
Husband's completed yrs of education		0.000	-0.002	0.000	0.000	-0.002		0.006	0.005		0.005	0.005
		[0.07]	[1.25]	[0.24]	[0.24]	[1.01]		[3.21]	[2.69]		[3.07]	[2.57]
Birth Order (=1 for the youngest)		-0.015	-0.015	-0.014	-0.014	-0.014		-0.002	-0.002		-0.001	0.000
		[2.69]	[2.79]	[2.52]	[2.52]	[2.61]		[0.35]	[0.32]		[0.11]	[0.08]
Child is twin		-0.076	-0.103	-0.091	-0.091	-0.116		-0.094	-0.091		-0.094	-0.091
		[0.83]	[1.22]	[1.14]	[1.14]	[1.55]		[3.32]	[3.20]		[2.91]	[2.79]
Mother's age <20 or >40		-0.029	-0.024	-0.032	-0.032	-0.027		-0.016	-0.015		-0.015	-0.014
		[1.66]	[1.38]	[1.86]	[1.86]	[1.58]		[0.91]	[0.83]		[0.83]	[0.74]
Mother had antenatal visit		0.003	0.001	0.009	0.009	0.007		0.038	0.038		0.039	0.039
		[0.13]	[0.05]	[0.38]	[0.38]	[0.28]		[2.30]	[2.30]		[2.36]	[2.37]
Child was premature		-0.091	-0.077	-0.086	-0.086	-0.074		-0.032	-0.032		-0.037	-0.036
		[2.63]	[2.56]	[2.58]	[2.58]	[2.49]		[0.91]	[0.87]		[1.08]	[1.03]
Birth weight was above average		0.017	0.014	0.015	0.015	0.013		0.024	0.021		0.023	0.021
		[0.88]	[0.76]	[0.83]	[0.83]	[0.73]		[1.07]	[0.94]		[1.11]	[0.97]
Birth weight was below average		-0.072	-0.069	-0.071	-0.071	-0.069		-0.078	-0.077		-0.075	-0.074
		[3.89]	[3.79]	[3.82]	[3.82]	[3.70]		[4.51]	[4.40]		[4.44]	[4.34]
Child had polio, diptheria, or rickets		-0.029	-0.027	-0.034	-0.034	-0.032		0.004	0.008		0.003	0.007
		[0.62]	[0.57]	[0.75]	[0.75]	[0.70]		[0.13]	[0.24]		[0.06]	[0.17]
R-squared	0.59	0.63	0.64				0.61	0.67	0.67			

Source: author's computations from NFHS, 1992-93. t-ratios in parenthesis. All standard errors take into account the presence of clustering in the survey design.

Table 5 - All states in NFHS Phase I - dependent variable log(weight)

	Males, n = 3481			
	log-linear		Robinson	
	(1)	(2)	(3)	(4)
log(age)	0.31	0.308		
	[66.64]	[69.36]		
No. months in high price regime	-0.008	-0.006	-0.007	-0.005
	[1.94]	[1.60]	[1.83]	[1.46]
Andhra Pradesh	-0.047	-0.027	-0.047	-0.026
	[1.20]	[0.74]	[1.18]	[0.72]
Madhya Pradesh	-0.051	-0.057	-0.050	-0.055
	[5.72]	[6.32]	[5.66]	[6.21]
Tamil Nadu	0.024	0.007	0.025	0.007
	[2.68]	[0.78]	[2.88]	[0.88]
Months*Andhra Pradesh	**0.011**	**0.004**	**0.011**	**0.004**
	[1.32]	**[0.56]**	**[1.31]**	**[0.55]**
Asset index		0.015		0.014
		[8.59]		[8.35]
Mother's completed yrs of education		0.001		0.001
		[0.52]		[0.68]
Husband's completed yrs of education		0.000		0.000
		[0.20]		[0.04]
Birth Order (=1 for the youngest)		-0.004		-0.004
		[1.90]		[1.87]
Child is twin		-0.166		-0.163
		[5.15]		[5.23]
Mother's age <20 or >40		-0.010		-0.010
		[1.19]		[1.20]
Mother had antenatal visit		-0.005		-0.002
		[0.64]		[0.32]
Child was premature		-0.01		-0.010
		[0.57]		[0.57]
Birth weight was above average		0.025		0.024
		[3.31]		[3.25]
Birth weight was below average		-0.046		-0.045
		[6.60]		[6.56]
Child had polio, diptheria, or rickets		-0.075		-0.076
		[2.36]		[2.45]
R-squared	0.62	0.66		

Source: author's computations from NFHS, 1992-93. t-ratios in parenthesis. All standard errors take into account the presence of clustering in the survey design. Other controls included in the regression are age and sex of household head, number of less than fourteen years old and number of more than sixty years old household members, household size, and dummies for rural sector, religion and scheduled caste or tribe.

Table 6 - All states in NFHS Phase I - dependent variable log(weight)

	Females, n = 3431			
	log-linear		Robinson	
	(1)	(2)	(3)	(4)
log(age)	0.33	0.328		
	[66.13]	[66.12]		
No. months in high price regime	-0.001	0.001	-0.0013	0.0014
	[0.24]	[0.34]	[0.28]	[0.32]
Andhra Pradesh	0.023	0.068	0.0179	0.0627
	[0.42]	[1.41]	[0.33]	[1.32]
Madhya Pradesh	-0.019	-0.02	-0.019	-0.0193
	[1.71]	[1.91]	[1.74]	[1.89]
Tamil Nadu	0.036	0.01	0.0367	0.0106
	[3.24]	[1.01]	[3.34]	[1.09]
Months*Andhra Pradesh	**-0.001**	**-0.013**	**0.0004**	**-0.0113**
	[0.06]	**[1.17]**	**[0.03]**	**[1.07]**
Asset index		0.011		0.0106
		[5.94]		[6.01]
Mother's completed yrs of education		0.002		0.002
		[1.81]		[1.84]
Husband's completed yrs of education		0.002		0.0023
		[2.67]		[2.66]
Birth Order (=1 for the youngest)		-0.001		-0.0005
		[0.59]		[0.27]
Child is twin		-0.069		-0.0656
		[2.16]		[1.97]
Mother's age <20 or >40		-0.02		-0.0182
		[2.13]		[1.99]
Mother had antenatal visit		0.013		0.014
		[1.65]		[1.80]
Child was premature		-0.016		-0.0162
		[1.04]		[1.03]
Birth weight was above average		0.036		0.0369
		[4.46]		[4.63]
Birth weight was below average		-0.043		-0.0405
		[5.62]		[5.37]
Child had polio, diptheria, or rickets		-0.095		-0.0972
		[1.99]		[2.04]
R-squared	0.62	0.66		

Source: author's computations from NFHS, 1992-93. t-ratios in parenthesis. All standard errors take into account the presence of clustering in the survey design. Other controls included in the regression are age and sex of household head, number of less than fourteen years old and number of more than sixty years old household members, household size, and dummies for rural sector, religion and scheduled caste or tribe.