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Productive Benefits of Health: Evidence from Low-Income Countries

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Abstract

Various household survey indicators of adult nutrition and health status are analyzed as determinants of individual wages. However, survey indicators of health status may be heterogeneous, or a combination of health human capital formed by investment behavior and variation due to genotype, random shocks, and measurement error, which are uncontrolled by behavior. Although there are no definitive methods for distinguishing between human capital and genetic variation in health outcomes, alternative mappings of health status, such as height, on community health services, parent socioeconomic characteristics, and ethnic categories may be suggestive. Instrumental variable estimates of health human capital and residual sources of variation in measured health status are included in wage functions to assess empirically whether the productivity of both components of health are equal. Evidence from Ghana, Cote d'Ivoire and Brazil suggests that the health human capital effect on wages is substantially larger than that associated with residual health variation.

Keywords: Health Human Capital, Wage Productivity, Brazil, Ghana, Cote D'Ivoire

JEL Codes: I12, J24, O12

1. Introduction

The benefits due to improving health in the last century are obvious and far reaching. Yet there is little agreement on how to quantify these benefits and compare them to the costs of achieving such improvements. Four reasons for this gap in our knowledge seem relevant. First, there is no consensus among health specialists on how to conceptualize and measure health status at the individual level. Consequently, validating survey instruments which approximate these measures of health status has progressed slowly. Second, there is a deep reluctance to summarize the benefits of health in terms of only their productive payoffs, or value as "human capital", because this appears to deny the "consumption value" of health and the distinctive "capability" aspect of health . Third, self-reported health status involves errors in measurement, even when continuous health indicators of a relatively objective form are analyzed. Fourth, although healthier people may be more productive, more-productive people may also allocate more resources to creating and maintaining their good health. Because of this two-directional relationship, the association between individual health and personal productivity is not a satisfactory estimate of the causal effect in only one direction.

These four barriers to assessing the benefits of health may help account for our ignorance on these matters. But they hardly justify this state of affairs. This situation also contributes to the lack of consensus on how to analyze non-experimental survey data on individuals and families to evaluate the health consequences of health programs, policies, or developments. The overall priority assigned to health programs and the relative effectiveness of specific categories of health expenditures are therefore adjudicated by appeal to the "best judgements" of professional experts (Murray and Lopez, 1994).

Similar arguments on the limitations of the human capital framework for guiding social policy have been raised with regard to education. The relationship between the schooling of workers and their wage rates (or hourly earnings of the self-employed) has been empirically replicated from scores of countries during the last 30 years, and has gradually attained the status of causal fact in the eyes of most social scientists, though not without long technical debate and extensive exploration of alternative frameworks and statistical methodologies (Griliches, 1977; Card, 1998, 2001). Research into the conceptual, statistical, and empirical methods designed to link health status and productivity of individuals might place health and education on a more comparable footing for the purposes of policy making, without claiming that either health or education fail to serve broader social objectives than economic growth. Areas of agreement on how to collect more suitable data and use them to describe with less bias this health-productivity relationship should clarify how private and social health inputs affect health status, and influence labor productivity in different socioeconomic environments in developing countries.

Section 2 discusses these four barriers to progress and indicates which ones I focus on. Section 3 sketches a general schematic framework within which the determinants and consequences of health can be analyzed. Section 4 reviews accumulating empirical evidence on some of these critical links in Ghana, Cote d'Ivoire, and Brazil. Section 5 concludes with some ideas on how new data and analytical approaches could help us answer these questions more confidently.

2. Basic Limitations in Health Evaluation Methods

A. Multiple Indicators of Health

Health has many dimensions, and it may at this stage be optimal to consult a variety of indicators of health status rather than select one as preferred. The most commonly cited health indicator is survival or life expectation given a person's age and sex. It has the appeal of an intrinsic "capability" on which personal welfare depends (Sen, 1998). But there is as yet no agreement on how to forecast an individual's expected lifetime. Without a consensus on how to measure health status at the individual level, the impact of four different types of health indicators on wages may be useful: (1) self-assessments of health status; (2) morbidity rates; (3) physical functional limitations; and (4) nutritional and physical growth outcomes.

In the first type, self-reported general health status may range from health being "much better" to "much worse" than the benchmark "average" group. Are individuals consulting the same benchmark of health, or are they referring to the health status of other persons in their neighborhood or socioeconomic class, or age? In addition, any self-reported health status could reflect conditioning experiences and perceptions of the particular individual that are potentially related to her socioeconomic behavior and outcomes, rather than being an objective index of health status. Nonetheless, these general indicators of health status have been shown to be significantly related to subsequent morbidity and mortality of the individual, and even social experiments which collect extensive clinical information continue to evaluate health outcomes by these self-assessed questions (Manning, et al., 1982).

The second type of health indicator is based on morbidity reported by individuals or administrative units during a reference period. Different socioeconomic groups have access to different medical care and possess different knowledge of health needed to self-diagnose illness and seek out professional care. Morbidity rates derived from administrative records by individual, socioeconomic group, or region tend to be, therefore, less than reliable evidence of clinically confirmed incidence of illness across all individuals, groups, or regions of a low-income country, even when the specific class of morbidity, such as malaria, is reasonably well-identified by the respondent, and the law requires those with the illness to register the infections.

Sample surveys also collect self-reported responses on illness or disability (from a 14, 28, or 180 day retrospective period), or the number of days ill, or days sufficiently ill to be disabled (i.e. unable to engage in her regular activity) during the reference period. Questions of this form are included in many labor force and household general surveys, and are not commonly subjected to multivariate analysis as an indicator of acute or chronic health status, perhaps because they are viewed as subjective and affected by culture (Johansson, 1991).[1]

A third type of health indicator is based on limitations individuals report in their physical capacity to perform Activities of Daily Living (ADLs). Typically they are asked whether these tasks can be performed easily, with difficulty, or cannot be performed at all, such as, for example: is the respondent capable of walking 300m; of carrying a pail of water; of engaging in light domestic chores; and of bathing oneself? In contrast to self-reported general health status, or recent illnesses, or days disabled, the number of functional limitations currently experienced may be more concrete, and in some cases the interviewer can observationally validate the response. It is argued, therefore, that ADLs tend to be less biased by socioeconomic endowments, conditioning factors, and perceptions, and thus less likely to be subjectively biased (Strauss, et al., 1995). Functional limitations appear to approximate a continuum of health statuses among the elderly for whom these physical limitations on everyday activities are commonplace. Concurrent clinical examinations have also validated the reliability of ADL responses, at least for the elderly in high-income countries (Steward and Ware, 1992). How well indicators of functional limitations differentiate health status among younger persons, or those living in poor rural societies, is less well documented. Yet ADLs are a class of health status indicators which promises to reduce subjective reporting bias, and yet be collected at a moderate cost, without incurring the risks of infection associated with the collection of

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[1] It is worrisome that self-assessed morbidity rates often are higher in higher-income countries, where survival (the ”gold” standard measure of health) is higher, or for morbidity to be reported more frequently in the upper wealth classes of a developing country. How then can the researcher explain these divergent trends in morbidity and mortality (Schultz and Tansel, 1997; Foster, 1994). Labor contracts can affect how many work days people miss due to illness, as when workers are eligible for a certain number of paid sick leave days per year. On the one hand, many wage workers in a low-income country are casual laborers and are penalized by the loss of their wages if they do not report for work during any given day. Alternatively, if they are caught “working” while ill and presumably less productive, the employer may view the worker as shirking and not employ the individual in the future, damaging his reputation. However, if the reported number of days unable to work in the retrospective period is a more informative indicator of productive health status for wage earners than for other persons, some procedure is then needed to correct for sample selection bias, if the statistical relationship between health determinants and reported morbidity rates for wage earners is corrected to represent the relationship in the entire population (Schultz and Tansel, 1997).

blood or biological samples.

The fourth type of health indicator measures physical growth outcomes that result from a lifetime accumulation of nutritional inputs, health care, diminished exposure to infectious disease, and reduced work and strenuous activities that consume calories (Faulkner and Tanner, 1986; Floud et al. 1990; Fogel, 1994; Strauss and Thomas, 1995, 1998; Steckel, 1995). The health environment and the nutritional inputs to the mother and child affect early childhood development, including uterine growth (Barker, 1992; Scrimshaw, 1997), and factors during the adolescent growth spurt may modify adult physical stature and capabilities (Scrimshaw and Gordon, 1968; Martorell and Habicht, 1986). These indicators include a variety of anthropometric dimensions, the most common being adult height, which is thought to be particularly sensitive to early childhood nutritional/health status. Because adult height does not change substantially from about age 25 to 55, it provides an readily observed, relatively fixed, indicator of adult health potential and is thought to convey information about early nutritional/health conditions that may proxy more general living standards (Fogel, 1986, 1994; Floud et al. 1990; Steckel, 1995). Adult height thus conveniently bridges the widely separated moments in the life cycle when critical health inputs in childhood appear to be most important, and adulthood when the stock of health human capital impacts on productivity, and then delays the onset and diminishes the severity of chronic health conditions, such as cardiovascular problems or diabetes (Costa, 2002). To otherwise link panel data on the entire life cycle from childhood environments to adult functional capacity and productivity is complex and costly (Waterlow et al.1977; Beaton et al. 1990; Fogel, 1991 ; Scrimshaw, 1997).

Weight-to-height-squared or Body Mass Index (BMI) reflects a shorter-term nutritional/health status, which at low levels (less than about 21 in metric units) is referred to as “wasting” and is associated with elevated risks of mortality and morbidity. Conversely, at high levels of BMI (above about 28) obesity increases risk of mortality and morbidity (Waaler, 1984; Beaton, et al. 1990; Fogel, 1994). But in low-income countries the majority of the population is likely to have a BMI below 27, and the predominant empirical tendency is for BMI to be associated with better levels of health and productivity, although BMI tends to be subject to diminishing returns (Strauss and Thomas, 1997; Schultz 2003). BMI is also approximately orthogonal to height, and consequently, both can be included as determinants of productivity without introducing severe multicollinearity among regressors. Other anthropometric physical growth indicators have also been proposed, such as menarche or the age at first menstruation for women (Knaul, 2000). The adolescent growth spurt and the timing of puberty has occurred earlier in high income countries in the last century, presumably due to better nutrition and health conditions (Eveleth and Tanner, 1976; Falkner and Tanner, 1986). A host of child physical development indicators, graduated by age and sex, have become standard tools for child health assessments and monitoring (Beaton et al. 1990).

But few studies have measured family endowments and local policy conditions which might be responsible for variation in a respondent's childhood health, and potentially affect adult productivity. If these formative health conditions could be accurately measured and assumed predetermined for explaining adult acute and chronic health outcomes, these long-gestating health human capital investments might be fruitfully analyzed, allowing one to calculate the internal rates of return on social resources needed to achieve these early improvements in health.[2] For example, Costa (1996) reports the relationship between labor force participation for older men and their Body Mass Index (BMI indicates nutritional status up to about 28) in the United States, first observed in a sample of Civil War Veterans in 1900, and then replicated 90 years later in 1985-91. But during this time period the US population has shifted out of the high mortality and low participation risk categories of BMI less than 23, which dropped from about half of the male population age 50-64 in 1900 to a quarter of the population in 1990. Strauss and Thomas (1998) find a similar pattern between height or BMI and participation in the labor force for urban male adults in Brazil in 1975. I shall focus on health effects only on wage rates, or labor productivity per unit of time worked, and neglect the parallel effects of health on labor force participation, hours worked, and intensity of work (Schultz and Tansel, 1997). These labor supply effects of health could be due to the decreased disutility of working in better health, and the increased real reward for working (i.e. substitution effect), which may be offset by an income effect encouraging the consumption of more leisure. The potential market income of males has increased more rapidly in high income countries during the last century than has the actual realized market income, because annual hours worked have declined due to shorter work hours during prime working ages, as well as later entry and earlier exit from the labor force. Reckoning the hours worked by women is more complex, because time series on women's work in the household are scarce, and tend to be excluded from national income accounts.

B. Health Human Capital

The objective here is to estimate how labor productivity is affected by different components of health status, that which is affected by the behavior of individuals, families, and society and can therefore be called

[2] The analyst would still face the challenge of determining how much of the costs of changing the formative health conditions, say of improving nutrition, is attributable to the health investment objective and how much is attributable to satisfaction of immediate consumption preferences, i.e. reduced hunger.

reproducible health human capital, and that component which is unaffected by social behavior or referred to as exogenous. Additional social benefits of health, especially for the young, old, and infirm dependents, may require different methods to empirically assess.

C. Measurement Error in Health Human Capital

A standard problem in statistics is measurement error in explanatory variables. In estimating the effect of human capital, such as education, on wages, it is common to consider the education variable – years of education completed – as measured with error. In a simple setting with random error, the resulting ordinary least squares (OLS) estimate of education's effect on the wage tends to be biased downward, or more precisely biased downward in proportion to the ratio of the variance of the measurement error in education to the total variance of education (Griliches, 1977). Extending this approach to the estimation of the effect of health human capital on the individual's wage, one expects that health status variables are also measured with error. The error in measured health might arise from the subjective nature of health, but also from the heterogeneity of health. Measured health status may be thought of as being the sum of genetic endowments and behaviorally influenced accumulation of health human capital. There is no reason to believe that the productive effects of genetic and human capital health variations are identical. The productive benefits of the socially-accumulated health component is, of course, the payoff that is relevant for most policy interventions that seek to improve health through changing private behavior and public expenditure programs [3].

Although the reasons for measurement error in health are not precisely the same as in the case of education, the statistical methods required to correct for measurement error are analogous. If there are instrumental variables (IV) that are correlated with the human capital component of health, and they are also uncorrelated with the wage or genetically dominated and fortuitous (non human capital) component, it may be possible to predict the health human capital based on the variation in the instruments, and estimate in a second stage the unbiased impact on the wage of the human capital component. Combining these two stages corrects the downward bias due to measurement error in estimating health effects on productivity and is otherwise consistent.[4] If the return to human capital investments

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[3] Discredited eugenic approaches to improving the fitness of populations might have promoted selective reproduction, and thereby sought to enhance genetic health potential. But modern biotechnology may be redrawing the limits of health human capital today.

[4] For example, if the public subsidized price of health services is the policy intervention that is expected to induce variation in the use of health services and to thereby affect the production of health human capital, the instrumental variable methodology requires only that the price of health services be significantly correlated with the

differs for different groups, this individual heterogeneity in response to a policy treatment suggests that the IV estimate disproportionately weights the groups that are most affected in their health behavior by the instruments (Card, 1999; Kling, 1999). For example, suppose the demand of relatively rich households for health care and nutritional inputs for their children are not very responsive to the prices of these health inputs, i.e. price inelastic, whereas the demand of relatively poor households for these health inputs are responsive to their prices, or elastic. Then, if the prices of these health inputs are specified as instruments to predict the use of the health inputs, and thus identify the returns to these forms of child heath care, the instrumental variable estimate will approximate the payoff to poor households of increasing their investment in their children's health care, and are likely to overstate in this case the payoff to health inputs for the average household in the population. Consequently, the choice of an instrument on which to base an IV estimate of health human capital returns should be selected to mimic the policy options which are being evaluated for implementation.

D. Feedbacks from Productivity to Health Behavior

There are several overlapping relationships described in Section 3 involving health, which should be analytically distinguished in designing an approach to identify the benefits of improving health. To identify the productive effect of health it is essential to understand how household and community factors produce good health. This is true if the productive effect of health status is heterogenous, or if there is simultaneous feedback from productivity to the demand for inputs which contributes to altering health. The standard example of this latter source of bias involves estimating the contribution of improved nutrition to worker productivity, while recognizing the reverse causal effect of more productive workers being able to purchase more nutrients (Strauss, 1986). Although progress has been made at the individual level in separating out these two simultaneous causal relationships, it is doubtful whether at the aggregate level of inter-country comparisons the relationship between the average health of a population and the productivity of workers has been identified (Pritchett and Summers, 1996).

indicator of health status in the first stages, and that the instrumental variable not be correlated with the residual variation in genetic health predisposition or measurement error. Income shocks due to deviations in weather from long-term averages have also been used to infer the health effect of exogenous variation in household income, and linked to perturbations in health human capital. This approach can document how poorer families with less capacity to borrow to finance unusual consumption and investment needs may not be able to protect their children's physical development and growth (and schooling) from such weather induced income shocks (Jacoby and Skoufias, 1992). What has not yet been done is to use these weather induced variations in human capital to explain adult wage productivity or performance.

3. A General Framework for the Analysis of Health Human Capital

Two questions motivate this paper. What is the effect of change in health status on the productive capabilities of an individual, and what malleable conditions of the individual, family, and community determine change in health status? With answers to these questions, one can begin to assess the resource costs of modifying those conditions that will improve health, and then calculate the internal rate of return on those outlays as a human capital investment. Several studies reviewed below have begun to answer the first question, but few studies have taken the next step to estimate the social costs of programs that have produced the improvements in health.

To evaluate the returns to health human capital involves many of the same problems that have occupied economists in estimating the returns to schooling, plus a few added complications specific to health. There is agreement that years of schooling completed by a worker is a reasonable first-approximation for the physical units of education, although it may be further refined to include various dimensions of duration and quality associated with that education. But in the case of measuring the stock of health human capital there is no natural metric at the individual level. In sum, health presents greater problems for survey measurement, more leeway for measurement error, and a need to distinguish more carefully between at least two parts of health: a fixed genetic endowment and a socially acquired human capital component.

The literature on health economics has emphasized that individual health heterogeneity can bias direct estimation of health production functions, h(.), that seeks to characterize the technological relationship between health inputs (I) and health outcomes (H), and residual variation in health (e_1) (Rosenzweig and Schultz, 1983). Individuals, their families, and perhaps their medical advisors will know more about the severity of illness or the frailty of individuals (g) than does the statistician trying to account for health outcomes. The health production function can thus be described, where both g and e_1 are unobserved:

$$H = h(I, g, e_1), \tag{1}$$

where subscripts for individuals have been suppressed for simplicity.

The demand for medical care and other health-related inputs, I , may be modified by, g, private knowledge of the individual's health endowment in the family and medical system, as well as by other factors affecting health input demand, X, such as the market prices of health inputs, the value of the time of the individual that is expended to use medical inputs, other income sources controlled by the individual of other member of the household, and another error, e_2 , inclusive of differences in the preferences of individuals or families:

$$I = d(X, g, e_2). \tag{2}$$

For example, individuals who know they are particularly ill will be the first to seek out medical care, contributing to a negative correlation between demand for curative health inputs and good health, rather than the anticipated positive technical relationship that is expected if beneficial health treatment were randomly allocated to equally sick patients. If the unobserved part of health heterogeneity is subsumed in the error in the health production function, e_1, this error is likely to be correlated with the unexplained use of health inputs, e_2, imparting an omitted variable bias to the health production function (1) when it is estimated by single-equation methods, such as ordinary least squares (OLS), in which health inputs are assumed exogenous.

The solution to this health heterogeneity problem is to treat the health inputs, I , as endogenous in the health production function (1) or behaviorally controlled, and employ instrumental variables (IV), such as the prices of, or access to, health inputs, X , as the basis for identifying the health input demands. Then, estimates of the health production function by two-stage methods are free of heterogeneity bias caused by the unobservable g (Rosenzweig and Schultz, 1983). Assuming that the input prices and access are not correlated with individual health heterogeneity, or that the covariance (X, g)=0 , and that the prices variables explain a statistically significant share of the variation in input demand, these IV estimates of the health production technology are consistent and should have desirable properties.

In the case at hand of evaluating how health human capital affects wages, an analogous problem arises. Assume that health status can be decomposed into two components, Hb, which is explained by the technological effect of behaviorally controlled health inputs responding to exogenous price constraints, X, and a remainder, Hg, that subsumes genetic heterogeneity, differences in preferences, other unexplained factors, misspecifications, and stochastic errors from both the production and input demand equations (Schultz, 2003):

$$H = Hb(X) + Hg(g, e_1, e_2)\ . \qquad (3)$$

Only the first component can be viewed as “man-made” or a form of reproducible human capital, derived from predicting the health outcome from the fitted reduced form equation for health that embodies both the health production function (1) and the health input demand equations (2). Following the health production literature, the instrument, X, that is suitable for predicting the human capital component is an individual’s local price of health inputs or community level institutional investments which affect exposure to disease and efficacy of treatment when ill. Social scientists have perennially sought to decompose variation in individual achievement between those factors associated with nature (genetics) and nurture (human capital). There is no entirely satisfactory method for identifying the human capital component from the other factors including genetic potential, and covariances between the two sets of factors cannot be allocated to one side or the other. In our case, some genetic variation in health will be correlated with household income, price, and community variables and thus may become embedded in the health outcome. Then, the instrumental variable estimate of the effect of health capital on wages will contain some of the genetic health effect, in addition to the behaviorally induced variation in health human capital.[5]

Labor productivity, approximated by the hourly wage rate, is then fitted to variation in individual human capital stocks, where health human capital (Hb) is only the variation in health status that is accounted for by the instrumental variable, and hence uncorrelated with e_1, e_2 or g, because these production and demand errors or genetic variations are likely to be correlated with e_3 in the wage function:

$$W = w\,(\,Hb(X), E, Z, e_3\,), \qquad (4)$$

where W is the logarithm of the hourly wage rate, E is education, Z are other observed factors affecting the wage that are not behaviorally determined, such as age, and e_3 is the error in the wage function. As noted, these IV estimates of the effect of health human capital on the wage also corrects for classical measurement error in the health indicators.

4. Empirical Evidence of the Productivity of Health Status in Low-Income Countries

In the last few years the relationship between labor productivity and indicators of adult health and nutritional status has been analyzed in a growing number low income countries. Those indicators of adult health which have comparable meaning across ages, such as height, can also clarify changes occurring over time in underlying health. First, analysis dealt with the intake of calories as an endogenous demand decision by individuals and families made in response to factors including the local prices of nutrients (Strauss, 1986). This approach was then extended to other nutritional intakes, such as proteins, and nutritional status proxied by BMI, which are expected to increase the productivity of a laborer and help him resist the debilitating effects of infections and all parasitic diseases (Scrimshaw, et. al. 1968). Although adult height may be largely determined during early child development (Martorell, 1986; Thomas and Strauss, 1997), adult height appears heterogenous and measured with error, and consequently IV methods are needed even to estimate the human capital effect of adult height on wages.

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[5] Hausman (1978) specification tests could be performed to determine whether the health human capital variable appears to be exogenous (or endogenous) in the wage function. Endogeneity would be confirmed if the behavioral and genetic components of health human capital variable received significantly different coefficients in the wage equation. In some health measures the genetic component appears to account for most of the variable's variation, such as height, whereas the categorical or disability measures of health are more readily explained by individual/family/community instrumental variables.

Strauss (1986) argued that the relationship between nutrition and agricultural labor productivity could be biased because productivity also stimulates the demand for increase nutrition and health inputs.[6] He estimated the marginal product of agricultural labor in Sierra Leone, where he hypothesized that labor might be more productive when family workers were supplied with more calories. Rather than estimate a wage function including calories as a human capital argument, as outlined in the previous section, he estimated the household agricultural production function, including an interaction between an endogenous supply of calories, and the labor input into farm production. He thereby allowed calories to raise labor productivity and be subject to diminishing returns as per capita calories in the family approached well nourished levels. Because higher family labor productivity could also contribute to increased food consumption, Strauss used community variation in the price of nutrients as an instrumental variable to predict the family's supply of calories. He found calories driven by food prices raised the marginal product of family labor, especially at low calorie levels.

Subsequent studies replicated and extended Strauss' findings, with Deolalikar (1988) analyzing data for wage earners in India, Sahn and Alderman (1988) in Sri Lanka, Haddad and Bouis (1991) in the Philippines, and Foster and Rosenzweig (1993) in India and the Philippines. In urban Brazil, Thomas and Strauss (1997) estimated the joint effects on hourly earning of calories, proteins, and BMI , all three of these endogenously instrumented on local relative food prices, while also controlling for education and height. They found strong effects for the various endogenous nutrition/health variables, with calories again subject to diminishing returns. They estimated the elasticity of earnings with respect to exogenous height for men and women and found it to be significant but small.

An important feature of adult height is its persistence, changing relatively little from about age 20 to 55 . Consequently, height can be compared across birth cohorts for 30 to 40 years in a single cross sectional survey, with periods of economic development marked by improvements in childhood nutrition and health conditions that are manifested in increased adult height. Economic historians construct time series on the height of select populations, such as recruits into the military or criminals for whom height was recorded, and seek to correct for sources of sample selection bias (Floud, et al. 1990). In France where all young males at a certain age registered for military

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[6] This possibility of a nutrition-based efficiency wage led development economists to speculate that poor laborers were unable to invest efficiently in their own nutrition. Moreover, employers could not capture the full productive benefits of paying their workers a higher wage and having them consume a more adequate diet, whereas a slave owner might have the incentives to feed their workers efficiently. Yet agricultural wages in India appear sufficient in the 1960s to escape such a Malthusian trap, though some European populations may have had large shares of the population malnourished in the 18th century (Fogel, 1986).

conscription, time series on male height by region closely parallel estimates of GNP per capita, measured twenty years earlier, when the registrants were infants (Weir, 1993). Fogel (1994) consolidated figures for West European countries for which adult height is estimated for periods of one to two centuries. For example, in the United Kingdom in the 19th and 20th Centuries, male height increased by .45 centimeter per decade on average. Japanese men reaching age 20 have been estimated by Shay (1994) to have added .88 cm per decade from 1892 to 1937. Economic historians have relied on national time series on height, BMI, and output per capita to shed light on the likely impact of health status on productivity, but without focusing on the estimation problems raised in Section 3.

A. Health and Wages in Cote d'Ivoire and Ghana

Living Standards Measurement Surveys coordinated by the World Bank were conducted from 1985 to 1989 in Cote d'Ivoire and Ghana which allow the joint estimation of the effects on wages of height, BMI, lifetime migration, and years of schooling for men and women (Schultz, 1995, 2003). In addition to Strauss' instruments -- local relative food prices -- the distance to health and school facilities, and parent education and occupation are added to account for these four human capital variables. If individuals reside in a different region from their birthplace, then these migrants are attributed the average local characteristics of their region of birth for the relevant community instruments that are expected to influence early human capital investments. When Wu-Hausman (1978) specification tests are performed to judge whether the human capital variables are heterogeneous or measured with error, the IV estimates differ significantly from the OLS estimates, rejecting exogeneity. Different combinations of these instrumental variables are considered and they suggest that the IV wage equations are robust, or pass over-identification tests (Schultz, 2003).

The OLS coefficients of these four human capital variables in the wage functions for men and women in the two countries are summarized in Table 1 in rows 1, 3, 5, and 7, whereas the IV coefficients are reported in rows 2, 4, 6, and 8. On the whole, the OLS and IV estimates for education and migration are roughly the same, whereas the wage effects of health (height) and nutrition (BMI) are sensitive to the choice of IV versus OLS estimates. As argued in the previous sections of this paper, height and BMI are expected to be heterogeneous, and the IV estimates are designed to focus on the wage differences associated with the reproducible variation in height and BMI, rather than the genetic and random variation in these anthropometric indicators. In the country with the greater child malnutrition, Ghana, the IV coefficient on height is 3.8 times larger for males than the OLS coefficient in the wage function, whereas the IV coefficient on height for women is 5.8 time larger than the OLS coefficient.[7] An increment of one centimeter in height is associated with a 6 to 8 percent increase in wages in Ghana, according to the preferred IV estimates. In the smaller samples from Cote d'Ivoire, the IV estimates of height on wages are not statistically significantly different from zero at the 5 percent level.

The IV coefficients on BMI are significant in all four gender/country samples, increasing three fold from the OLS coefficients for males in Cote d'Ivoire and by one half for females, whereas in Ghana the IV coefficient on BMI increases by half for males, and more than doubles for females. An increase in BMI of one unit is associated with a 9 percent increase in wages for men in both Ghana and Cote d'Ivoire, whereas for women an increase in BMI of one unit is associated with a 7 percent increase in wages in Ghana and a 15 percent increase in Cote d'Ivoire. As a whole, these estimates of wage functions for two West African countries imply that the productive wage benefits associated with the reproducible variation in health human capital (i.e. height and BMI) are substantially larger than the OLS productive wage benefits associated with all of the measured variation in height and BMI. These results are consistent with the hypothesized heterogeneity in measures of nutrition and health.[8]

These LSMS surveys document the different achievements of neighboring countries. The height of adult females and males, respectively, from Ghana who were age 20 to 60 at the time of the survey, have been plotted as five year moving averages by date of birth (Schultz, 2001). Height has increased until the cohorts born in 1960, but

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[7] The World Bank estimated that 36 percent of the children under age five were malnourished in Ghana in 1990, whereas only 12 percent were in Cote d'Ivoire (World Bank, 1991). It is also documented in a variety of sources that the rate of infant and child mortality has declined rapidly in Cote d'Ivoire since 1960 as incomes per capita have risen sharply. In Ghana, which started the post Colonial era as one of the richest countries in Africa and initially had relatively high schooling rates and low infant mortality rates, growth has been slow, with little if any improvements in under five mortality during the 1970's and early 1980s (Benefo and Schultz, 1996).

[8] In Cote d'Ivoire a subset of the survey sample is reinterviewed in the following year and can be matched, allowing one to assess the random measurement error by comparing the wage estimates for this smaller group based on the average height in the two years versus that based on the individual year observations which are expected to be more noisy. As anticipated, the wage effects associated with the two-year averaged health human capital indicators are larger than those estimated from the individual-year values. Classical measurement error may be important in these health status indicators, but is not likely to account fully for the increase in the magnitude of the IV over the OLS estimates. Additional heterogeneity or endogeneity is probable. Nonetheless, the panel averages illustrate there can be serious problems in measuring reliably height and weight in a household survey (Schultz, 2003).

after independence the increase in height slows or is nonexistent.[9] Males in Ghana age 20-29 report an average height of 170 cm, an increase of 2 cm, over Ghanaian men age 50-65, whereas in neighboring Cote d'Ivoire the height of males 20-29 years old is 171 cm, or an increase of 4 cm. over men age 50-65 (Schultz, 2001, Figures 3,4) . Estimates of GNP per capita have also increased more rapidly in Cote d'Ivoire than in Ghana during the three decades 1960-1990, 316 versus 70 percent, respectively (World Bank, 1991). For these same age groups, women increased their height in Cote d'Ivoire by 3 cm and in Ghana by 1 cm. Little research has been conducted on how gender differences in height are affected by health or economic developments, perhaps because much of the historical evidence is derived from military records (Steckel, 1995).

Instrumental variable predictions of the number of days disabled are used to account for variation in wages among adult workers in Ghana and Cote d'Ivoire (Schultz and Tansel, 1997). The instruments employed to predict the self-assessed morbidity variables included access locally to health services and facilities, development infrastructure that should improve access to health care, climate and local malaria problems, parent education and occupation, region of birth, and local relative food prices. Although the reported days disabled is only weakly related to wages based on OLS estimates of the wage function by sex, the instrumental variable coefficients on this measure of "days disabled" are larger and statistically significant for men and women in Ghana and Cote d'Ivoire (Schultz and Tansel, 1997). According to the preferred IV estimates, an increase of one more day disabled in the last four weeks is associated with a reduction in hourly wages of 10 percent, and an additional three percent reduction in hours worked.

B. Height and Wages in Brazil

Based on the 1989 Health and Nutrition Survey (PNSN) of Brazil, the height of individuals born from 1929 to 1969 (age 20 to 60 at the time of the survey) has been plotted (Schultz, 2001; Figures 5,6). Fitting a linear time trend to height for individuals implies that Brazilian women born a decade later were on average 1.00 cm taller, and men 0.96 cm taller. Among only wage earners in 1989, the linear estimate of the increase in height was 1.18 cm per decade for women, and .98 cm for men. The first regression in Table 2 estimates the determinants of height for the wage earners conditional on a quadratic in age, controls for three nonwhite racial categories, and seven characteristics of local communities (i.e. municipios) as measured in the 1990 IBGE Census which were expected

[9] The lack of growth in height may also be due to the selective out-migration from Ghana which is said to have led to the departure of half their professional medical staff in the 1960s and 1970s, and it might be expected that the out migrants would have been taller on average than the nonmigrants.

to affect the local public health environment and exposure to disease. Residents tend to be taller in communities in which a larger fraction of the households have safe running water, there are more hospital beds per capita, and family income per capital is higher. But contrary to expectations about social externalities of education and sanitation, adult height is not significantly associated with the community average adult education, holding individual education constant, or in communities with greater access to household sanitation.

Table 2 column (2) reports OLS estimates of the log hourly wage regressions for the same Brazilian samples of male and female wage earners, based on the assumption that height is homogeneous, measured without error, and exogenous. Since it is likely that part of the differences in wages by race is due to other human capital or environmental factors and not entirely caused by differences in healthiness proxied by height, the three race dummies are also included directly in the specification of the conventional Mincerian wage function. Column 3, Table 2 reports the IV estimates of the wage equation, treating height as endogenous and measured with error. The IV estimates imply a 3.9 percent wage gain per centimeter in male height, and 5.6 percent wage gain per centimeter for females. The IV estimates are three to four times the magnitude of the OLS estimates, and the Wu-Hausman (1978) specification tests confirm that the OLS and IV estimates are significantly different, strengthening the statistical argument for accepting the asymptotically unbiased IV estimates. Interpreting these results in the model outlined in Section 3 with two components of health, the coefficient on the human capital component is significantly larger than that on the socially unexplained residual health variation. The specification appears to be relatively robust to changes in the subset of IV variables used to identify the effect of health human capital.[10] The magnitude of height's effect on wages estimated by instrumental variables appears to be substantial in Brazil, even though incomes levels are much higher than in Ghana and Cote d'Ivoire, and one might expect to find diminishing returns to this dimension of health status. Even in the United States in 1989-93, IV estimates suggest an additional centimeter in height is associated with men receiving 3.0 percent higher wages, and women 4.6 percent higher wages, where instruments include both regional health conditions and residence at age 14 (Schultz, 2002).

C. Wage and Inequality Changes Associated with Height and Education

To illustrate the likely contribution of advances in height and education to the growth in Brazilian wages from 1950 to 1980, the 1989 wage regressions (Col. 3, Table 2) are used to weight the changes in height and

[10] Including 31 additional control instrumental variables for local climate and population density to improve the predictions for the regional variations in height does not greatly affect the second stage IV estimates of the impact of height on wages. The wage gains for males are then estimated to be 4.0 percent per centimeter and for females 5.6 percent (not reported) (Schultz 2001).

schooling as reported in the third panel of Table 3, for adults born in 1930-34 and 1960-64, who might have entered the Brazilian labor force in approximately 1950 and 1980. The increase in height of 1.03 cm per decade between these birth cohorts (3.14/3 in Table 4), separated by 30 years, could account for a rise per decade in male wages of 4.1 percent (.0394*1.03) , and in female wages of 5.8 percent (.0564*1.03). In contrast, the increase in years of schooling completed was 1.05 years per decade for males, associated in 1989 with a rise in wages of 16 percent (.152*1.05) per decade for males, while the increase in schooling for females accounts for growth in wages of 22 percent. Thus, improvements in nutrition and health associated with birth cohort height accounted for somewhat less than a third of the wage growth associated with schooling (i.e. 5 percent versus 18 percent per decade).

Economic inequality in Brazil is among the highest in the world (Schultz, 1998). Measuring inequality by the variance in the logarithms of wages and the variance in human capital endowments helps to account for inequality in wages or its change over time, neglecting as second-order effects the covariances between age (experience), schooling, and height. According to Table 3, the variance in height has remained relatively stable in Brazil across these thirty years of birth cohorts, decreasing for men by 5.3 percent while increasing slightly for women by 0.9 percent. The variance in years of schooling, however, increased by 78 percent for Brazilian males and by 127 percent for females. The growing variance in the receipt of schooling has contributed to increasing economic inequality in Brazil (holding the 1989 wage structure constant), whereas inequality in health status, represented by height, is not linked to changes in inequality between the older and younger birth cohorts (Cf. Strauss and Thomas, 1995: fig.34.3).

D. Health and Wages: Latin America

The Inter American Development Bank coordinated a series of health and productivity studies based on recent Latin American household surveys (Savedoff and Schultz, 2000). These studies examined data from Peru collected in 1994 and 1995, Colombia from 1991 and 1993, and Mexico from two 1995 surveys. In each analysis of one or more health indicators -- height, BMI, self-assessed health status, self-reported days disabled, ADLs , and age at menarche for women -- were found to be weakly related to wages in a standard OLS specification, but when the health status indicators were estimated by IV techniques, relying on local health infrastructure and socioeconomic characteristics, all of these health indicators were related to wages in the anticipated manner, although the results for males were frequently more significant than for the smaller samples of female wage earners and self employed workers.[11]

5. Conclusions and Directions for Research and Data Collection

A range of survey indicators of adult nutritional and health status have been reviewed as potential determinants of individual wages and labor productivity in low-income countries. Several investigations have analyzed adult height as a proxy for uterine and early childhood nutritional/health status which is widely thought to be an important determinants of adult chronic health problems, particularly cardiovascular, and a determinant of longevity among the elderly (Barker, 1992; Fogel, 1991). Estimates of wage functions at the individual level from representative household surveys that include adult height find that height is partially associated with modest increments to wages, confirming its association with health and productivity, as emphasized by physical anthropologists and economic historians. But when the indicator of health status or health human capital is measured with random error, and is potentially generated by heterogeneous processes (e.g. genetic and reproducible), it becomes necessary to treat such a variable as endogenous, and one approach is to estimate its effect on wages by using instrumental variable techniques. This study of the determinants of wages has treated adult height as heterogenous and measured with error, and proposes using as instruments for adult height the local prices of food, community health services, and parental family income. These IV estimates of the effect of height on wages are substantially larger in magnitude than the OLS estimates and are also often more precise. An additional centimeter in height is associated with a gain in wage rates of roughly 5-10 percent, and more rapidly growing countries, such as Brazil, have achieved increases in adult height of a centimeter per decade. These instrumental variable estimates of adult health status on labor productivity are larger than the OLS estimates, presumably because these health indicators are not homogeneous and measured with error. The instruments for health status are local food prices, health infrastructure, and in some cases parent socioeconomic characteristics which are designed to explain the socially reproducible component of adult health status that is akin to the health human capital. The statistical interpretation is that the socially predictable component in the observed variation in height, BMI, days

[11] For example, in 1995 a Mexican survey asked women age 18 to 54 what age their first menstruation occurred, and the average was 13.1 years, with the linear time trend implying age at menarche decreased by .11 year per decade (t= 8.54) (Knaul, 2000). Knaul interprets this variable as an indicator of the timing of the adolescent growth spurt in Mexican women that is expected to occur earlier when childhood nutrition/health status improves (Wyshak and Frisch, 1982; Faulkner and Tanner, 1986). Age at menarche occurred later for Mexican women residing in rural than in urban areas, and for women who had completed fewer years of schooling, controlling for age. When age at menarche is added to the wage equation for these women, and instrumented by local public health, education, and housing variables, a highly significant partial relationship is obtained, in which a one month decrease in age at menarche is associated with a 1.9 to 2.3 percent increase in female adult wage rates.

disabled, ADLs , and age at menarche exerts a stronger influence on wages, and presumably on adult health, than does the unexplained remainder of the variation in health indicators which are attributable largely to genetic diversity and measurement error.

Self reported morbidity, such as days disabled, may exhibits no significant direct partial (OLS) relationship with wages, while community health instrumental variables suggest these health indicators tends to be better in communities in which wages are higher. Functional limitations of daily living, disability days, height, and age at menarche are all found to be similarly powerful in IV estimates of wage functions for workers in Mexico, Colombia, Peru, Brazil, Cote d'Ivoire and Ghana.

These studies of wages and health human capital are only beginning to propose suitable functional forms to approximate these relationships, which might be expected to exhibit some degree of biological generality across national populations. Diminishing returns to nutritional inputs are expected, and perhaps a similar pattern will emerge with respect to other physical growth indicators of health. Because of the discrete and unusual distributions of such health indicators, such as number of days disabled in a reference period or aggregated ADLs, the estimation of ordered Probit models may provide a useful method to begin scaling and aggregating health indicators.

It should be emphasized that all of the IV studies referred to in this paper have used concurrent community and family health-related conditions as instruments to predict health human capital. The health conditioning variables should be measured over the individual's entire lifetime, weighted for the sensitivity of adult health to inputs at each stage in the individual's prior lifetime. Current clinical and some panel studies conclude that the uterine environment and early childhood are most important, suggesting that the community and family health conditions should be measured for the individual prenatally and in the first years of life. If individual migration histories were collected retrospectively by household surveys, the individual could then be matched to regional records on locality-specific health programs at residence when the adult respondent was a susceptible infant. Food prices and rainfall in rural residential regions have provided such random shocks to identify an exogenous source of variations in child growth in the Cebu survey, which permitted the estimation of the effect of this child growth on later child achievement in school tests (Glewwe, et al. 1999). The resulting IV estimates become a useful tool for evaluating community health policy, which seeks to achieve food security for the poor. The empirical problems of evaluating the consequences of new health programs and policies would be facilitated if community health interventions were implemented in a staggered and randomized manner, to assure that the local allocations of health program resources would be statistically independent of unobserved heterogeneity across localities.

The connection between the accumulation of health human capital and labor productivity is a starting point for appraising priorities in many health programs and policies. The major complexity posed by health, which is less of a problem with education, is that the indicators which represent health are multifaceted and are not always adequately justified by their correspondence with mortality, morbidity, and the quality of life. Many of these health indicators may represent proxies for human capital, consuming current social resources and yielding over the life cycle of cohorts increased production potential. These indicators are a mixture of exogenous measurement error and genetic components, on the one hand, and an endogenous (or human capital) component. This distinction is perhaps most evident in the case of adult height, which has been emphasized here. In all of these studies of height, community health service and socioeconomic characteristics of parents account for only 2-10 percent of the variation in the population, and much of the unexplained variation in height is undoubtedly due to genotypic variation across individuals and surveys measurement error.[12]

The weakest link in the conceptual and empirical methodology outlined in this paper is in measuring satisfactory instrumental variables at the level of the formative family and childhood community. Certain instruments should be most relevant to different health indicators. The choice of these instruments should be informed by consulting the medical literature on what are likely to be effective interventions, since the choice of instrumental variables should mimic policy variations if the IV estimates are to be most useful in guiding policy choices.

Finally, heterogeneity in a population in its response to health treatments is to be expected, and this should lead to estimation of the impact of policy interventions on wages for different socioeconomic groups. Quantifying these distributional consequences of interventions is a critical ingredient in policy evaluation. The convenient simplifying assumption of homogeneity in treatment response that is implicit in many program evaluation studies needs to be reconsidered. With the analysis of individual data collected in matched household-community surveys, there is nothing to prevent such a reappraisal at several levels. First, interactions can be directly estimated between the treatment (price instruments, or random health inputs) and different exogenous socioeconomic groups in either

[12] More explicit analysis of matched siblings, and the exploitation of fixed effect estimation, might illuminate the relative importance of family and sibling fixed effects. It would not be clear, however, whether the sibling/family effects were only genetic in origin, even after many observed socioeconomic characteristics of the family had already been controlled. Nonetheless, such estimates should provide another way to identifying how changes over time in the community public programs work their effect on height and correspondingly affect adult wages of persons who benefitted from these local programs because they came into a specific family before or after the program started.

the health reduced-form or wage equation (Schultz, 1984). Second, the analysis should choose instrumental variables that capture distinctive program strategies that promise to yield special benefits for disadvantaged groups. The choice of these program characteristics may be informed by theories drawn from the biomedical sciences, sociology, anthropology, political science, or economics. Third, quantile wage regressions, using instrument variable methods may be employed to clarify what health determinants have larger productive benefits for individuals who are least productive.

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Table 1: Alternative Estimates of Human Capital Wage Returns for Schooling, Mobility and Nutrition-Health: Cote d'Ivoire and Ghana, 1985-1989 a

	Sample Size	Years of Education	Migration from Birthplace (Migrant = 1)	Height in centimeters	Weight to Height Squared (BMI)
Cote d'Ivoire LSMS: 1985-1987					
Males	1692				
1. OLS: ln Wage Effects		.109 (16.4)	.715 (8.73)	.00862 (2.00)	.0451 (4.55)
2. IV: ln Wage Effects		.107 (3.88)	.691 (3.09)	-.0105 (.56)	.159** (3.00)
Females	1180				
3. OLS: ln Wage Effects		.0730 (7.18)	.891 (8.26)	.00416 (.62)	.0613 (6.88)
4. IV: ln Wage Effects		.0731 (3.58)	.961 (4.80)	-.0435* (1.78)	.0950** (2.50)
Ghana LSMS: 1987-1989					
Males	3414				
5. OLS: ln Wage Effects		.0437 (9.86)	.348 (6.75)	.0148 (5.02)	.0530 (6.80)
6. IV: ln Wage Effects		.0445 (2.46)	.218 (2.26)	.0569** (3.45)	.0793 (1.95)
Females	3400				
7. OLS: ln Wage Effects		.0375 (7.26)	.531 (8.46)	.0129 (3.63)	.0420 (7.63)
8. IV: ln Wage Effects		.0356* (2.69)	.361 (2.98)	.0748** (3.44)	.0981** (4.11)

*/** Hausman (1978) test of the exogeneity of this human capital input in the wage function is rejected at the 5 percent confidence level (**),and should therefore be estimated by IV methods, and * is 10 percent level.

a Coefficients estimated on four human capital variables in log hourly wage equation, including dummy variables for age, region of birth, ethnic/language group, and season.
Source: Schultz, 2003.

Table 2: Estimates of Height and Log Hourly Wage Functions, Brazil 1989:Age 20-60, Wage Earners[a]

Dependent Variable Estimation Method	Males			Females		
	Height OLS (1)	Wage OLS (2)	Wage IV [b] (3)	Height OLS (1)	Wage OLS (2)	Wage IV [b] (3)
Height in Centimeters		.0131	.0394		.0153	.0564
		(11.1)	(9.01)		(8.55)	(7.60)
Post School Experience		.0735	.0744		.0599	.0630
		(25.7)	(25.9)		(16.3)	(16.9)
Experience Squared ($x10^{-2}$)		-.101	-.0976		.0782	-.0734
		(20.1)	(19.2)		(11.3)	(10.6)
Education Years		.147	.152		.148	.157
		(56.4)	(59.1)		(43.2)	(44.9)
Rural Resident		-.458	-.444		-.416	-.399
		(24.5)	(23.7)		(12.9)	(12.3)
Age Years	.0187			-.0406		
	(.40)			(.67)		
Age Squared ($x10^{-2}$)	-.156			-.0985		
	(2.61)			(1.23)		
Race:						
Black	-.455	-.310	-.279	.346	-.367	-.356
	(1.33)	(7.77)	(6.97)	(.80)	(6.66)	(6.45)
Yellow	-5.06	.128	.264	-3.99	.299	.452
	(4.37)	(.95)	(1.94)	(2.85)	(1.67)	(2.50)
Brown	-2.29	-.182	-.0879	-1.42	-.208	-.102
	(14.0)	(10.5)	(3.91)	(6.81)	(8.59)	(3.43)
Density Population	-.102			.053		
	(2.24)			(1.05)		
Density Squared	.0042			-.0023		
	(2.07)			(1.02)		
Percent Household with Running Water	.0536			.0597		
	(9.15)			(7.59)		
Percent Household with Sanitation	-.0025			-.0054		
	(.77)			(1.21)		
Hospital Beds per 1000	99.1			103.8		
	(4.59)			(3.98)		
Family Income per Capita	.942			.838		
	(3.77)			(2.89)		
Years of Education Adults Age 15+	-.079			-.359		
	(.82)			(2.98)		
Intercept	165.6	-3.99	-8.53	-8.53	-4.52	-11.1
	CLXXVII.	(19.5)	(11.4)	(11.4)	(15.7)	(9.36)
R^2 Adj.	.103	.419	.417	.0894	.410	.408
(Prob > F)	(.0001)	(.0001)	(.0001)	(.0001)	(.0001)	(.0001)
Hausman t test of exogeneity of height (Prob > t)	--------	-------	9.17 (.0001)	------	-------	6.97 (.0001)
Mean Dependent Variable (standard deviation)	168. (7.29)	-.297 (1.05)	-.297 (1.05)	156. (6.69)	-.557 (1.06)	-.557 (1.06)

a Beneath regression coefficients are the absolute value of t (OLS) and asymptotic t (IV) statistics.

b The instrumental variables identifying the effects of height in the wage equation (3) are the seven community characteristics for population density to adult years of education.

Table 3 :Means and Standard Deviations in Parentheses of Height and Schooling by Country, Selected Age Groups, and Sex

Country Age	Height (cm.)		Schooling (yrs.)	
	Female	Male	Female	Male
Ghana: 1987-89				
Age 25-29	158.53 (6.25)	169.46 (6.63)	5.29 (4.97)	8.29 (5.09)
Age 55-59	156.93 (5.96)	169.00 (6.51)	2.12 (4.29)	5.68 (5.97)
Change	+1.60 (+0.29)	+0.46 (+0.12)	+3.17 (+0.68)	+2.61 (-0.88)
Cote d' Ivoire: 1985-87				
Age 25-29	159.11 (5.67)	170.11 (6.70)	2.78 (3.99)	6.12 (5.07)
Age 55-59	157.57 (6.11)	168.48 (6.88)	0.23 (1.32)	2.30 (3.98)
Change	+1.54 (-0.44)	1.63 (-0.18)	+2.55 (+2.67)	+3.82 (+1.09)
Brazil: 1989				
Age 25-29	156.27 (6.62)	168.90 (7.27)	6.36 (4.31)	5.66 (4.22)
Age 55-59	153.16 (6.59)	165.79 (7.47)	2.21 (2.86)	2.52 (3.16)
Change	+3.10 (+0.03)	+3.10 (-0.20)	+4.15 (+1.45)	+3.14 (+1.04)
Vietnam: 1992-93				
Age 25-29	152.16 (5.39)	162.10 (5.39)	7.90 (3.21)	8.35 (3.38)
Age 55-59	148.73 (5.64)	159.19 (5.93)	3.74 (2.59)	6.48 (3.82)
Change	+3.43 (-0.25)	+2.91 (-0.54)	+4.16 (+0.62)	+1.87 (-0.44)

Source: Author's tabulations.

a. Beneath regression coefficients are the absolute value of t (OLS) and asymptotic t (IV) statistics.

b. The instrumental variables identifying the effect of height in the wage equation are the seven community characteristics.

Appendix

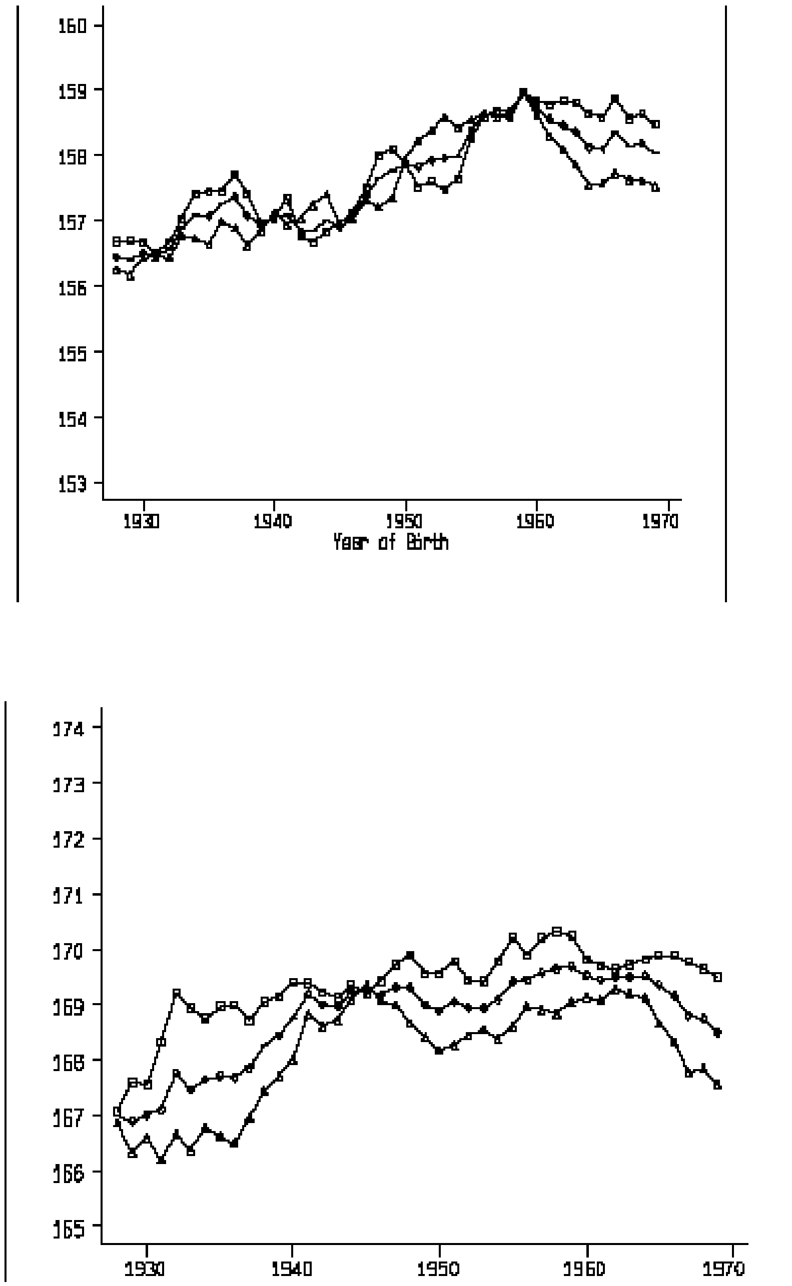

Figure 2: Height in Centimeters of Adult Males in Ghana in 1987-1989: by year of birth, total (circle-o), rural (triangle-Δ), and urban (square-□) regions

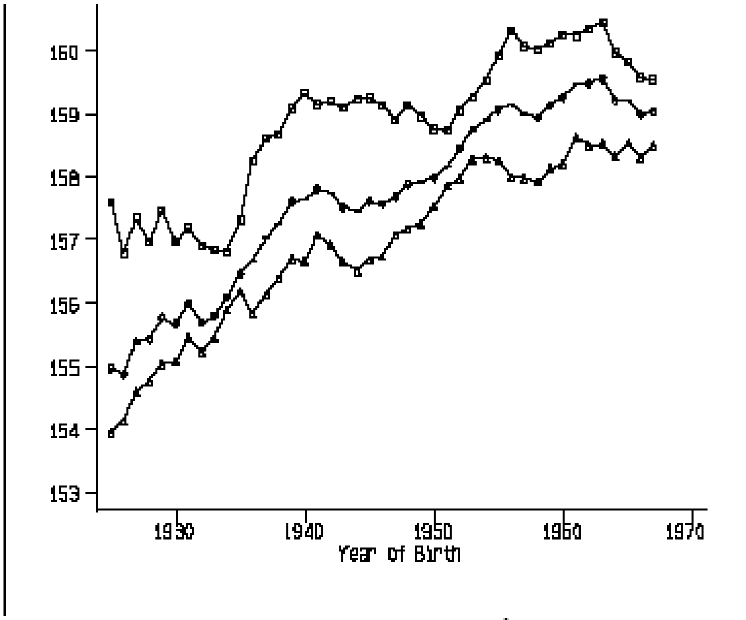

Figure 3: Height in Centimeters of Adult Females in Côte d'Ivoire in 1985-1987: by year of birth, total (circle-o), rural (triangle-Δ), and urban (square-□) regions

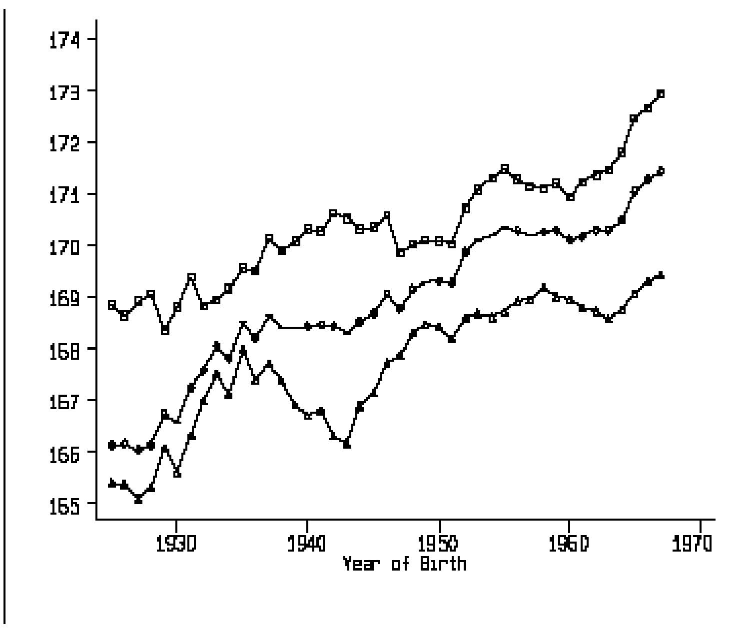

Figure 4: Height in Centimeters of Adult Males in Côte d'Ivoire in 1985-1987: by year of birth, total (circle-o), rural (triangle-Δ), and urban (square-□) regions

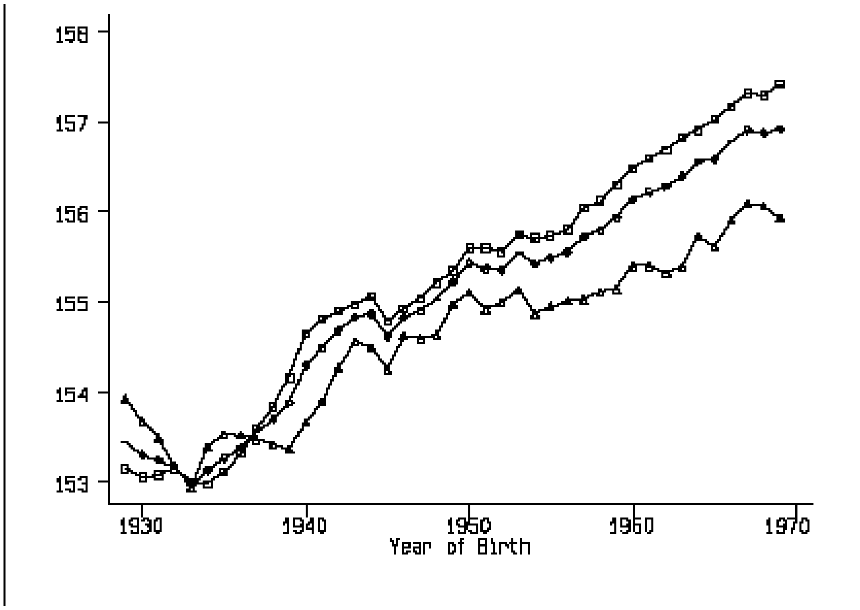

Figure 5: Height in Centimeters of Adult Females in Brazil in 1989: by year of birth, total (circle-o), rural (triangle-Δ), and urban (square-□) regions

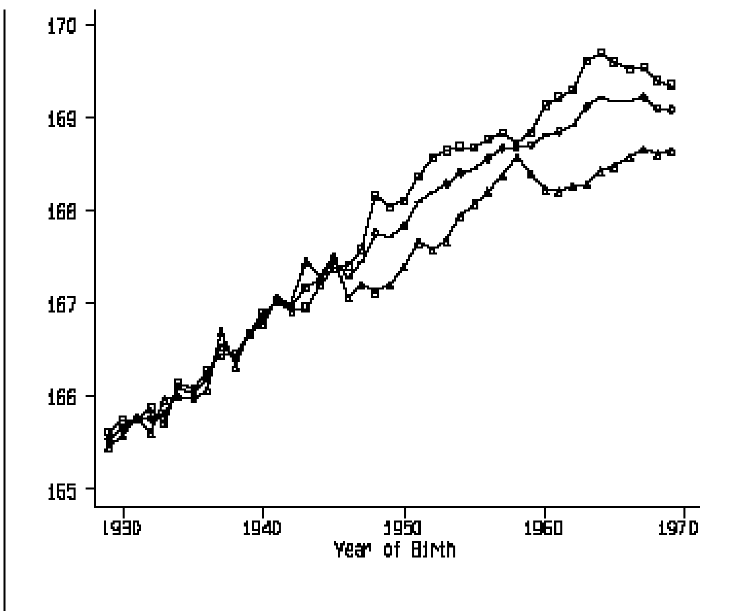

Figure 6: Height in Centimeters of Adult Males in Brazil in 1989: by year of birth, total (circle-o), rural (triangle-Δ), and urban (square-□) regions