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Delayed Primary School Enrollment and Childhood Malnutrition in Ghana

An Economic Analysis

Paul Glewwe
Hanan Jacoby

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Delayed Primary School Enrollment and Childhood Malnutrition in Ghana

An Economic Analysis

The Living Standards Measurement Study

The Living Standards Measurement Study (LSMS) was established by the World Bank in 1980 to explore ways of improving the type and quality of household data collected by statistical offices in developing countries. Its goal is to foster increased use of household data as a basis for policy decisionmaking. Specifically, the LSMS is working to develop new methods to monitor progress in raising levels of living, to identify the consequences for households of past and proposed government policies, and to improve communications between survey statisticians, analysts, and policymakers.

The LSMS Working Paper series was started to disseminate intermediate products from the LSMS. Publications in the series include critical surveys covering different aspects of the LSMS data collection program and reports on improved methodologies for using Living Standards Survey (LSS) data. More recent publications recommend specific survey, questionnaire, and data processing designs, and demonstrate the breadth of policy analysis that can be carried out using LSS data.

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FOREWORD

Education is one of the cornerstones of economic development. Similarly, improving child health is a critical objective of development. Yet there are relatively few studies which examine the interaction between education and health. This paper examines a puzzling phenomenon in developing countries which has, until now, received scant attention in the development literature: enrollment in primary school at an unusually late age. Its main finding is that infant and child nutrition have a major effect on age at enrollment, which suggests that education and health are complementary inputs in the development process.

This paper is part of a broader research effort in the Policy Research Department (PRD) that examines the role of human resources in economic development. This work is located in the Poverty and Human Resources Division. The data used are from the Ghana Living Standards Survey, which is one of the Living Standards Measurement Study (LSMS) household surveys which the World Bank has implemented in many developing countries.

Lyn Squire
Director
Policy Research Department

ABSTRACT

This paper investigates why children in low income countries often delay primary school enrollment, despite the prediction of human capital theory that schooling will begin at the earliest possible age. We explore a number of explanations for delayed enrollment, but focus on the hypothesis that delays are rational responses to early childhood malnutrition. We test these alternative hypotheses using recent data from Ghana. Our estimates, which address a number of previously ignored econometric issues, strongly support the notion that childhood malnutrition causes delayed enrollment. We find no support for alternative explanations based on borrowing constraints and the rationing of places in school.

I. INTRODUCTION

High opportunity costs of child time, low income, poor nutrition, and inadequate schools are often cited as the major constraints on human capital investment in developing countries. Which of these constraints is most important, and therefore which policies can best promote schooling, is a question that has provoked a large body of research on the determinants of school enrollment and school attainment.[1] In this paper we examine a phenomenon that, although common in low income countries, has received virtually no attention; namely, delayed enrollment in primary school.[2] Delayed enrollment presents an interesting puzzle to adherents of human capital theory. After all, would it not be less costly to send a child to school at the earliest possible age, when the value of the child's time is lowest? Understanding why many children start school late can shed light on the barriers to education faced by families in low income countries.

Consider the case of Ghana, the country we investigate in this paper. Table 1 reveals that, of those Ghanaian children age six to fifteen who have already enrolled in school, less than half have done so by age six.[3] The average delay (beyond age six) is about two years, compared to average school attainment of seven years.[4] A simple back-of-the-envelope calculation gives an idea of the cost of delayed enrollment. Assume the following: constant post-school earnings, zero earnings prior to and during school enrollment, zero school fees, a

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[1]Among the many studies are Rosenzweig and Evenson (1977), King and Lillard (1983), Birdsall (1985), Jamison and Lockheed (1987), Psacharopoulos and Arriagada (1989), and Harbison and Hanushek (1992).

[2] Jacoby (1991) finds that about ten percent of primary school children in Peru start at least one year late. Moock and Leslie (1986) indicate that delayed entry is important in Nepal, but do not pursue the issue.

[3]Age of school enrollment is calculated under the assumption that grade repetition and temporary withdrawal from school do not occur. As we discuss in section IV, these phenomena are very uncommon in Ghana.

[4]Because of censoring of delay durations, our figure of two years is a predicted value from our regression below that controls for censoring. The school attainment figure is based on a sample of individuals in their twenties who have mainly finished school.

constant three percent real interest rate, an infinite horizon, and that those who do delay complete the same number of grades and earn the same amount as delayers. With these assumptions, the cost of the average delay is about six percent of individual life-time wealth.[5] Even if the true cost of delayed schooling is half this amount, it still represents a sizeable loss of wealth.

Table 1

Age of School Enrollment for Children 6-15 in Ghana

AGE ENROLLED	PERCENT
Never Enrolled	20.2
5 and under	12.9
6	24.0
7	17.8
8	12.7
9	7.1
10	3.1
11 and over	2.3

Source: Ghana Living Standards Survey (1988-89), sample size=1948.

In this paper we develop a number of explanations for delayed enrollment, but the main focus is on malnutrition. Chronic childhood malnutrition, which is extensive in Ghana, has been shown to stunt growth and retard mental development as well as reduce motivation and energy levels. Pollitt (1984) reviews a large number of studies showing that children with severe protein-energy malnutrition in infancy and prior to school enrollment perform significantly worse on intelligence tests than well-nourished control children. Moreover, Pollitt observes that "[a]s children grow older biological maturation tends to move them -- as in all living organisms --

[5]The total cost of a two-year delay is given by $(y/r)e^{-rs}[1 - e^{-2r}]$, where r is the interest rate, y is earnings and s is school attainment. Meanwhile lifetime wealth is $(y/r)e^{-r(s+2)}$, so the ratio of total costs to wealth is simply $e^{2r} - 1$.

towards a normal course of development. In other words, adverse developmental effects from early trauma may be reversible with maturation" (p. 9, 1984). Based on these observations, we argue that chronically malnourished children have a low rate of return to schooling and thus tend to be kept out of school. But the physical and mental development of the child as he or she grows can eventually compensate, to a degree at least, for this initial retardation. Thus, while it may not be worthwhile to send a malnourished child to school at the minimum age of enrollment, it may be worthwhile at some later age; in other words, there may be an optimal age of primary school enrollment for a malnourished child that is above the minimum age.[6]

The model developed in the next section also predicts that the malnourished child will complete less schooling than the well-nourished child. Only a few previous studies have investigated the effect of childhood nutrition on school attainment. Moock and Leslie (1986) and Jamison (1986) both find that, among children enrolled in school (in Nepal and China, respectively), taller children are likely to have completed more grades than shorter children of the same age. These findings are interpreted as showing that better nourished children progress farther or perform better in school. However, the results may largely reflect delays in school enrollment.[7] Indeed, since both studies are school-based and hence only observe currently enrolled children, neither is capable of establishing a direct connection between nutrition and *ultimate* school attainment. Another problem arises in a recent study of Brazilian data by Gomes-Neto and Hanushek (1992), which estimates the effect of anthropometric indicators on the probability of dropping out of school, conditional on the age of the child. This dropout regression will tend to understate the negative impact of malnutrition, because children who start

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[6]Leslie and Jamison (1990) state this point in noneconomic jargon: "A child's readiness for school can be defined in terms of a number of characteristics, including physical capacity, cognitive ability, psychological well being [etc.]. These are determined in part by the child's health and nutrition...Depending on the nature and severity of the unpreparedness, a child may be entirely incapable of attending school...may be on a slow development path and thus be unable to begin school at the standard age, or may be able to attend but be severely disadvantaged relative to more adequately prepared peers." (p. 195).

[7]Jamison explicitly mentions that malnourished children might enter school late, but he focuses on grade repetition. His study also does not control for family background and income.

school late will also be older when they quit, for a given number of grades completed.[8] Gomes-Neto and Hanushek, in fact, find no significant effect of child height-for-age on the dropout probability. In section III, we develop a method for identifying the effect of childhood nutritional status on school attainment when delayed enrollment is common. The advantage of our household level data in this regard is that we do observe the ultimate school attainment of some children.

Another shortcoming of these previous studies, remedied in this paper, is that they do not address the endogeneity of nutritional status. This issue arises both in investigating school attainment and delayed enrollment. Unobserved child or household specific factors may contribute to better nutrition and faster progress through school, leading to a positive association between the two even though there is no causation (see, e.g., Behrman and Deolalikar, 1988). As we will see in section III, the fact that one important anthropometric indicator, namely age-standardized height, is determined well before the school enrollment decision ameliorates the identification problem.

The Ghanaian data set used in this study is unique in that it provides anthropometric measurements in the context of a comprehensive, multi-purpose household survey, and it also includes detailed information on the characteristics of local schools. This latter feature allows us to assess the importance of school quality and availability in determining delayed enrollment. After discussing the data in section IV, section V reports estimates of the determinants of delayed primary school enrollment, as well as estimates of the effects of malnutrition on school attainment. Our results strongly support the notion that malnutrition at the minimum age of entry deters parents from enrolling their children on time. However, we find no evidence that malnutrition impedes ultimate school attainment. Section VI summarizes these findings.

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[8]As an example, consider two sixteen year-old dropouts, one malnourished child who delayed enrollment for a year and one well-nourished child who enrolled on time. The dropout regression obscures the fact that the malnourished child has completed one year of school less. In their large study of these same Brazilian data, Harbison and Hanushek (1992) find delays are pervasive: "Our second graders typically entered school more than one year late" (p. 48).

II. EXPLANATIONS OF DELAYED PRIMARY SCHOOL ENROLLMENT

Delayed school enrollment cannot be analyzed in the usual static time allocation framework (e.g., Rosenzweig and Evenson 1977), since it concerns the timing of human capital investment. So here we consider a simple dynamic model. To fix ideas, assume that parents have perfect foresight, and that the cost of attending school is foregone child earnings (or home production) plus a fixed school fee, f. Also assume that prior to enrollment child earnings are constant at y_0, while post-school earnings, $y(s;Q)$, are an increasing concave function of years schooling, s,[9] as well as an increasing function of an index of school quality, Q. For now we simply take Q as given and return to it later.[10]

Suppose a child reaches the minimum schooling age at time zero, at which point parents decide on the enrollment date, t_0, and on s. Assuming perfect access to credit (or sufficiently high initial assets), parents choose t_0 and s to maximize the present discounted value of the child's income stream, V,[11] where

$$(2.1) \quad V = \int_0^{t_0} y_0\, e^{-rt} dt - \int_{t_0}^{t_0+s} f\, e^{-rt} dt + \int_{t_0+s}^{T} y(s;Q)\, e^{-rt} dt ,$$

and r is the rate of interest and T is a fixed retirement age. We can write the derivative of V with respect to t_0 as

$$(2.2) \quad \partial V/\partial t_0 = e^{-rt_0}[y_0 + f] - e^{-r(t_0+s)}[f + y(s;Q)] .$$

[9]Glewwe (1991) finds that wages indeed increase with schooling in Ghana. Better educated workers are also more likely to obtain formal sector jobs.

[10]It is also assumed that children do not work at all while attending school. Relaxing this assumption does not change the basic thrust of the analysis.

[11]We assume that schooling does not provide parents or children with direct utility. Incorporating tastes for schooling would not appear to help explain delayed enrollment.

If the net present value of going to school for s years is greater than that of not going to school at all, then it follows that (2.2) is negative.[12] But, if V is decreasing in t_0, then delaying school enrollment does not make sense; i.e., an interior solution for t_0 does not exist.

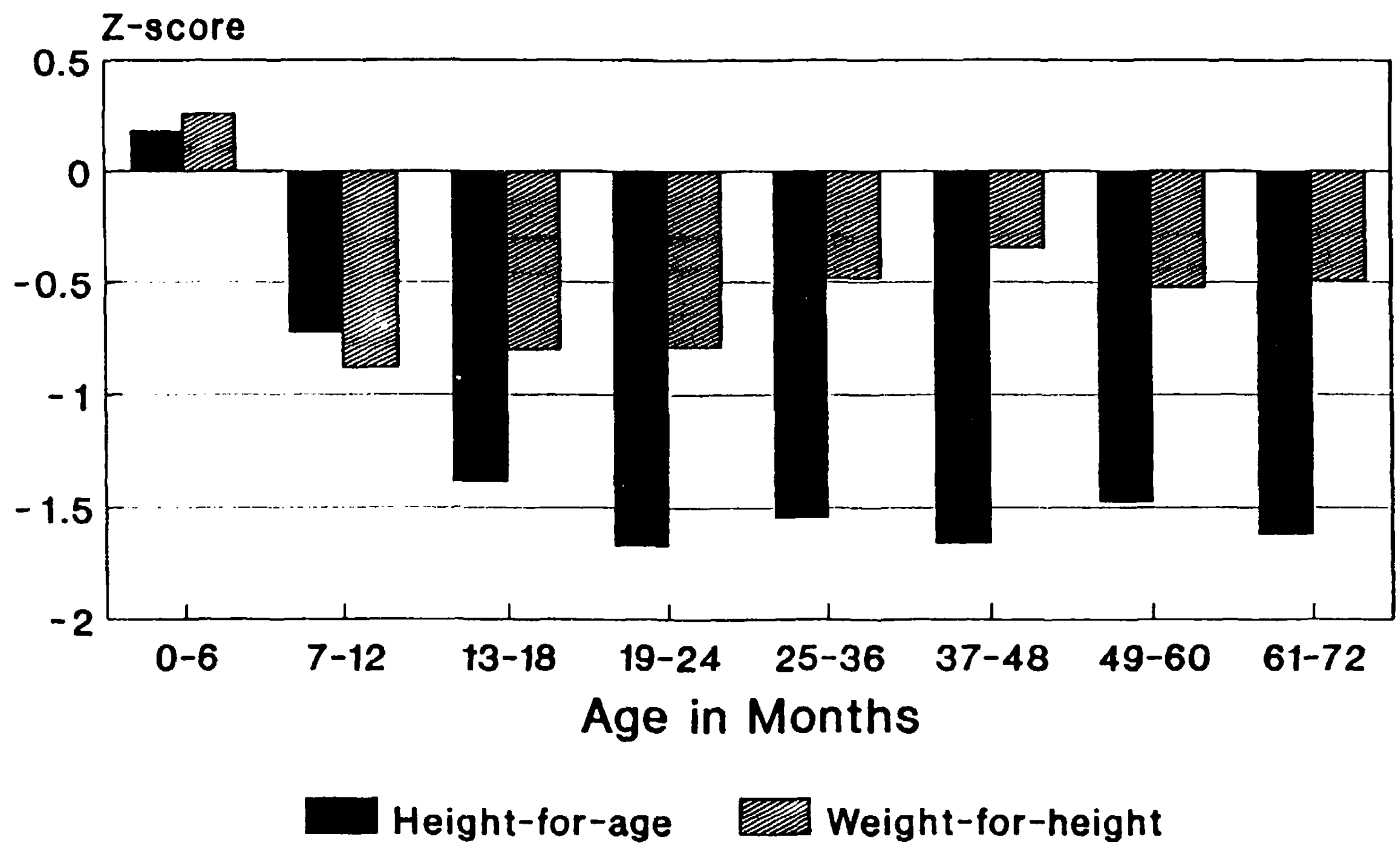
Large values of y_0 and f clearly do not help explain delays, and only clutter the exposition. So, in what follows, we set these parameters to zero and, as an approximation, let T go to infinity. The maximization of V with respect to s then yields the familiar necessary condition $y_1/y = r$ (subscripts denote partial derivatives with respect to that argument); i.e., the rate of return to schooling is equated to the rate of interest. We now proceed to modify the model slightly in order to obtain delayed enrollment.

Malnutrition and Delayed Enrollment

Before incorporating nutritional considerations into the model, let us turn to the anthropometric evidence from the Ghana Living Standards Survey. Height-for-age measures chronic malnutrition (stunting), and both the Jamison (1986) and Moock and Leslie (1986) studies found this anthropometric indicator to be the most strongly associated with school progress (compared to measures of acute malnutrition, such as weight-for-height). The Z-score indicates how much a Ghanaian child's height-for-age deviates from the mean in a healthy population of children. Figure 1 shows that children in Ghana begin falling behind healthy children (negative Z-scores) after the first half-year of life (after weaning), but that the entire

[12]This comes about because $V > \int_0^T y_0 e^{-rt} dt$ (schooling is worthwhile) implies $e^{-rt_0}[y_0 + f] - e^{-r(t_0+s)}[f + y(s;Q)] < [y_0 - y(s;Q)]e^{-rT} < 0$.

Figure 1
Z-scores in Ghana (ages 0-72 months)



Source: GLLS 1988-89

Z-score shortfall occurs within the first two years. In this sense, the average child's height-for-age is pre-determined relative to the school enrollment decision.[13]

Now, let R(t) be a child's physical and mental "readiness" for school (using Leslie and Jamison's term) at time t,[14] which we will measure (perhaps with error) by child height-for-age. Assume that R(0), readiness at the minimum enrollment age, has been determined by parental nutrition and health-care decisions in a previous optimization problem. Assume further that readiness grows exogenously with t (i.e., after age six) and, for simplicity, that it does so linearly, with $R(t) = R(0) + bt$. Finally, suppose that greater readiness effectively raises the marginal return to an additional year of schooling. In other words, write post-school earnings as an increasing function of readiness at the date of school entry, so that $y = y(s,R(t_0);Q)$ and assume that $\partial(y_1/y)/\partial R > 0$. Assume further that y is concave in s and R.

Again parents choose t_0 and s to maximize the present value of child income, leading to the following necessary conditions (with $y_0=f=0$ and $T=\infty$)

$$(2.3)\quad \partial V/\partial t_0 = [-y(s,R(t_0);Q) + \frac{by_2(s,R(t_0);Q)}{r}]\, e^{-r(t_0+s)} = 0$$

$$(2.4)\quad \partial V/\partial s = [-\, y(s,R(t_0);Q) + \frac{y_1(s,R(t_0);Q)}{r}]\, e^{-r(t_0+s)} = 0.$$

The second term in (2.3) represents the marginal increase in future earnings due to delaying. Now an interior solution for t_0 is possible. In this case, (2.3) and (2.4) can be solved to obtain s^* and t_0^* as functions of the exogenous or pre-determined variables: r, R(0), b, and Q.

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[13]While figure 1 indicates that, on average, height-for-age is determined prior to the minimum age of school enrollment, the possibility still exists that height-for-age changes after that age for some children. For example, malnourished children may fall further behind or they may catch up. One recent piece of evidence that height-for-age is likely to also be pre-determined at the individual level comes from a longitudinal study of Guatemalan children by Martorell, et al. (1990), which shows that height-for-age at age five is uncorrelated with the change in height-for-age after age five.

[14]For expositional purposes assume that age 6 is the normal age of entry into school; so set $t = 0$ on the day the child becomes 6 years old.

Under our assumptions, it is easy to show that $dt_0^*/dR(0) < 0$ and $ds^*/dR(0) > 0$. That is, children who are less ready for school initially (more malnourished at age six) will delay enrollment longer and complete fewer years of school. The latter result is due to their lower rate of return to schooling. The effect of greater readiness on the age at which the child quits school, $s^* + t_0^*$, is theoretically ambiguous.

How will increases in school quality affect t_0^* and s^*? If we assume that increases in school quality raise the rate of return to schooling (as in Behrman and Birdsall, 1983), so that $\partial(y_1/y)/\partial Q > 0$, then $ds^*/dQ > 0$. However, higher school quality reduces delays if and only if $\partial(y_2/y)/\partial Q < 0$; that is, if and only if better schools lower the rate of return to physical or mental readiness.

Alternative Explanations of Delayed Enrollment

Another route to delayed school enrollment is borrowing constraints. If parents cannot borrow against the future earnings of their children, have no savings, and must pay a fixed school fee (such as f above), then delays may be optimal (see Glewwe and Jacoby, 1992, for a formal model). During the delay period, parents put the child to work at home, on the farm, etc. (earning y_0), in order to accumulate sufficient savings to finance consumption while the child attends school. The existence of large school fees is crucial to this story. While fees are not extremely burdensome in Ghana, they become substantial once school uniforms and other fixed costs are considered.[15] Under the borrowing constraints hypothesis, lower income households tend to take longer to accumulate the requisite savings and thus delay child school enrollment

[15]Our data show that the average direct cost of sending a child to primary school in 1988-89, including infrequent costs such as school uniforms, was 3,929 Cedis, or about 1% of average household expenditure. This percentage would be higher for poor households, and higher still for households with several school-age children. On the other hand, some households appear not to purchase school uniforms in Ghana, even though the official policy is that they are mandatory.

longer. Thus, in contrast to the nutrition model, this hypothesis predicts that household income should be negatively associated with delays (conditional on the nutritional status of the child).[16]

Stochastic fluctuations in family income or in child productivity may also lead parents to delay enrolling their children in school. A bad harvest or lower crop prices, for example, lowers family income and may lead parents to delay enrolling their child, particularly with fixed attendance costs. However, depressed agricultural productivity also lowers the opportunity cost of child time, thus discouraging a delay.[17] This argument for delays implicitly assumes that borrowing is constrained or that insurance against these various risks is unavailable. Without longitudinal data, the effects of risk cannot be investigated.[18]

Finally, there is a supply side explanation for delays. Suppose that in a given year too few public primary school slots are available relative to the quantity demanded in a particular community. Assume further that the available slots are rationed to children on the basis of age, so that a number of six year olds (assuming this is the minimum age of entry) are turned away.[19] The next year these same children, now seven years old, reapply, and they are given priority for the available slots, again rationing out some of the current six year olds. The supply constraints hypothesis implies that children will start school later on average in communities with tighter constraints.

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[16]Another possible inducement to delay arises when there are two or more closely spaced siblings in a borrowing constrained household. In order to smooth household consumption, parents may space out the schooling of their children by holding a younger child back, especially if there are substantial school fees (which discourage part-time school attendance).

[17]Another potential shock is illness of the child or of some other family member, especially one for whom the child's labor is readily substitutable. However, illnesses are usually temporary and so would be unlikely to cause many full year delays. This point is discussed further below.

[18]Jacoby and Skoufias (1992) find large effects of income and child productivity shocks on school attendance using panel data from rural South India.

[19]In the data from Ghana 34% of primary schools report that not all children who wish to enroll are admitted, and 85% of them cite age of the child as the most important criteria for admitting children.

III. ECONOMETRIC STRATEGY

In this section we consider how to consistently estimate the optimal years delayed function for child i, namely

$$(3.1)\quad t_{0i}^{*} = X_i'\beta_0 + \gamma_0 h_i + u_{0i}$$

as well as the optimal school attainment function,

$$(3.2)\quad s_i^{*} = X_i'\beta_s + \gamma_s h_i + u_{si}.$$

In order to test some of the hypotheses outlined in the previous section, the vector of explanatory variables X_i should include household income, family background characteristics, and school attributes. We denote child i's current height-for-age by h_i, which, as we argued above, reflects height-for-age at the minimum age of primary school enrollment.[20] The random components, u_{0i} and u_{si}, include, among other things, the child's aptitude and motivation for school, as well as unobserved family background factors (tastes, parental motivation, etc.) influencing the enrollment and dropout decision, respectively.

Censoring

Most studies of school enrollment behavior focus on samples of children, the majority of whom are still attending school. This paper is no exception. For children, household variables observed today better reflect the actual circumstances faced when making schooling decisions than they do for adults. Also, anthropometric data are typically available only for children. Inevitably then, both t_0^{*} and s^{*} will be frequently right censored. While the censoring

[20]More precisely, we view height-for-age as an indicator of initial readiness, so that $R(0)_i = h_i + \epsilon_i$, where ϵ_i is random measurement error. This equation implies a classic errors-in-variables model. In using instrumental variables, our estimation procedure corrects for this type of measurement error anyway.

of t_0^* creates no major difficulties in the estimation of (3.1), this is not the case for equation (3.2) when s^* is right censored.

If a child had not enrolled in school by the time he or she was six years old, then we know that years delayed is *at least* current age (as of the beginning of the school year) minus five, assuming eventual enrollment. In other words, for any child not yet enrolled in school we have $u_{0i} > age_i - 5 - X_i'\beta_0 - \gamma_0 h_i$. Thus, (3.1) can be estimated as a censored regression model (in our case, an ordered probit) with a variable censoring limit, namely $age_i - 5$.

Now consider the censoring of grade attainment, s^*. For children still attending school, the number of grades completed is simply current age minus six minus number of years delayed entry (assuming no grade repetition). We also know that the number of grades completed up to now is less than or equal to s^*. Using (3.2) and rearranging gives us the following censoring condition on the unobservable,

$$(3.3)\quad u_{si} > age_i - 6 - t_{0i}^* - X_i'\beta_s - \gamma_s h_i \quad \text{if in school now.}$$

Thus, in this case, the censoring limit is $age_i - 6 - t_{0i}^*$,[21] which is problematic because it depends on an endogenous variable. To properly estimate this model we can proceed by inserting (3.1) into (3.3) to obtain

$$(3.3')\quad u_{si} + u_{0i} > age_i - 6 - X_i'(\beta_s + \beta_0) - (\gamma_s + \gamma_0)h_i$$

as a reduced-form censoring rule. Equation (3.2) and (3.3') can then be estimated jointly as a generalized tobit model, which allows for the correlation between $u_{si} + u_{0i}$ and u_{si}. However,

[21]We subtract six here, instead of five, because grade attainment is measured as years completed and so does not include the current year.

because of the discrete ordered nature of the dependent variable, standard two-step methods cannot be used.[22]

Rather than attempt joint estimation, we propose an alternative scheme for obtaining unbiased estimates of β_s and γ_s. Consider a regression equation for the age at which the child quits school,

$$(3.4)\quad s_i^* + t_{0i}^* = X_i'\beta + \gamma h_i + u_i,$$

where $\beta = \beta_0 + \beta_s$, $\gamma = \gamma_0 + \gamma_s$, and $u_i = u_{0i} + u_{si}$. For individuals who have not yet finished school, or who have not yet started, $s_i^* + t_{0i}^*$ is right censored with the censoring limit again being age_i - 5. Clearly, β and γ are estimable even with censoring (provided there are some children in the sample who have finished school) and once we have secured consistent estimates of β_0 and γ_0 from equation (3.1), we can calculate β_s and γ_s by subtraction.[23]

Endogeneity of Child Height-for-Age

Height-for-age is statistically exogenous in equations (3.1) and (3.4) provided that $Eh_iu_{ki} = 0$, k=0,s. However, if parents optimally determine child height-for-age prior to the school enrollment decision, then this orthogonality condition is unlikely to hold. In the standard Beckerian household production model, the demand function for child height is written as $h = g(p,I,\mu,\xi)$, where p is the relevant vector of prices, I is income or wealth, μ is a vector of health endowments, and ξ is a taste shifter. Thus, h_i is endogenous when, for example, highly motivated parents provide their children with a more nutritious diet as well as enroll them in

[22]Note also the lack of exclusion restriction; i.e., variables present in the selection equation (3.3') but not in the equation of interest, (3.2).

[23]Because we use an ordered probit model to estimate the equations of interest, simple subtraction of the coefficient estimates is no longer appropriate, but a method analogous to it serves the same purpose (see below).

school earlier and/or keep them there longer. If we assume that this unobserved "taste" effect is an additive component of the u_{ik}'s, and that it is the same for all children in a given household, then we have a household fixed effects model. Provided that there is sufficient exogenous variation in height-for-age within households,[24] we can test whether height-for-age is uncorrelated with u_{ik} using a fixed effects estimator.

The presence of child specific endowments in the u_{ik}'s is another source of simultaneity bias. Parents may make nutritional investments conditional on knowledge of the child's future learning ability (or some other endowment), and provide less food to low ability children. In this case, we require instruments that are correlated with height-for-age, but do not directly influence the school enrollment decision. The prices of health services or medicines are good candidates.[25] Behrman and Deolalikar (1988) criticize the use of such price variables as instruments in estimating equations analogous to (3.1) and (3.4). They argue that in the usual static household model the various attributes of child "quality", including nutrition and education, are determined simultaneously so that in general all demands are functions of the same set of prices. However, we claim that height-for-age is determined prior to the primary school enrollment decision, and hence it cannot be a direct substitute for educational investments.[26]

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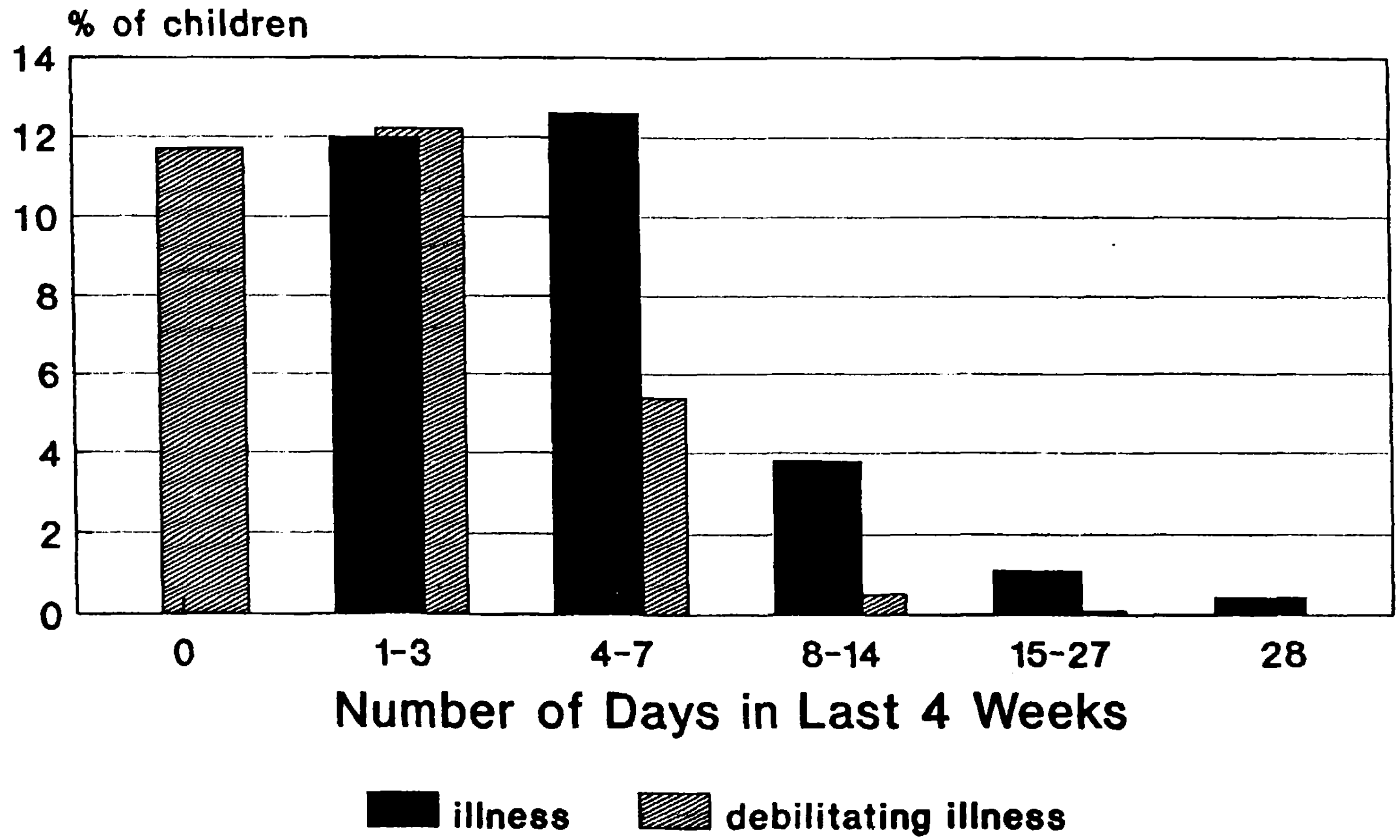
[24]John and Foster (1992), using longitudinal data from Guatemala and Bangladesh, show that within-household differences in child weight (which eventually translate into differences in height-for-age) can be explained by differences in infectious disease experiences, and that differences in disease susceptibilities across children are uncorrelated with nutritional status, and are due in large part to unobserved heterogeneity.

[25]More generally, health "prices" refer to availability and distance to health facilities, under the assumption that placement of these facilities is exogenous to the household. Because we use cross-sectional data, we must assume that the geographic relative price structure is constant over time, meaning that current prices reflect those that the household faced when it made earlier nutrition and health-care decisions.

[26]These price variables would not be valid instruments if delays are caused by temporary illnesses when children are at the minimum age of school enrollment, since the probability of illness may be correlated with the cost and quality of local health facilities. However, Figure 2 shows that in Ghana the average duration of debilitating child illness is in fact quite short, so temporary illness would be unlikely to lead to many delays.

Figure 2
Child Illness in Ghana (ages 4-9)



Source: GLSS 1988-89; Sample=1,433

Ideally, we would want to use a procedure that produces consistent estimates under the hypothesis that both types of simultaneity are present. Unfortunately, such a fixed effect instrumental variables estimator places great demands on the data, requiring instruments that are correlated with within-household differences in height-for-age. One potential source of such instruments is information on when health facilities were established, since older children may not have had the same access as their younger siblings.

IV. DATA AND SAMPLE

The 1988-89 Ghana Living Standards Survey (GLSS) consists of a broad household questionnaire supplemented with detailed information on the characteristics of nearly 500 local schools. However, the school data are only available for one half of the 3200 households in the survey. In addition, the GLSS has information on local health clinics, hospitals and pharmacies, including distance from the household and kinds of services and medicines provided at those facilities.

All individuals present in the household on the date of interview had their height measured, so heights are available for most young children as well as many of their mothers. However, children older than fifteen were frequently no longer living at home and thus could not be measured.[27] Another consideration in selecting the sample of children for analysis is that we are using cross-sectional data, which only captures current conditions. Given that income and other conditions change over time, we must examine a cohort that is reasonably close to the initial primary school enrollment decision, yet also old enough to contain children who have finished school. We thus focus on the 1,757 children ages 6 to 15, about seven percent of whom have already left school.[28]

As mentioned in the Introduction, grade repetition is relatively rare in Ghana. Only about 3% of students in the 250 primary school surveyed, and 1% of the students in the 217 middle schools, are repeating the grade that they attended the previous year. Also, using the panel portion of the two-year GLSS survey, we find that it is uncommon for Ghanaian students to temporary withdraw from school. Specifically, when we look at the one-hundred or so children between the ages of 8 and 15 that we are able to match across years, we can verify that only four children attended school in the second year but not in the first.[29] The upshot of these two facts is that, for children currently enrolled in school, we can define years delayed as age

[27]Another problem, but of less quantitative importance, is that some of the children living in the household were not present on the date of interview.

[28]Our sample is smaller than the one used for table 1 because of missing data on the explanatory variables.

[29]We were unable to use the panel data in our empirical analysis because of insufficient sample size.

minus grades completed minus 5.[30] As was mentioned earlier, years delayed (to date) for children not yet enrolled is simply age - 5, with an upper bound set at 3 years.[31]

Means of the variables used in the analysis are shown in the first column of Table 2 (definitions of the school variables are given in the Appendix). We use per-capita household expenditures as a proxy for income, as in many other studies using LDC data (e.g., Thomas and Strauss, 1992). In the absence of borrowing constraints, consumption expenditures should reflect permanent income.

Since school characteristics may reflect household choices (see Glewwe and Jacoby, 1992), we use the means across schools in the child's cluster of residence[32] rather than the characteristics of the school actually attended. Using cluster means also enables us to include children who have not yet started school. As discussed in section II, of particular relevance to the delay decision is the primary school enrollment fee[33] and a variable that indicates whether the primary school denies admission to some students. This latter variable measures the degree to which six year-olds are rationed out of local schools. We also include parental education, number of siblings, and ethnic and regional dummies in the regressions.

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[30]The fixing of the "normal" enrollment age at exactly six years old is somewhat arbitrary, but this choice should not affect the results.

[31]This upper bound is imposed because some children who have not yet started may never attend school. It was chosen after examining children with very brief school attendance (which in the limit amounts to not going to school at all). It was rare to observe such a child who was not at least 3 years late. To assess this assumption, we also estimated our delayed entry model excluding all children older than nine who had not yet started. Our results were hardly affected.

[32]Clusters are roughly equivalent to villages in rural areas and large neighborhoods in urban areas.

[33]Because school uniforms are apparently not compulsory in Ghana, we do not consider uniform (and other school supply) costs in our analysis.

V. ESTIMATION RESULTS

Table 2 reports estimates of the delayed enrollment function, (3.1), and the dropout age function, (3.4). To handle the right censoring problem and the discrete ordered nature of the dependent variable, we use a variant of the ordered probit model that incorporates the censoring conditions discussed in section III. Since the ordered probit assumes that the error term is normally distributed, we can use the Two-Stage Conditional Maximum Likelihood (2SCML) approach of Smith and Blundell (1986) and Rivers and Vuong (1988) to construct exogeneity tests for height-for-age as well as for per-capita expenditures. The latter could be endogenous because children not enrolled in school might contribute substantially to household income. Selected coefficient estimates from the first stage regressions of these endogenous variables are reported in Table A2 of the Appendix. Residuals from these two regressions are included in both ordered probits.

The second column of Table 2 shows the results for delayed enrollment. Of immediate note is the highly significant and negative coefficient on height-for-age.[34] This finding strongly supports our hypothesis that children who have experienced stunted growth delay school enrollment longer. From these ordered probit parameter estimates, we calculate that $\partial E[t_0^*]/\partial h = -0.41$ at the sample means, implying an elasticity of 0.35. Another indication that physical maturity is of prime importance in the decision to delay enrollment is the strong significance of the primary school travel time variable. The further the nearest primary school is from the household, the longer parents wait to enroll their children.

[34]The standard errors do not need to be corrected here since the height-for-age Z-score and per-capita expenditure residual terms are insignificant.

Table 2: Delayed Enrollment and Dropout Age Ordered Probits for Children 6-15

Independent Variable	Mean (Standard Dev.)		Delayed		Dropout Age	
Female	0.482	(0.50)	0.046	(0.72)	-0.060	(0.39)
Age (months)	132	(34)	0.032	(3.97)	0.024	(1.32)
Age Squared	18,495	(9,033)	-0.00010	(3.28)	-0.000082	(1.23)
Height-for-Age Z-score	-1.74	(1.23)	-0.363	(3.93)	-0.479	(2.12)
Z-score Residual	0.00	(0.41)	0.052	(0.58)	0.465	(2.06)
Log Expenditure/Capita	10.75	(0.55)	-0.081	(0.59)	0.346	(0.97)
Expenditure Residual	0.00	(1.12)	-0.060	(0.40)	-0.337	(0.94)
Mother's Schooling (years)	3.33	(4.63)	-0.040	(5.17)	0.017	(0.81)
Father's Schooling (years)	6.03	(5.95)	-0.018	(2.94)	0.028	(1.86)
Siblings	4.41	(3.02)	-0.010	(0.79)	0.043	(1.14)
Akan	0.451	(0.498)	-0.234	(2.64)	-0.187	(0.85)
Ewe	0.183	(0.387)	-0.053	(0.47)	-0.068	(0.23)
Ga-adangbe	0.048	(0.215)	0.050	(0.32)	-0.029	(0.07)
Rural	0.478	(0.50)	-0.227	(2.45)	0.129	(0.61)
Semi-rural	0.211	(0.408)	-0.016	(0.17)	0.096	(0.45)
Travel Time to Middle School (minutes)	28.2	(46.9)	-0.0006	(0.60)	-0.0068	(2.72)
Travel Time to Primary School (minutes)	13.2	(15.8)	0.0091	(4.71)	0.0027	(0.62)
Teacher Experience (years)	9.16	(3.21)	0.0028	(0.21)	0.039	(1.23)
Teacher Schooling (years)	11.70	(1.74)	0.0035	(0.17)	0.014	(0.29)
Teacher Training (years)	2.59	(1.0)	-0.095	(2.06)	-0.094	(0.89)
Blackboards	0.903	(0.118)	-0.515	(1.68)	-0.560	(0.73)
Books/room	51.100	(29.6)	0.0017	(1.31)	-0.0047	(1.59)
Leaking Classrooms	0.280	(0.223)	-0.055	(0.31)	-0.290	(0.64)
Unusable Classrooms	0.066	(0.108)	-0.258	(0.73)	-0.769	(1.02)
Shed Classrooms	0.180	(0.209)	0.405	(2.37)	-0.466	(1.02)
No Desks	0.262	(0.363)	0.327	(2.87)	-0.100	(0.33)
Private School	0.058	(0.148)	-0.036	(0.15)	-0.237	(0.40)
Complete School	0.950	(0.140)	-1.233	(3.70)	-1.541	(1.73)
Enrollment Fee (cedis)	129.4	(151.6)	-0.00005	(0.24)	-0.00054	(1.25)
School Denies Admission	0.267	(0.298)	0.080	(0.74)	-0.281	(1.01)
Sample Size	1757		1757		1399	
Number of Censored Observations	–		358		1280	
Mean (Standard Dev.) of Dependent Variable						
All Observations	–		1.91	(1.40)	10.98	(2.78)
Uncensored Observations	–		1.78	(1.49)	9.80	(2.97)
Log Likelihood	–		2385.65		533.19	

Notes: 1. Asymptotic t-values in parentheses. All regressions include a constant term, three regional dummies (Coast, Forest, Savannah) and several "threshold parameters". School variables are cluster means of primary school characteristics (see Appendix for variable definitions).

2. The dependent variable in the delayed enrollment regression is the years of delay, assuming that the standard age of starting school is 6 years. The dependent variable of the dropout age regression is age when left school, as calculated by the sum of years delay plus years of completed schooling. Note both dependent variables are right censored.

3. The dropout age regression excludes 358 children who have not started school.

Meanwhile, we find no support for the borrowing constraints hypothesis. Neither the logarithm of per-capita expenditures, a proxy for income, nor the primary school enrollment fee significantly affect the duration of delays. The former result holds up when we take out the first stage residual and treat expenditures as exogenous. Moreover, we obtain similar estimates (not reported) when we only consider those children below age eleven. For those households that face borrowing constraints, per-capita expenditures should closely reflect current income, so by restricting the sample to these younger children we obtain a more accurate measure of income at the time of the initial enrollment decision.

The supply constraints hypothesis fares no better than that of borrowing constraints, as the deny admission indicator is statistically insignificant. We also find no evidence that children are explicitly rationed out of schools by height. Specifically, we tried including an interaction term between height-for-age and the deny admission indicator. A positive and significant coefficient on this term would suggest that short children must wait longer to enroll in those schools that ration slots. In fact, this interaction term turns out to be completely insignificant.

Other primary school attributes perform quite well in the delay equation. The presence of better trained teachers, blackboards, desks, and suitable classrooms all reduce the average length of delays. Children also enroll earlier in primary schools with a complete set of grades. The significance of these primary school "quality" indicators suggests that the rate of return to delaying enrollment falls as schools improve. However, it might also be argued that their significance is evidence of school rationing; i.e., there are longer waits to enter the better schools. However, when we excluded all quality variables from the regression except for the deny admission indicator, the latter variable was still not significantly different from zero. Thus, if there is a rationing effect, it is not picked up by our rationing variable.

Finally, note that the child's age is a significant determinant of delayed enrollment. Since the ordered probit estimation accounts for censoring (i.e., a six-year old not yet enrolled is considered one *or more* years delayed, rather than just one year delayed), we interpret this finding as a cohort effect. Together the two age coefficients imply that delays are longest for those children who are now fourteen years old, and steadily decline for younger cohorts. Since the data were collected in 1988 and 1989, the estimates imply that enrollment delays peaked in the early 1980s. This cohort effect is consistent with the history of Ghana's educational system, and with our finding that school quality reduces delayed enrollment. In particular, during the 1970's and early 1980's, school quality declined in Ghana, but began to rebound in the mid-1980's (see World Bank, 1989). Although Ghanaian household income also declined during this period, we do not find a strong income effect on delayed enrollment.

Table 3: Height-for-Age Effect for Alternative Specifications

Specification	Height-for-Age	Height-for-Age Residual	Log Likelihood	Sample Size
(1) Delayed Enrollment w/ mother's height	-0.374 (3.24)	0.067 (0.57)	2385.63	1757
(2) Delayed Enrollment ignoring censoring	-0.355 (4.03)	0.081 (0.90)	2625.40	1757
(3) Delayed Enrollment: random household effects	-0.294 (10.64)	-- --	--	1421
(4) Delayed Enrollment: fixed household effects	-0.235 (6.41)	-- --	--	1421
(5) Grade Attainment ordered probit	-0.387 (1.60)	0.512 (2.15)	454.55	1399

Notes: 1. Asymptotic t-values in parentheses.
2. Dependent variable in (5) is number of grades attained, which is right censored.

Based on the insignificance of the height-for-age residual in column 2, we cannot reject the exogeneity of nutritional status in the delay equation. However, it is worth checking the robustness of these 2SCML estimates. We do so in Table 3. One potential difficulty arises from the fact that we exclude mother's height from the delay equation, although it might be correlated with unobserved family background factors that effect school enrollment decisions. The first row of Table 3 reports the height-for-age coefficient estimate when mothers height is included in the delay equation. The change in the estimated effect is miniscule (though the standard error rises a bit), and we still cannot reject exogeneity of height-for-age.

Next, we dispense with the 2SCML procedure altogether, and estimate both fixed and random effects models. Taking a subsample of 1421 children who have at least one sibling in our original sample of 1757, we estimate a fixed effects (household dummy variables) model as well as a random effects model. These linear models ignore censoring and the discrete nature of the dependent variable, so they must be viewed with caution. However, it turns out that taking censoring into account does not appreciably change the estimates of the delayed enrollment equation; compare the height-for-age coefficient estimate from the ordered probit without censoring, reported in the second row of Table 3, with its counterpart in Table 2.

Rows 3 and 4 of Table 3 thus report the random and fixed effects estimates of the height-for-age coefficient, respectively. Both are highly significant and the Hausman test of the single restriction that the household fixed effects are orthogonal to height-for-age has t-value of 2.5, which is also significant. As one would expect, ignoring fixed effects induces an upward bias in the height-for-age coefficient (compare rows 3 and 4). Although smaller in magnitude than the random effects estimate, the fixed effects estimate still strongly supports the finding that short children enroll in school later than tall children.[35]

In an attempt to obtain an estimator that is consistent under both household fixed effects and unobserved child specific endowments, we use information on the date of establishment of

[35]We also investigated the possibility of measurement error in the reported age of the child. Such measurement error could artificially generate a significantly negative height-for-age coefficient because an overestimated (underestimated) age will make a child appear to be both short (tall) for his or her age and also to delay enrollment longer (less). We re-estimated the delayed enrollment regression on the subsample of children for whom we have an exact month and year of birth and still obtained a significantly negative coefficient on the height-for-age variable.

health facilities to construct instruments for child height-for-age that vary across children within the same household. For example, we allowed the distance to the nearest clinic to vary within a household depending on whether or not the clinic was established before the child in question turned two years old. Unfortunately, the first stage regressions revealed that such instruments had no real explanatory power, so this estimation procedure was abandoned. It seems unlikely, however, that if this procedure were successful, it would overturn our central finding that stunting leads to longer delays in primary school enrollment.

Turn now to the last column of Table 2, where we report estimates of the dropout age function. Notice that we exclude 358 children from the full sample who have not yet started school. Since many of these children may be delaying enrollment because they are stunted, selection bias could be a problem. When we tried to correct for selection bias by estimating the ordered probit jointly with the probability of having started school, the likelihood function failed to converge. Models based on the bivariate normal are notoriously difficult to estimate, and, unfortunately, there is no tractable alternative in this case.

Possible sample selectivity notwithstanding, we find that tall children leave school significantly *earlier* than short children. Notice that we can reject the exogeneity of height-for-age in the dropout age function. The sign of the residual term also indicates that the direction of the simultaneity bias is as expected; taller children appear to be doing better than they actually are. But remember also that taller children start school earlier on average, so for a given age we are observing them farther along in their schooling careers. As discussed in section III, to separate out this delayed enrollment effect we must subtract away the height-for-age effect estimated in column 2 from that in column 3. In the case of the ordered probit, the estimate of interest is the change in the expected value of $s^*+t_0^*$ minus the change in the expected value of t_0^*, all with respect to a change in height-for-age. We obtain $\partial E[s^*+t_0^*]/\partial h = -1.36$, and from above $\partial E[t_0^*]/\partial h$ = -0.41, which implies that $\partial E[s^*]/\partial h$ = -0.95 (t-statistic= 1.47),[36] an unexpectedly negative yet insignificant effect of height-for-age on school attainment.

Now, what if we were to infer the effect of malnutrition on school attainment by estimating a regression such as (3.2)? Row 5 of Table 3 reports the estimate of the height-for-age coefficient from just such an ordered probit school attainment regression. As with the age of dropout regression, this estimate is negative, and is not quite significant at the 10% level. Using this estimate, we calculate that $\partial E[s^*]/\partial h$ = -1.10 (t-statistic=1.71). Thus, equation (3.2) would lead us farther toward the conclusion that chronic childhood malnutrition *enhances* school attainment!

This paper is not intended as the definitive word on the nutrition-schooling connection. Our estimates of the dropout age function suffer from the fact that there are few dropouts in our sample,[37] and possibly also from selectivity bias. However, unlike previous studies that use school-based samples, we have obtained the first direct evidence of the effect of malnutrition on ultimate school attainment. We have also demonstrated a simple solution to the problem of estimating school attainment regressions when delayed enrollment is pervasive, although it turns out not to make a great deal of difference in our sample.

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[36]The approximate standard error is calculated by assuming that the coefficients on the height for age variable in both equations are uncorrelated and by ignoring the sampling variance of the parameter estimates.

[37]Height-for-age Z-scores are only available for children seventeen years-old and under. Thus, with cross-sectional data we can only analyze the school leaving behavior of children up to age seventeen. Adding sixteen and seventeen year-olds to our sample turned out not to change any of our estimates appreciably, nor did it improve their precision.

VI. SUMMARY

In recent years a consensus has emerged regarding the crucial role of human capital in economic growth and poverty alleviation. While the connection between child health and nutrition on the one hand and human capital accumulation on the other has long been recognized, the precise mechanisms by which these outcomes are linked is only gradually being uncovered. This paper began with a puzzle: Why do children in poor countries so often delay school enrollment, despite its apparent costs? We have found strong evidence in favor of the view that delayed primary school enrollment is the consequence of nutritional deficiencies in early childhood. Child height-for-age is negatively associated with the duration of delays in entering school, and this correlation appears in fact to be a causal relationship (subject to our identifying assumptions, of course). Moreover, we find no support for our alternative explanations of delayed enrollment. Conditional on height-for-age, family income, as measured by per-capita expenditures, has no significant impact on delays. In addition, school fees have virtually no effect. These results cast doubt on the borrowing constraints story. The fact that local primary schools deny some students admission, i.e., supply constraints, also has no perceptible effect on delayed enrollment.

Our robust finding that better nourished children tend to start school earlier and thereby enter the labor force earlier, all else equal, has potentially important implications for policy. If the back-of-the-envelope calculation performed in the Introduction is any indication, early childhood nutrition interventions can lead to substantial increases in lifetime wealth. We have also argued that past studies do not provide a convincing answer to the question of whether malnutrition has a detrimental effect on ultimate school attainment. Our estimation results, which address a number of previously unexplored econometric issues, are regrettably inconclusive on this point. We suspect that cross-sectional data may not be well suited to answer this question. Future research on this important topic will undoubtedly benefit from the collection of high quality longitudinal data that recognizes the link between nutrition and human capital accumulation.

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APPENDIX TABLES

Table A1: Definitions of Variables

Teacher Experience - School-wide teacher's years of teaching experience.

Teacher Schooling - School-wide teacher's years of schooling.

Teacher Training - School-wide teacher's years of teacher training.

Blackboards - Fraction of school's classrooms that have blackboards.

Books/Room - Number of textbooks divided by number of classrooms. In middle schools this is broken down into new JSS curriculum and old Middle School curriculum.

Leaking Classrooms - Indicates proportion of total classroom which cannot be used when it rains.

Unusable Classrooms - Indicates proportion of total classroom which are completely unusable.

Shed Classrooms - Indicates proportion of total classroom which are of very simple construction.

No Desks - Indicates that the school lacks desks or tables for some children.

Private School - Dummy variable indicate that the school is private.

Complete School - Dummy variable indicating that the primary school has all 6 grades.

Enrollment Fee (Cedis) - Annual school fee, which for middle schools is separated into JSS grades (7 and 8) and Middle School grades (9 and 10).

School Denies Admission - Dummy variable taking the value of one if school does not admit all children who want to enroll, zero otherwise.

Table A2: Selected First Stage Regression Results

Instrumental Variables	Log Expenditures/Capita		Height-for-Age Z-Score	
VCluster Mean Log Expenditure/Capita	0.3403	(5.49)	0.4051	(2.40)
Schooling of Head of Household	0.0148	(4.94)	0.0227	(2.77)
Height of Mother	0.0001	(0.43)	0.0041	(6.49)
No Data on Height of Mother	-0.0152	(0.62)	-0.1118	(1.68)
Log (Agricultural Land)	-0.0005	(0.07)	-0.0227	(1.08)
Head is Farmer	-0.1214	(3.07)	-0.0607	(0.56)
Log (Value of Livestock)	0.0515	(7.47)	0.0263	(1.40)
No Livestock	0.2676	(4.61)	0.2714	(1.72)
Head Works in Food Processing	-0.1423	(4.35)	-0.0450	(0.51)
Head Works in Manufacturing	-0.1214	(3.23)	-0.0595	(0.58)
Head Works in Commerce	-0.1548	(5.74)	0.0422	(0.58)
Head Works in Services	-0.0789	(1.80)	0.0582	(0.49)
Log (Capital of Household Business)	0.0250	(7.28)	-0.0087	(0.93)
Clinic has Program for Malnourished Infants	-0.0092	(0.25)	0.1766	(1.78)
Clinic Provides Child Immunizations	-0.0413	(0.85)	-0.2052	(1.55)
Distance to Nearest Clinic	0.0163	(1.62)	-0.0186	(0.68)
Clinic has Malaria Drugs	-0.3101	(2.23)	-0.1159	(0.31)
Clinic has Aspirin	0.3578	(4.72)	0.3635	(1.76)
Clinic has Rehydration Salts	0.1732	(4.33)	0.1350	(1.24)
R^2	0.4447		0.1750	

Notes: 1. Asymptotic t-values in parentheses.
2. Variables that did not serve as identifying instruments are not included in this table.

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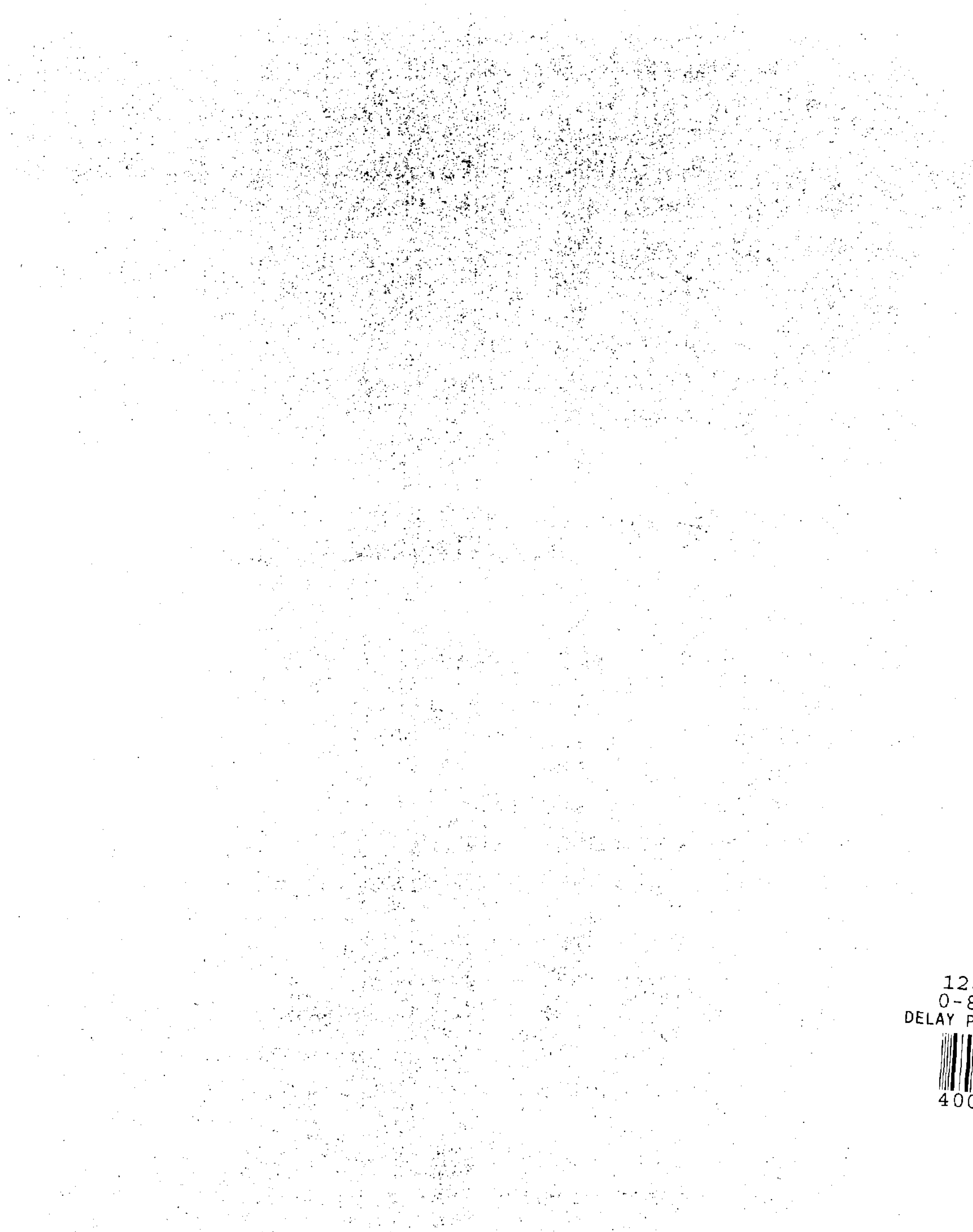

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