How well do improvements in economic status track non-monetary measures of well-being? Evidence from child height

Eric V. Edmonds*
Dartmouth and NBER

http://www.dartmouth.edu/~eedmonds

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Official measures of poverty generally track economic status, the idea being that changes in well-being more broadly understood move with measures of economic status like per capita expenditures or personal income in a consistent manner over time. However, during a period of economic expansion (or contraction), there will be both changes in the household's external environment that in a fundamental way can alter the conditional expectation of non-monetary measures of well-being given economic status. This study analyzes the ability of improvements in economic status to track improvements in one alternative measure of well-being during Vietnam's economic boom in the 1990s. Improvements in economic status as measured by per capita expenditures can explain 60 percent of the improvement in child nutritional status as measured by height for age z-scores in the under 10 population and 74 percent of the improvement in households below the poverty line. The findings of this study are consistent with a model where improvements in food intake associated with rising economic status affect large nutritional gains for children. Once food intake is sufficient, environmental factors become a relatively more important determinant of the nutritional status of children, and the ability of economic status to track improvements in child height deteriorates.

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1. Introduction

The on-going debate over poverty and globalization is based on two empirical questions. First, does globalization affect poverty? Goldberg and Pavcnik (2004) survey the recent literature on trade and poverty, and Deaton (2003) discusses the measurement issues inherent in tracking poverty through time. Second, are the observed movements in economic status meaningful in terms of other, non-monetary measures of well-being? This is an old discussion (see Anand and Ravallion 1993), but it has taken on a new relevance in the contemporary globalization debate. This later question is the subject of this paper.

Case and Deaton (2003) make a case for considering measures of adult health and educational outcomes as non-monetary measures of well-being. Their case is based on the fact that these are easy to measure relative to real consumption and assignable to individuals rather than households. The present study considers child nutritional status as measured by child height. Child height is also assignable to individuals and relatively straightforward to measure. Moreover, a strong case can be made for it as a critical component of human capital and individual welfare (Duflo 2003). This study takes as given that child height is an outcome policy cares about. The present question, then, is given that countries currently track (and will continue to track) economics status, how well do improvements in economic status predict improvements in child height.

This question is integrally tied to research on the income gradient in child nutritional status even though the existence of an income gradient is not sufficient to establish co-movement. Cross-country comparisons are broadly consistent with the belief that improvements in economic status lead to improvements in health and nutrition (Pritchett and Summers 1996, Smith and Haddad 2002). However, the microeconomic evidence on the relationship between child height and economic status is not as compelling as one might expect. First, most of the research focuses on the relationship between economic status and nutrient intake rather than nutritional status (Strauss and Thomas 1995). Nutritional intake is one of many inputs that contribute to nutritional status, but the correspondence between the two is affected by aspects of the child's health and environment. Second, the research that focuses on the relationship between improvements in economic status and child nutritional status is decidedly mixed in its conclusions (Deaton 2003). Most of the published literature finds a small, positive correlation between improvements in economic status and child height although estimates are not large enough in magnitude (generally) to explain the changes in child nutritional status that have occurred in many growing economies in recent history (Haddad et al 2003).[1] Third, a number of studies emphasize a causal relationship between child nutritional status and policy, technology, or other environmental factors that may lead to a correlation between changes in economic status and nutritional status through time that has nothing to do with improvements in individual economic status directly (Strauss and Thomas 1995; Grossman 2000). Thus, the extent to which child height and economic status track one another is not clearly established.

The idea that child height moves with improvements in economic status in effect rules out certain kinds of price effects. That is, the idea that child height will move with economic status implies that as economic status improves through time, child height will evolve as if this through time process is occurring at a single point in time, that the conditional expectation of child height at any given economic status is stable. Child height becomes like that observed in richer households. The empirical work in this study uses non-parametric regression techniques to implement this idea directly. Using a household panel dataset from Vietnam with 1900 households with children under 10 interviewed in both 1993 and 1998, observations on the association between child height and per capita expenditure at a single point in time are coupled

[1] Sahn 1990, Thomas, Strauss, and Henriques 1990, Thomas, Strauss, and Henriques 1991, Thomas and Strauss 1992, and Block 2002 find positive but small marginal effects of improvements in per capita expenditures on child height. Duflo looks at the effect of pension income on child height in South African and finds effects that are large relative to what has been found in the literature that works with expenditures (Duflo 2000 and 2003). The following studies find a positive relationship between per capita expenditures and child height that is not statistically significant from zero: Horton 1986, Wolfe and Behrman 1987, Strauss 1990, Sahn 1994, Thomas, Levy, and Strauss 1996, Ponce, Gertler, and Glewwe 1998, and Glewwe, Koch, and Nguyen 2003.

with observations on improvements in per capita expenditures through time to predict changes in child height that are in turn compared to actual changes in child height.

Child nutrition status (measured by the height for age z-scores of children under 10) improves by 20 percent between 1993 and 1998 in Vietnam. The incidence of severe undernutrition declines by 50 percent. Improvements in economic status as measured by per capita expenditure can explain 60 percent of the overall improvement child nutritional status and 74 percent of the improvement in households below the poverty line in 1993. While this is encouraging for the co-movement of improvements in economic status and child height, the decomposition gives decidedly weaker results for wealthier households. For relatively wealthy households, unexplained variation in child nutritional status is correlated within communities. This finding is consistent with a model where nutritional status is determined by both food intake and environmental factors (as discussed in Ravallion 1990). Once basic food requirements are met, other environmental factors become more significant. Thus, while the present data suggest a strong link between economic status and child nutritional status, these data from Vietnam are not encouraging for the ability of economic status to proxy for child nutritional status as countries become richer.

This article is organized as follows. The next section develops the decomposition used herein in the context of the literature on the determinants of child nutritional status. Section 3 introduces the data and discusses changes in per capita expenditure and child height observed in Vietnam between 1993 and 1998. Section 4 examines the association between improvements in economic status and the nutritional status of children. Section 5 concludes and emphasizes the implications of the patterns observed in this study for researchers evaluating targeted programs or estimating health production functions.

2. Methodology

2.1 Theory

There are a variety of mechanisms through which economic status may influence the nutritional status of children (for surveys, see Behrman and Deolaliker 1988, Strauss and Thomas 1995, Strauss and Thomas 1998, and Deaton 2003). Increased economic resources at the household level can lead to improved diets, better sanitation and health practices, or more effective use of these health services. Rising household incomes may changes discount rates or induce other behavioral changes. Whether improvements in child height track economic status depends on how important relative price changes are in the child height determination process.

Child height *y* for a member of household *i* at time *t* is influenced the value of the household's exogenous endowment *m*, external prices *q* that are affected by the value of the household's endowment, and by exogenous prices *p* that reflect the household's policy and technology environment:[2]

$$(1) \qquad y_{it} = f\left(p_t, q_{it}\left(m_{it}\right), m_{it}\right).$$

f() summarizes a complicated household decision-making process where internal shadow prices are important in the household's decision. However, these shadow prices ultimately depend on *p*, *q*, and *m*.

An obvious way to consider the question at hand is to relate changes in child height to changes in the household's endowment. Consider the case of two time periods (indexed 0 and 1). The relationship between changes in child height and changes in the value of the endowment could be written as:

$$(2) \qquad y_{i1} - y_{i0} = g\left(m_{i1} - m_{i0}\right) + e_i$$

where *e* is mean zero regression error. Ignoring for the moment the problem that exogenous endowments are unknown to the econometrician, the problem with analyzing the link between changes in the value of the endowment and child height is that changes in the value of endowments are likely to be correlated with changes in exogenous prices. Consider studying one

[2] Exogenous prices might also reflect relative income effects if relative income status influences health.

individual observed at two points in time (indexed 0 and 1). Using (1), the observed change in *y* can be viewed as:

$$(3) \qquad y_{i1} - y_{i0} \simeq \frac{\partial f}{\partial p}\left(p_1 - p_0\right) + \left(\frac{\partial f}{\partial q}\frac{\partial q}{\partial m} + \frac{\partial f}{\partial m}\right)\left(m_{i1} - m_{i0}\right)$$

The concern is that if changes in the policy or technology environment are correlated with changes in the value of endowments, there will be a correlation between *e* and $\left(m_{i1} - m_{i0}\right)$ in (2), and thus (2) misattributes the effect of exogenous price changes to endowment changes. The literature on child nutritional status highlights several factors that may be associated with both improvements in the value of endowments (through economic growth for example) and relative price movements. These factors may include policy changes that affect diets (Strauss and Thomas, Foster 1995), sanitation and water quality (Strauss and Thomas 1995), health practices (Strauss 1990), health services (Barrera 1990, Thomas and Strauss 1992), or access to formal or nutrition education (Thomas, Strauss, and Henriques 1991, Webb and Block 2003)

Researchers typically address the problem of the endogeneity of income in (2) by assuming a linear functional form on (2) and using an instrumental variables technique to solve the endogeneity problem.[3] The assumption of a linear functional form is problematic in general when consider the effects of improvements in income, because it seems implausible to think that the effects of income on household well-being should be linear. In the nutrition case, linearity implies that the impact of a dollar on child nutrition should be the same when a child is starving as when a household lives in relative opulence.

While the linearity assumption is easily relaxed, finding a plausible instrument for household income is substantially more difficult. Researchers are often forced to rely on strong assumptions in modeling for identification (Duflo 2003 is an exception). The idea of the present decomposition is to use a cross-section of data when households face common external prices to map the relationship between variation in household income and the outcome of interest. That

[3] Of course, non-linear IV options are available, but they do not appear to have been used in the present context.

is, consider the experiment of comparing 2 individuals (indexed 1 and 2) observed at time 0. The difference in (1) between these two individuals can be written:

$$
\begin{aligned}
y_{10} - y_{20} &\simeq \frac{\partial f}{\partial p}\left(p_0 - p_0\right) + \left(\frac{\partial f}{\partial q}\frac{\partial q}{\partial m} + \frac{\partial f}{\partial m}\right)\left(m_{10} - m_{20}\right) \\
&= \left(\frac{\partial f}{\partial q}\frac{\partial q}{\partial m} + \frac{\partial f}{\partial m}\right)\left(m_{10} - m_{20}\right)
\end{aligned} \qquad (4)
$$

Because two individuals observed at the same time face the same exogenous prices, the cross-sectional mapping between differences in *y* and differences in income maps the association between the two. Note that this mapping reflects both the changes in the value of endowments and changes in external prices the move with the value of endowments and is independent of exogenous price changes through time.

(4) is the basic idea of this paper. Absent exogenous price changes that fundamentally alter the way endowments map to child height, the cross-sectional mapping between child height and a measure of the value of the household's endowment predicts changes in child height through time. This is essentially, then, a Blinder-Oaxaca decomposition. That (4) characterizes how well-being evolves with some measure of economic status is an implicit assumption in policy that only tracks changes in economics status through time. To the extent that the mapping between non-monetary measures of well-being and economic status is stable through time, tracking economic status alone is sufficient for monitoring well-being.

2.2 Empirical Methods

This section outlines how to construct the counterfactual of how child height would change through time if exogenous prices are fixed so that the mapping between the value of the household's endowment and child height is stable over time. That is, the counterfactual of interest is what would happen to child height if all that happened during growth is that poorer households became like their richer neighbors. The value of the household's endowment is unobserved, so per capita expenditures are used as a proxy. These expenditures are chosen jointly with inputs into child height, so it is important to emphasize that the empirical work does not recover causal relationships. The motivation in using per capita expenditures as a proxy for changes in the value of endowments is two fold. First, per capita expenditures are typically the measure of economic status that policy tracks. Second, it has some theoretical justification under the permanent income hypothesis. Implicit within the use of per capita expenditures as a proxy of the value of household endowments is the assumption that a given vector of exogenous prices p and value of the household endowments m maps to a unique per capita expenditure.

Child height and per capita expenditures are observed at two points in time, t and t+1. Specifically, consider a household with a per capita expenditure of \$100 at time t and \$150 at time $t+1$. The estimate of what child height should be at time $t+1$ with only improvements in per capita expenditure is based on the child height observed at time t in households with a per capita expenditure of \$150. This simple matching method is not possible to implement directly, because the data does not offer continuous support for the per capita expenditure distribution. Moreover, with measurement error in per capita expenditures, the closest individual match may be a poor match for the true (absent measurement error) changes in per capita expenditure.

Thus, this study employs non-parametric smoothing methods to compute the counterfactual of what child height would be expected if improvements in economic status progressed across the baseline relationship as in (4). Consequently, the decomposition proceeds in 3 steps:

> *Step 1*: The expected child height at time t conditional on per capita expenditure at time t, $E\left[y_{it} \middle| m_{it}, q_{it}, p_t\right]$, is computed by the nonparametric regression of child height on per capita expenditures. That is: $y_{it} = f_t\left(m_{it}\right) + e_{it}$.
>
> *Step 2*: The expected per capita expenditure in time $t+1$, $\hat{m}_{it+1} \equiv E\left[m_{it+1} \middle| m_{it}\right]$, for a household with per capita expenditure m_{it} is computed by the nonparametric regression of per capita expenditure in time $t+1$ on per capita expenditure in time t: $m_{it+1} = h\left(m_{it}\right) + u_{it+1}$.
>
> *Step 3*: The counterfactual of what child height would be expected at time $t+1$ if all that happened between time t and time $t+1$ is that poorer households became

like their richer neighbors (e.g. p_t is held constant) is constructed by plugging in the result from step 2 into the result from step 1:

(5) $$\hat{y}_{it+1} \equiv E\left[y_{it+1} \middle| \hat{m}_{it+1}, q_{it+1}(\hat{m}_{it+1}), p_t \right] = E\left[y_{it+1} \middle| \hat{m}_{it+1}, p_t \right] = f_t\left(h\left(m_{it}\right)\right).$$

$\hat{y}_{it+1}$ can then be compared to the observed child height at time *t* and to the realized child height at time *t+1*. $\hat{y}_{it+1} - y_{it}$ is the change in child height that is expected if changes in child height through progress as if households are moving across the baseline cross-section. The residual $\rho_{it+1} \equiv y_{it+1} - \hat{y}_{it+1}$ is the change in child height that cannot be explained by improvements in economic status and the baseline relationship.

Before turning to the data, it is important to review the reasons why the baseline relationship and improvements in per capita expenditures may fail to explain improvements in child height. First, changes in relative (exogenous) prices may be important and thereby fundamentally alter the association between per capita expenditures in child height. Second, the cross-sectional relationship may reflect a number of factors that happen to be correlated with per capita expenditures and child height but have nothing to do with the association between the two. That is, there may be cross-sectional heterogeneity in exogenous prices p. Third, measurement error in per capita expenditures may bias estimates of $E\left[y_{it} \middle| m_{it}, q_{it}, p_t \right]$ and $E\left[m_{it+1} \middle| m_{it} \right]$.[4] With classical measurement error, this is an attenuation problem, and Fan and Thruong (1993) are extremely pessimistic about the ability to deal with measurement error when the appropriate econometric relationship is non-linear. This study considers the question of whether observations on per capita expenditure track changes in a non-monetary well-being measure such as child height and does not attempt to separately identify explanations for any failures of observations on per capita expenditure to track changes in child height.

3. Data

[4] There is measurement error in child height as well. This may be less of a significant issue, because child height is directly measured by an enumerator in the present survey. In contrast, measuring economic status depends on the recall of the respondent and the imputation of values to goods and services that are not acquired with cash.

3.1 The Vietnam Living Standards Survey

This study analyzes changes in child nutrition during an episode of growth using the Vietnam Living Standards Surveys (VLSS). The first round of the VLSS took place between September 1992 and October 1993, and the second round of the VLSS took place between December 1997 and December 1998 (World Bank 2000). Both rounds are designed to be nationally representative, cross-sectional household surveys. However, the decomposition in this study focuses on the 1,901 panel households that are observed with children 0-10 in both rounds of the survey.[5] The VLSS is a multi-purpose household survey following the format of the World Bank's Living Standards Measurement Surveys, and the questionnaires are nearly identical in each round of the survey.

Table 1 presents summary statistics for each nationally representative cross-section of households with children 0-10 (columns 1 and 2) and the panel dataset used in this study (columns 3 and 4). Means in columns 1 and 2 are weighted to be nationally representative of the population of children 0-10.[6] Because this study focuses on panel households that have children under 10 in both 1993 and 1998, there are some differences between the data used in this study (columns 3 and 4) and the nationally representative data. First, selected households tend to have more children under 10 in 1993. With limited child fostering, more children under 10 implies that at least 1 of these children is likely to be relatively young, and therefore more likely that the household meets the criteria for selection by having a child under 10 in each round. This also is confirmed by the observation that selected children are slightly younger in 1993 and older in 1998 than the nationally representative data. Second, per capita expenditures and height for age

[5] Glewwe and Nguyen (2003) discuss attrition in the panel and conclude that the panel appears to be approximately nationally representative. The panel recaptured 89.6 percent of its targeted households. In the present case, 92.2 percent of targeted households with children under 10 were recaptured in the second round of the VLSS.

[6] In the second round of the VLSS, there was a large increase in sample size from 4800 to 6000 sampled households. However, as Edmonds (2003) discusses, there was also a large decline in fertility between 1993 and 1998 that can be found in other datasets as well. Thus, the number of sampled children under 10 in column 2 declines despite the increase in households interviewed.

z-scores are smaller in the selected sample. This might stem from the association between age of the household, fertility, and economic status.

Economic status is measured by household per capita expenditures. The calculation of the expenditure aggregate for the VLSS is described in World Bank (2000).[7] The expenditure measure is defined as annual expenditure, and most expenditure is on food. Expenditure includes both purchased goods and the imputed value of home production that is consumed in the household. Durable goods are not included in total expenditure, but an imputed rental value of durables is included. Expenditure is deflated so that expenditure in both 1993 and 1998 is expressed in hundreds of January 1998 Dongs.

Between 1993 and 1998, mean per capita expenditure increases 52 percent. Figure 1 pictures the distribution of the logarithm of per capita expenditure for all VLSS households in 1993 and 1998 weighted to be nationally representative. The vertical line in figure 1 is the official 1993 poverty line (approximately USD $106 per person per year). The poverty line's calculation is described in the *Vietnam Development Report 2000*. It is the estimated cost of acquiring enough food to consume 2100 calories per person per day plus an allowance for nonfood expenditures.

The dramatic improvement in economic status between 1993 and 1998 is evident in figure 1. Despite being deflated to be in the same units, the mass of the entire distribution of per capita expenditure is shifted right. In 1993, 58 percent of the population is below the poverty line. In fact, 25 percent of households have per capita expenditures below the estimated costs of purchasing 2100 calories per day. 5 years later, only 8 percent of the population has 1998 expenditures below this level, and 33 percent of the population lives below the 1993 poverty line.[8] Not only is the shift in the distribution dramatic, but the shape of the two densities are largely unchanged between 1993 and 1998. In fact, Glewwe, Gragnolati, and Zaman (2002) find

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[7] The January 1998 exchange rate was 13,300 Dongs per dollar.

[8] There is also a 1998 poverty line calculation that puts the poverty line slightly above the inflated 1993 line. The discussion in the text focuses on the 1993 line alone for consistency.

that improvements in per capita expenditure are roughly uniform throughout the distribution and overall inequality is largely unchanged.

3.2 Child Nutrition in the VLSS

The question of this study is whether changes in child nutritional status during an episode of rapid growth can be explained by a stable association between economic status and child nutritional status from a baseline relationship. Nutritional status in this study is measured by the child's height for age z-score. Height for age is a measure of cumulative nutritional status and is therefore of greater interest than more transitory nutritional measures of nutritional status in considering the relationship between growth and nutrition. In children below the age of 36 months, low height for age is generally believed to reflect a process of failing to grow or stunting. In older children, a low height for age indicates having failed to grow or being stunted.

The VLSS collects data on height and age for each household member. For children below the age of 10, age is collected in months. For children 24 months and older, height is measured as standing height. Height for age z-scores are then computed for all children ages 0 to 119 months using the standard NCHS/WHO international reference curves for age, sex, and height. Summary statistics for these z-scores are summarized in Table 1.[9] Figure 2 plots the distribution of height for age z-scores (HAZ) for each round of the VLSS. All children 0 to 119 months in each cross-sectional survey are included in Figure 2 so that Figure 2 is representative of the changes in child nutrition occurring in Vietnam during the same window as the improvements in living standards pictured in Figure 1.

The extent of undernurishment in Vietnam in 1993 is striking. A HAZ below -2 is generally perceived as evidence of undernutrition. The average HAZ among children under 10 is -2.0 in 1993. 56 percent of children suffer from at least moderate undernutrition (compared to a

[9] The WHO suggests examining the standard deviation of the HAZ distribution as a check on the reliability of the data. The standard deviation of HAZ should be between 1.1 and 1.3 in credible data. The standard deviation of HAZ is 1.3 in 1993 and 1.26 in 1998. Following convention, HAZ below -6 and above +6 are assumed to be in error and are dropped from the analysis. This eliminates 0.5% of the 1993 sample and 0.3% of the 1998 sample of children 0-10. Errors may be attributable to measurement error in height or age misreporting. A robustness check will consider whether results are sensitive to excluding these extreme z-scores.

prevalence of 2.3 percent in a well-nourished population). A HAZ below -3 is indicative of severe undernutrition. The vertical line in Figure 2 is at -3. 20 percent of children appear to suffer from severe undernutrition in 1993.

The shift in the height for age distribution is similar to the shift that occurs in the per capita expenditure distribution. The 1998 distribution shifts to the right, and the distribution becomes (slightly) more concentrated. The mean HAZ in 1998 is 20 percent higher than the 1993 distribution. The incidence of at least moderate undernutrition declines almost 30 percent, and severe undernutrition declines by nearly 50 percent. Koch and Linh (2000) discuss these improvements in child nutritional status further. They note that these improvements in nutritional status stem from both better nutritional status of children born between 1993 and 1998, and improvements in nutritional status in children that are observed in both survey rounds. Koch and Linh report that 34 percent of with a height for age z-score below -2 in 1993 improve their height for age to above -2 in 1998. Though malnutrition declines between 1993 and 1998, it is still prevalent. 11 percent of children appear to suffer from severe undernutrition in Vietnam in 1998. This paper considers the relationship between Vietnam's dramatic improvements in economic status and height for age.

4. Main Findings

4.1 The Decomposition with a Series Estimator

This subsection presents the inputs used to generate the expected child height based on improvements in per capita expenditures. This section uses a flexible Fourier form in per capita expenditure for the nonparametric regressions used in the decomposition.[10] The first step of the decomposition is to estimate the relationship between nutrition and per capita expenditures in the baseline cross-section: $y_{i93} = f\left(m_{i93}\right) + e_{i93}$ where $f\left(m_{i93}\right)$ denotes a flexible Fourier form in per capita expenditure in 1993, e_{i93} is mean zero conditional on m_{i93}, and y_{i93} is the mean height

[10] The Fourier form is implemented by transforming per capita expenditure onto the interval 0 to 2π and including the transformed 1993 per capita expenditure, its square, *sin(jx)*, and *cos(jx)* in the regression where *j=1,2,..,5*.

for age z-score of children under 10 in household *i*. $f\left(m_{i93}\right)$ is the mapping of how child height for age evolves in the per capita expenditure distribution that will be used to separate changes attributable to poor households becoming like their richer neighbors from external changes in the household's exogenous policy or technology environment. Figure 3 presents the results of this regression (step 1). The vertical line in Figure 3 and all subsequent pictures is the 1993 poverty line. Because nonparametric methods perform poorly in areas with low density, Figure 3 and all subsequent analysis is limited to households between the 5th and 95th percentiles per capita expenditure distribution for the population of children 0-10.

Each point on the dotted curve labeled 1993 indicates the expected height for age z-score for children in 1993 with the indicated per capita expenditure in 1993. Although one is tempted to test hypothesis about the curve pictured in Figure 3, it is important to remember, that the decomposition in this study is focused on explaining changes in child height at various points of the baseline distribution. Thus, while the shape of the curve is of interest in summarizing how the association between per capita expenditures and child height varies across the distribution, this study is not testing hypothesis about the shape of the curve itself. 90 percent confidence bounds for the expectation of child height for age at each point in the 1993 distribution are also pictured.[11] Figure 4 plots the per capita expenditure elasticity of child height for age calculated from the regression results pictured in Figure 3.

There appear to be three distinct areas in the relationship between height for age and per capita expenditure in 1993. First, in the poorest households, height for age does not appear to be increasing as we compare very poor to slightly less poor households. Second, in the neighborhood of 7.0 on the log scale, child height seems be increasing with per capita expenditures. 7.0 corresponds to the estimated costs of purchasing 2100 calories per day per person in 1993 (Vietnam Development Report 2000). The implied elasticity of height for age

[11] Confidence bounds are bootstrapped percentiles. That is, 2000 clustered bootstrap samples are drawn. The expectation of height for age is computed for each draw. These expectations are then sorted, the 5th and 95th percentile of these expectations at each point in the grid form the pictured confidence intervals.

with respect to per capita expenditures increases to a peak of 0.56 at 7.17 in Figure 4 (roughly $97 per person per year in 1998 USD). Third, the association between per capita expenditures and height for age begins to flatten in the neighborhood of 7.57 ($146 per person per year) and 0 becomes a part of the 90 percent confidence interval for the elasticity at the poverty line. The upturn at the top end of distribution may be substantive or an artifact of the small sample size at the top of the distribution.

The goal of this study's decomposition is to consider whether the association between per capita expenditures and child height is stable over time. Figure 5 shows the change in child height that occurs in each point in the baseline distribution. At the bottom of figure 5 is the relationship between child height and per capita expenditures in 1993, taken directly from figure 3. The top line in Figure 5 presents the expected child height for age z-score observed in 1998 for each point in the 1993 distribution: $y_{i98} = \phi(m_{i93}) + v_{i98}$ where $\phi(m_{i93})$ is a flexible Fourier form in the log of real per capita expenditure in 1993, v_{98} is the error term that is mean zero conditional on m_{i93}, and y_{i98} is the mean height for age z-score of children under 10 in household *i* in 1998. 90 percent confidence bounds for each estimate of height for age in both 1993 (dashed) and 1998 (solid) are also pictured.

Child height improves throughout the baseline (1993) distribution. Even the wealthiest part of the 1993 distribution experiences improved height for age z-scores. The largest improvements in child height appear to be concentrated in households that were just below 7.0 on the log-scale in 1993. Recall that these households are just below the estimated costs of purchasing 2100 calories per day per person. Moreover, there is almost no overlap in confidence intervals for the expectation of child height in 1998 and the expectation of child height in 1993 except at the very bottom of the distribution. Thus, the dramatic changes in the distribution of child height evident in Figure 2 are apparent in improvements in child height throughout the living standards distribution. This study estimates how much of these improvements in child height can be associated with the dramatic growth evident in figure 1.

The changes in child height in figure 5 reflect both improvements in economic status and policy and technology changes in the household's environment that are concurrent with growth. Two factors are used to construct the counterfactual of what height for age would be in 1998 if the relationship between growth and child height were driven by the process of poorer household becoming like their richer neighbors. First, Figure 3 contains the cross-sectional variation between child height and per capita expenditures from 1993 (step 1). Second, Figure 6 pictures how per capita expenditures have increased between 1993 and 1998 for each point in the 1993 distribution (step 2). That is, it is the result of estimating: $m_{i98} = h\left(m_{i93}\right) + u_{i98}$ where m_{i98} is the log of real per capita expenditure in 1998, $h\left(m_{i93}\right)$ is a flexible Fourier form in the log of real per capita expenditure in 1993, and u_{98} is mean zero conditional on m_{i93}. In figure 6, poorer households experience larger changes in per capita expenditure than do richer households on average.[12] Average real per capita expenditures do not decline in any part of the baseline distribution.

The counterfactual is computed for each point in the baseline distribution by looking at the expected per capita expenditure in 1998 in Figure 6, then finding the expected height for age z-score for this level of per capita expenditure from Figure 3, $f\left(h\left(m_{93}\right)\right)$. The explanatory power of improvements in per capita expenditure alone is then judged at each point in the baseline distribution by comparing this counterfactual to the height for age observed in 1998 at each point in the 1993 distribution (Figure 5).

4.2 Results

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[12] One reason for working with $E\left[m_{i98} \middle| m_{i93}\right] \equiv \hat{m}_{i98}$ rather than m_{i98} is to use smoothing to deal with mismeasurement in individual changes. In Figure 6, the change in the expectation of per capita expenditure in 1998 is decreasing in 1993 per capita expenditures. To the extent that measurement error in per capita expenditure is not locally mean zero, then mismeasurement should attenuate how much of the observed changes in height for age can be attributed to changes in per capita expenditure, because the changes in per capita expenditure may not be real.

Living standards improvements are most successful in explaining improvements in nutrition in very poor households. Figure 7 contains the results of the decomposition. Rather than presenting the absolute change in child height that can be explained by improvements in per capita expenditures, it is more meaningful to compare the explained change to the total change. Thus, Figure 7 presents the percent of the total change in child height that can be explained by improvements in per capita expenditures for each point in the 1993 baseline per capita expenditure distribution.

Below the poverty line, improvements in economic status can explain a majority of the change in child height, while the decomposition performs substantially worse above the poverty line. Of course, as evident in Figure 1, a majority of the population is below the poverty line in 1993. The explanatory power of improvements in living standards is largest for children whose per capita expenditures in 1993 are in the neighborhood of the estimated costs of purchasing 2100 calories per person per day. This result could be expected since this is the region where the cross-sectional elasticity is highest (Figure 4) and where the marginal return to spending on nutrition would be largest in an efficiency wage setting such as Dasgupta and Ray (1986).

Figure 7 shows the percent of the observed change in child height at each point on the baseline distribution that can be associated with improvements in economic status. It is likely that policy is more interested in the explanatory power of improvements in economic status across regions of the distribution rather than the point wise results of Figure 7. Table 2 summarizes the explanatory power of improvements in economic status across regions of the 1993 distribution. The summary statistics are computed by taking the weighted average of the results in Figure 7 where the weights are the density of per capita household expenditures for children 0-10 in the population of Vietnam in 1993. For each range of the baseline distribution, Table 2 also indicates the results of two hypothesis tests. One hypothesis is that there is no association between improvements in economic status and child height. This hypothesis is rejected if 0 is not within the 90 percent confidence interval, and a rejection of this hypothesis is indicated by a * in Table 2. The second hypothesis is that improvements in economic status can explain all of the improvements in child height. This hypothesis is rejected if 100 is not within the 90 percent confidence interval, and a rejection of this hypothesis is indicated by a ^ in Table 2.

In the full sample, the data reject the absence of any association between economic status and child height improvements as well as the hypothesis that improvements in economic status can explain all of the improvements in child height. Overall, 60 percent of the improvements in child height can be associated with improvements in per capita expenditure. For children in households below the poverty line in 1993, 74 percent of the improvements in child height can be explained by improvements in economic status, but again the data reject the hypothesis that all of the improvements in child height can be attributed to improvements in economic status. Explanatory power is highest for the second quartile of the population as is evident in Figure 7. For the second quartile, improvements in economic status can explain 97 percent of the improvements in child height, and the data do not reject the hypothesis that improvements in status can explain all of the estimated changes in child height. In contrast, the results for the richest quartile reject the hypothesis that improvements in economic status can explain all of the observed changes in child height and do not reject the hypothesis that improvements in economic status can explain none of the changes in child height. 18 percent of the improvements in child height in the top quartile can be attributed to improvements in economic status.

This inability of improvements in economic status to explain changes in child height in the richest segment of the population could reflect something about the relationship between child height and economic status in relatively wealthy households or it could be an artifact of the methodology in this dataset. The causal story is that in very poor households, additional income goes directly towards nutrition. In richer households, environmental factors play a larger role in variation in nutritional status than does the household budget. Moreover, Wagstaff and Nguyen (2003) document that most of the improvements in health services, drinking water, and sanitation in Vietnam have been concentrated in the communities where the wealthiest quartile of the population live. The methodology explanation is that the 1998 per capita expenditures observed in the top quartile of the 1993 population are not frequently observed in the 1993 population. Thus, the data driven methodology of this paper performs poorly in these regions of limited support as is reflected in the wide confidence bounds. It is not possible to identify which of these two factors is behind the inability of changes in per capita expenditures to explain changes in child height in the top quartile with the existing methodology.

4.3 Residual variation in child height

This section considers whether the residual changes in child height that cannot be attributed to improvements in economic status are correlated within communities. If so, this finding would be consistent with the idea that community level environmental, policy, or technology changes might be more substantive for improvements in nutritional status after basic food intake requirements are met (see Strauss and Thomas 1995 for a survey). Wagstaff, Doorslaer, and Watanabe (2003) in a related study find that most of the inequality in height for age in Vietnam can be explained by inequality in consumption and community attributes. Thus, their results would suggest scope for correlation within communities in the unexplained changes in child height. The first step in this analysis is to compute the residual: $y_{i98} - \hat{y}_{i98} \equiv \rho_{i98}$. This is the difference between observed child height for age in 1998 and that which is predicted based on improvements in economic status. The second step is to regress these residuals on a vector of community fixed effects.[13] The fitted values of this regression $\bar{\rho}_{i98}$ give the mean unexplained residual in household *i*'s community. From this, it is possible to compute the expected child height observed in 1998 based on improvements in per capita expenditures and the changes in

[13] With this approach, it is possible to condition on other observed changes in household attributes. In unreported regressions, I have considered whether observed changes in household age composition, gender mix, sources of water, type of toilet, or method of garbage disposal are associated with the residual change in child height. None of the observed changes in these household attributes explain more than 2 percent of the variation in the residual, and their inclusion in the has no substantive impact on this sections findings that are not evidence in the regressions with community fixed effects alone. Thus, I limit the discussion to the community fixed effects results, because their interpretation is simpler.

child height that occur within the community that are independent of the change in child height predicted by improvements in per capita expenditure: $\overline{\rho}_{i98} + \hat{y}_{i98} \equiv \tilde{y}_{i98}$.

Mechanically, these two factors on average must explain 100 percent of the change in child height between 1993 and 1998. The interesting question surrounding $\tilde{y}_{i98}$ is then whether community level changes in the local health and nutrition environment could be responsible for the improvements in child height at the top of the baseline distribution. For this to be the case, there must be clustering in the per capita expenditure data such that the community fixed effects are not uniformly distributed across the per capita expenditure distribution. Thus, the test of whether there is scope for community level factors to be important in the unexplained changes in child height is based on examining whether community residuals are evenly distributed across the baseline per capita expenditure distribution.

The data suggest scope for community level changes in the health or nutrition environment to be important in areas where improvements in economic status explain little of the change in child height. This inference is based on whether $\tilde{y}_{i98}$ is uniformly above $\hat{y}_{i98}$ or whether community fixed effects $\overline{\rho}_{i98}$ are largest for households where per capita expenditure improvements can explain little of the improvement in child height. Figure 8 mimics Figure 7 in presentation. The dashed curve is the percent of the total change in child height that can be attributed to improvements in economic status (Figure 7). The bold, solid curve is the percent of the total change in child height that can be explained by community fixed effects and improvements in economic status ($\overline{\rho}_{i98} + \hat{y}_{i98}$). 90 percent confidence bounds are pictured for this combined prediction from improvements in economic status and common community factors in the residual.

The community fixed effects are statistically significant in their additional explanatory power for households above the median per capita expenditure of households with children under 10 (7.2 on the log scale). Moreover, in regions below the poverty line, the common community residuals are small relative to the residuals at the top of the distribution. From Figure 8 it is possible to conclude that there is significant clustering of communities in the per capita expenditure distribution. Thus, this leaves open the possibility that common, community level changes in the health environment could be responsible for the improvements that occur at the top of the distribution where improvements in per capita expenditure have little explanatory power.

5. Conclusion

This study considers the extent to which improvements in child height during an episode of rapid growth in Vietnam can be associated with improvement in per capita expenditures. The econometric problem is to separate improvements in child nutrition associated with improving economic status from changes associated with policy and technology changes that are concurrent and not fully observed. The idea behind the decomposition is that at any point in time, individuals face a common technology and policy environment. Thus, the counterfactual of what nutrition would be with only the observed improvements in economic status and no changes in the household's exogenous environment is constructed by using observations on improvements in economic status through time and the relationship between economic status and child nutrition at a single point in time.

Using panel data with repeated observations on 1900 households with children from Vietnam's rapid growth in the 1990s, this study finds that improvements in economic status can explain 60 percent of the overall improvement child nutrition and 74 percent of the improvement in households below the poverty line in 1993. In richer households, improvements in economic status explain less of the observed changes in child nutrition. For these relatively wealthy households, the data are consistent with a greater role for common, community characteristics in affecting improvements in child nutritional status. This is consistent with a model where nutritional status is determined by both food intake and environmental factors (as developed in Ravallion 1990). Once basic food needs are met, environmental factors become relatively more important.[14] Hence, when households are near subsistence, improvements in living standards explain much of the observed improvement in child nutrition. However, after basic needs are met, other environmental factors become relatively more significant. If a model such as this is representative of what occurs in other countries, it would support Preston's (1975) conjecture that the relationship between inequality and health across countries may reflect the income distribution within countries. In very poor countries, conditional on income, more inequality means that there will be more people in the region where child nutritional status is elastic with respect to economic status. Thus, there could appear to be a link between inequality and income when that relationship only reflects non-linearity in the association between health status and income.

The results of this study have two implications for the analysis of the relationship between changes in per capita expenditure and child nutrition. First, the association between economic status improvements and child height varies across the distribution. The focus on averages in most studies of the income elasticity of child nutritional status misses this heterogeneity that might be very important for policy and may understate the importance of improvements in economic status for severe malnutrition in the very poor (Duflo 2003 being an exception). Second, the relationship between child nutrition and economic status should be assumed to be non-linear as there are substantive non-linear aspects of the association between economic status and child height. Subramanian and Deaton (1996) find non-linearity in the cross-sectional relationship between nutritional intake and per capita expenditure, but this appears undocumented in most studies of nutritional outcomes like child height.

The substantive role of non-linearity has major implications for researchers interested in the determinants of child nutritional status. For instrumental variable estimates of the effect of per capita expenditure changes on child height, non-linearity implies that the interpretation of the

[14] The data would also be consistent with many of the studies referenced in Steckel and Floud (1997) that document that stunted children can catch up but normally nourished children cannot exceed their growth curve. However, moderate malnutrition is still prevalent in the upper quartile of the Vietnamese under 10 population, so I put less emphasis on this explanation.

IV result is that of a local effect of variation in per capita expenditure. That is, IV estimates will change based on the margin of per capita expenditure affected by the instruments. The local nature of IV estimates may explain why there is such heterogeneity in estimates of the relationship between per capita expenditure and child height and why authors such as Thomas, Strauss, and Henriques (1990) have found that their estimates of the relationship between economic status and child height are sensitive to the choice of instrument. Moreover, when the purpose of the conventional policy is to motivate policy, it is important to consider whether the margin affected by the instruments is relevant for policy.

Non-linearity also has implications for researchers estimating health production functions or evaluating targeted programs aimed at improving nutritional status (Behrman and Deolalikar 1988 and Strauss and Thomas 1995 are surveys). Misspecification of the relationship between economic status and child nutritional status can bias inference substantively. Assume the relationship between economic status and child height is as it appears in the Vietnamese data: highly non-linear with rapid improvements in child height in the neighborhood of the cost of basic food needs. Moreover, assume a researcher controls for the relationship between economic status and child height with a linear term for per capita expenditure. If the covariate (or policy treatment variable) of interest is correlated with the region of the per capita expenditure where non linearity is most important (as would be the case in this dataset if the covariate was most prevalent among the poor), then the specification error from the linear per capita expenditure term will be attributed to the covariate or program even when there is no causal effect of the covariate on child height. For example, suppose that poor sanitation has no impact on child height (although it almost certainly does), but poor households have worse sanitation than wealthier households. A researcher runs a linear regression of child height on a linear per capita expenditure term and a dummy variable for poor sanitation. This specification can lead to the researcher to (in this example) falsely infer that poor sanitation is a cause of poor child height. This example is not chosen to imply that there is no relationship between sanitation and child height. Rather, it illustrates the difficulties that face researchers when the importance of the fundamentally non-linear relationship between economic status and child nutritional is neglected.

Finally, this study began with the question of how closely improvements in economic status track changes in child nutritional status. The methodology applied herein is useful as a benchmark for policy to weigh whether non-financial measures of well-being need to be tracked in order to monitor well-being. In the present case, a majority of the improvements in child nutrition appear to be associated with improving economic status, especially for the poor. However, the data do not present any reason to expect a strong tracking between economic and child nutritional status as Vietnam continues to develop. At some point, child nutrition may be sufficient that policy need not track it, but even in the wealthiest quartile of the Vietnamese population, stunting is still prevalent. The results of this study suggest that separate monitoring of child nutritional status may be warranted if policy considers the elimination of malnutrition an important goal of development.

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Table 1: Summary Statistics for Children under 10

	Nationally Representative Cross-Sections		Panel	
	1993	1998	1993	1998
Sample Size (Children)	5,998	5,482	4,048	3,406
Household Attributes				
Household Size	6.03	5.76	6.13	5.87
	(0.11)	(0.07)	(0.14)	(0.09)
Total # Children under 10	2.42	2.10	2.64	2.19
	(0.05)	(0.04)	(0.06)	(0.04)
Ln Real Per Capita Expenditure	7.23	7.58	7.17	7.50
	(0.03)	(0.03)	(0.03)	(0.03)
Child Attributes				
Age in Months	61.07	67.04	54.17	72.88
	(0.48)	(0.63)	(0.51)	(0.81)
Female	0.49	0.49	0.50	0.51
	(0.01)	(0.01)	(0.01)	(0.01)
Height for Age	-2.02	-1.62	-2.08	-1.70
	(0.04)	(0.04)	(0.04)	(0.04)
Severe Undernutrition (HAZ<=-3)	0.20	0.11	0.22	0.11
	(0.01)	(0.01)	(0.01)	(0.01)

Means in columns 1 and 2 are weighted to be nationally representative.

Standard errors in parenthesis. All summary statistics are corrected for sample design.

Table 2: Decomposition Results

Percent of Change in Child Nutrition Explained by Improvements in Economic Status

Various Population Subgroups

	Height for Age
Full Sample	59.8 *^
Subgroup of Baseline Distribution	
Below the Poverty Line in 1993	74.3 *^
1st Quartile	62.2 *^
2nd Quartile	97.2 *
3rd Quartile	50.4 *^
4th Quartile	18.4 ^

* 0 is not within a 90 percent confidence interval.

^100 is not within a 90 percent confidence interval.

Confidence intervals are bootstrap percentiles based on 2,000 replications.

The bootstrap replicates sample design by drawing psus.

Figure 1: Log Deflated Per Capita Expenditure Distribution in 1993 and 1998
Nationally Representative Sample

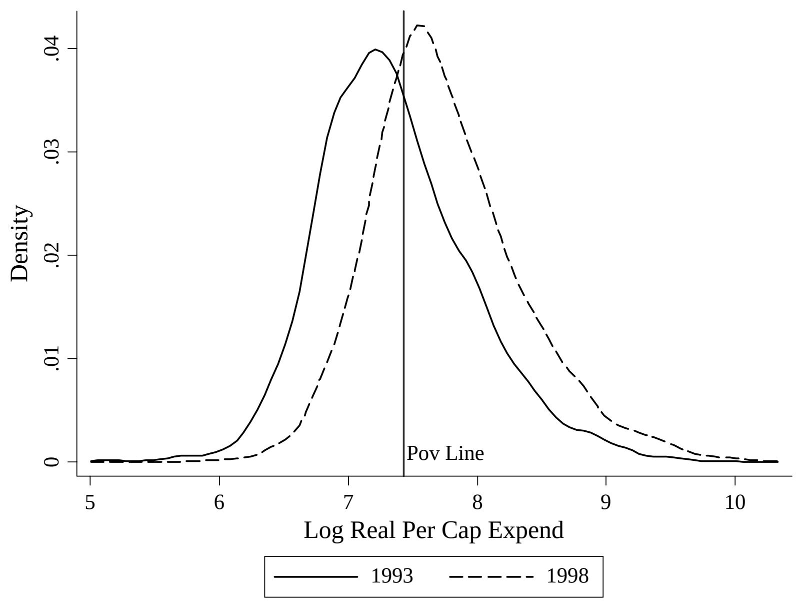


Figure 2: The distribution of Height for Age Z-Scores in 1993 and 1998
Children under age 10, Nationally Representative Sample

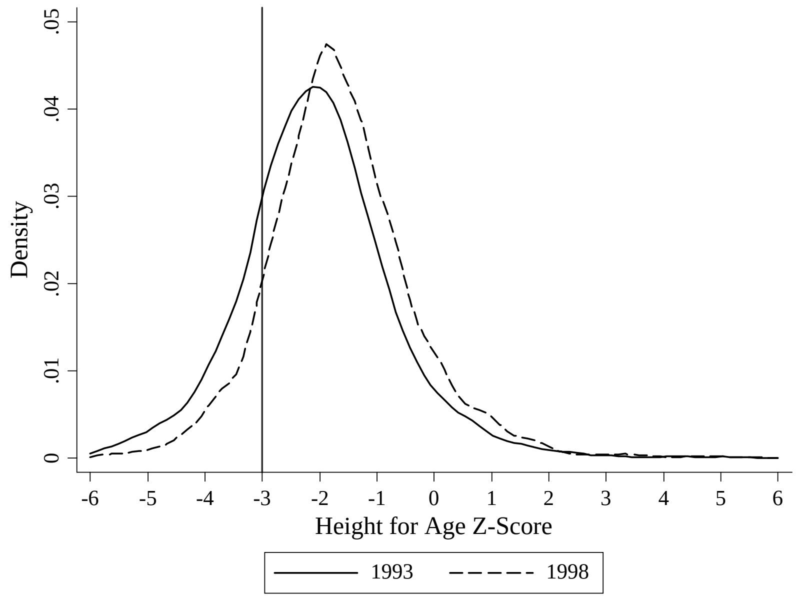
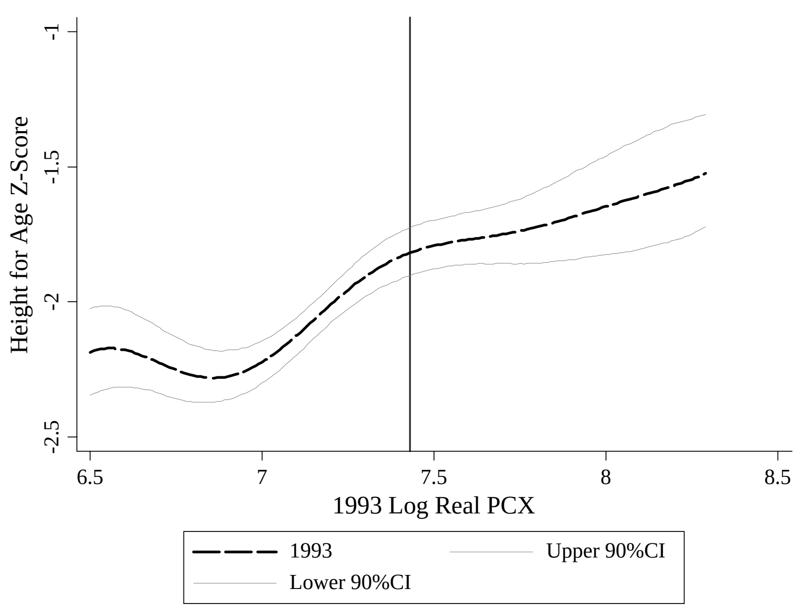
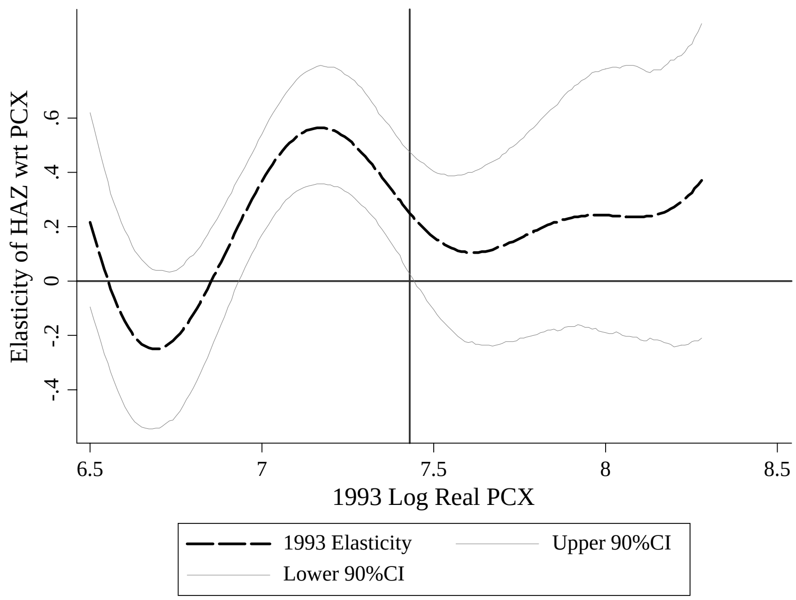


Figure 3: The Height for Age - Per Capita Expenditure Relationship in 1993 (Baseline) for children under 10 in Panel Households



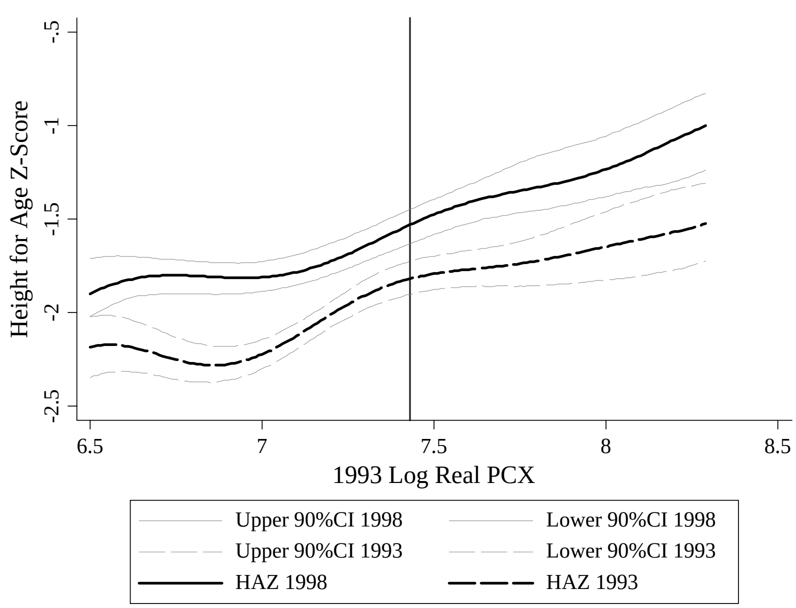
Confidence bands are bootstrap percentiles based on 2,000 replications. The bootstrap replicates the clustered sample design. The vertical line is the official 1993 poverty line.

Figure 4: The Per Capita Expenditure Elasticity of Height for Age in 1993 from Figure 3



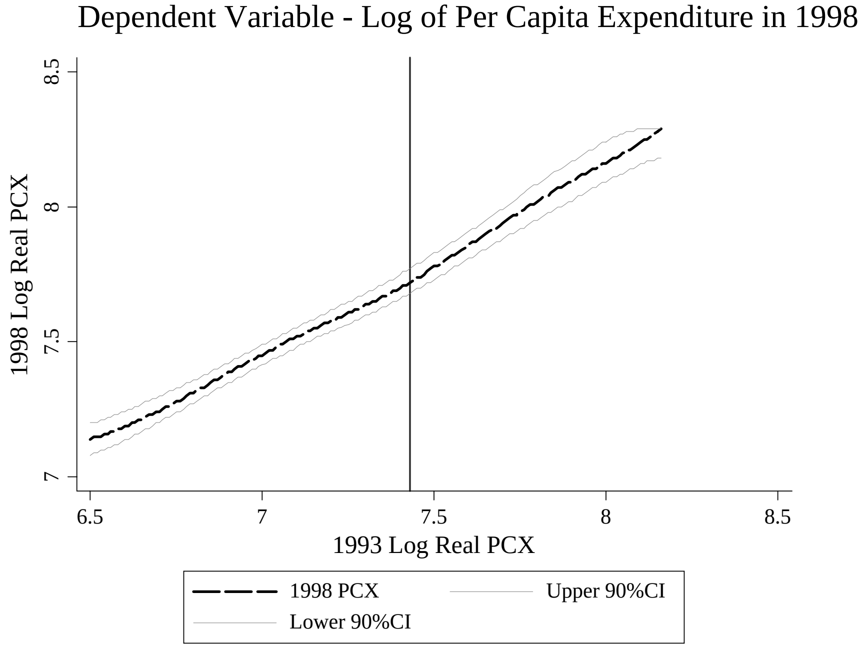
Confidence bands are bootstrap percentiles based on 2,000 replications. The bootstrap replicates the clustered sample design. The vertical line is the official 1993 poverty line.

Figure 5: Improvements in Height for Age between 1993 and 1998 and Per Capita Expenditure in 1993 for children under 10 in Panel Households



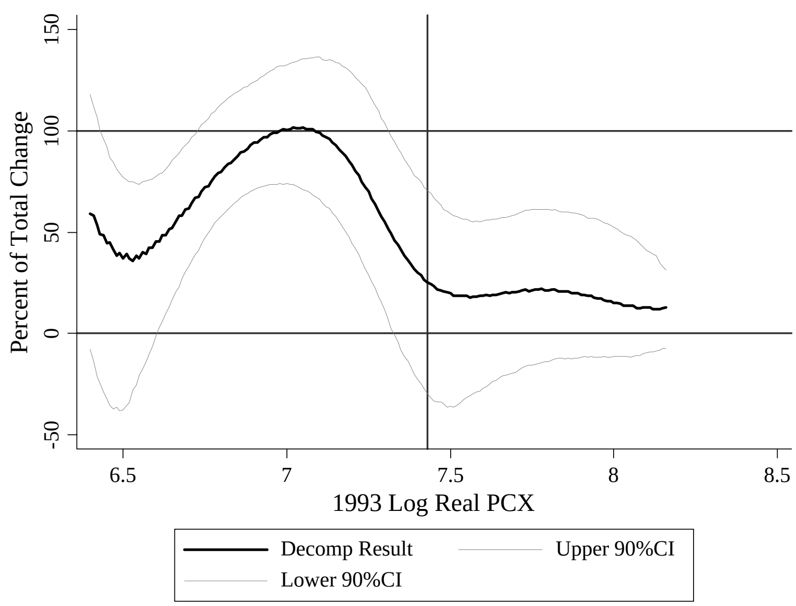
Confidence bands are bootstrap percentiles based on 2,000 replications. The bootstrap replicates the clustered sample design. The vertical line is the official 1993 poverty line.

Figure 6: Economic Status Improvements and the Baseline Per Capita Expenditure Distribution



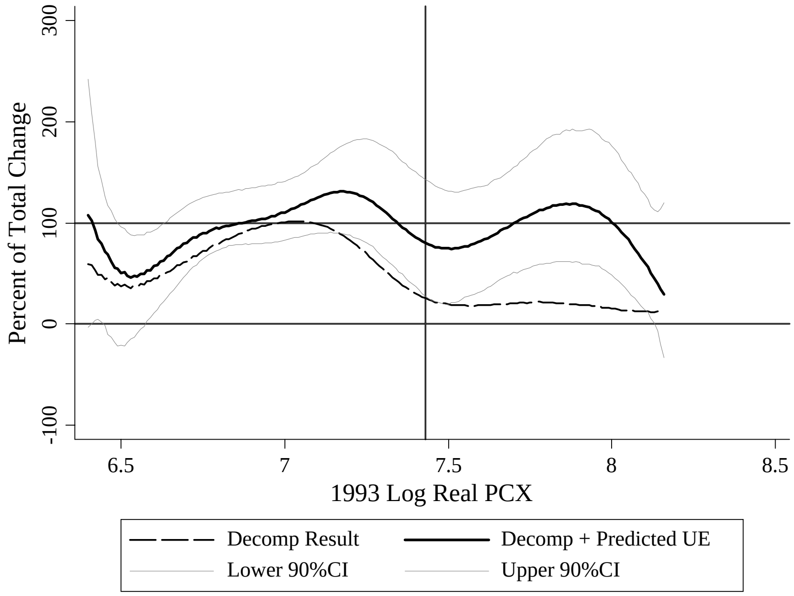
Confidence bands are bootstrap percentiles based on 2,000 replications. The bootstrap replicates the clustered sample design. The vertical line is the official 1993 poverty line.

Figure 7: Percent of Total Change in Child Height that can be attributed to Improvement in Economic Status, Decomposition Results



Confidence bands are for the ratio of the predicted change in height for age z-scores to the actual change in height for age z-scores (*100). Confidence bands are bootstrap percentiles based on 2,000 replications. The bootstrap replicates the clustered sample design. The vertical line is the official 1993 poverty line.

Figure 8: Percent of Total Change in Child Height that can be attributed to Improvement in Economic Status and Common Community Changes



Confidence bands are for the ratio of the predicted change in height for age z-scores to the actual change in height for age z-scores (*100). Confidence bands are bootstrap percentiles based on 2,000 replications. The bootstrap replicates the clustered sample design. The vertical line is the official 1993 poverty line.