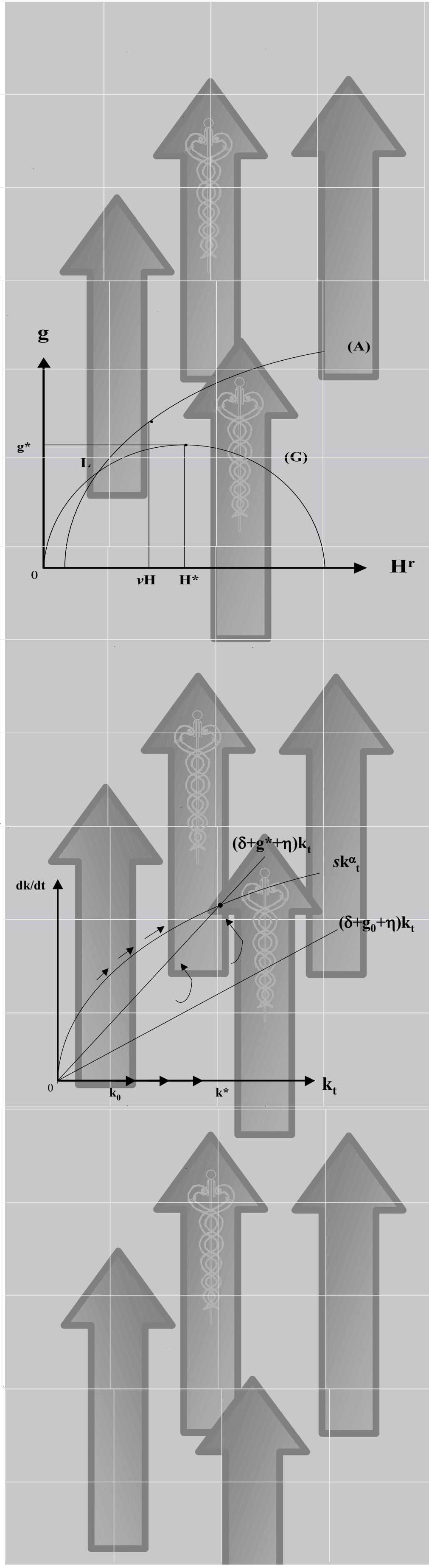

Health, Human Capital and Economic Growth

Food for Thought: Basic Needs and Persistent Educational Inequality

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Program on Public Policy and Health
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Abstract

We give evidence that human capital accumulation by the poor is only possible if a minimum level of health and well-being has been attained. When families do not have enough resources to invest in the satisfaction of basic needs and health care, and finance is not available for this purpose, a poverty trap may exist with low health, education and income. These poverty traps may persist if policies financing education are applied which do not also address deficiencies in nutrition and health impairing human potential. This link between health and education contributes to explain the important, long-term effects of nutrition and health on economic growth and implies that nutrition and health may play a causal role in the persistence of inequality and in the effects of inequality on growth.

1. Introduction

Education has become an indispensable condition for raising living standards and achieving economic growth. However, in the absence of appropriate public policies, low levels of well-being and health may constitute a barrier to the accumulation of human capital that the poor may be unable to overcome. Successful education requires a minimal level of health[1] that depends on the satisfaction of basic needs and on addressing specific health problems. We show that, when families cannot borrow to satisfy their basic needs, the minimal health requirement may give rise to a poverty trap that may not dissapear if funds are made available for education but not for basic needs and health[2] . The poverty trap gives rise to two classes of families, one poorer, less healthy and unskilled and the other richer, healthier and skilled. The health-related poverty trap we propose can be thought of as an addition and continuation of the efficiency theory of wages, that explains the possibility of a low productivity trap due to low nutrition (e.g. Leibenstein, 1957; Mazumdar, 1959; Mirlees, 1975; Stiglitz, 1976; Bliss and Stern, 1978; Das-

[1] We include nutrition in 'health'.

[2] We shall talk about funds becoming available for the satisfaction of basic needs and health to stress that *somebody* has to finance the expenditure, for example through private credit or through public expediture that may be repaid through higher taxes in the future by recipients. This is more suggestive to non-economists than the somewhat criptic *credit restriction* that is the economic technical term.

gupta and Ray, 1984, 1986; Dasgupta, 1991) and documents substantial effects of nutrition on labor productivity (for surveys see Barlow, 1979; Martorell and Arrayave, 1984; Strauss, 1985; Srinivasan, 1992; Behrman and Deolalikar, 1988). Here we suggest that low nutrition and health in children may lead to low levels of education and therefore to an intergenerational poverty trap.

Identifying this health-related poverty trap contributes a new dimension to the study of the economic effects of health. It is remarkable that although the basic importance of health is well recognized in the study of poverty and development, for example by its inclusion in the Human Development Index (United Nations Development Programme, 1990), health-related poverty traps do not received much attention in the empirical and theoretical literature. The possible existence of health-related poverty traps is supported by Mayer (2002) in a study showing that the distribution of life expectancy was twin-peaked in 1962 and 1997, with half the countries in the lower peak shifting to the higher peak during the period. The remaining countries were trapped in life expectancies shorter than 55 years. Ranis, Stewart and Ramírez (2000) study the interrelationship between human development and economic growth. They find that it is more likely for countries to experience virtous cycles in economic growth if they first experience virtous cycles in human development. In more recent work, Arcand (2001) shows that nutrition has substantial effects on economic growth both directly and through life expectancy and possibly schooling. Thus, overcoming health-related barriers to the accumulation of human capital may be an important preconditon to achieving higher income levels.

In the literature the main antecedents to our poverty trap are the low-nutrition trap mentioned above (due to the effects of food consumption on labor productivity) and the impact of poverty on patience' or time-preferences, which may depend on prospective life expectancy. Differences in time preferences are supported by US data, which show that differeces in discount rates between white, college-educated families in the top 5 percent of the labor income distribution and non-white families without an education in the bottom fifth percentile can be up to 7% (Lawrance, 1991). If the poor are more impatient it follows that they will experience slower economic growth (see for example work in recursive preferences by Hertzendorf, 1995 and Mantel, 1998). The income distribution may bifurcate when agents maximize health using endogenous discount rates themselves dependent on health (Mayer, 1999). Here, however, we examine a different causal channel: the effect of health on education. Our approach deepens the literature that explains the persistence of poverty through the presence of credit constraints (Galor and Zeira, 1993; Banerjee and Newman, 1993). We show that the constraints that exist on borrowing for the satisfaction of basic needs and health, themselves necessary ingredients for education, may make acquiring the later impossible even when finance for education is available.

The strong empirical correlation that exists between aggregate measures of health and income has been recognized since Preston's 1975 cross-country study, which showed life expectancy to be positively correlated with income. In a more recent study, Pritchett and Summers (1996) also corroborate that countries with higher incomes enjoy higher health. In 'Divergence Today' (Mayer, 2002c) shows that the evolution of life expectancy by groups of countries closely parallels income per capita.

The opposite causal relation running from health to income, productivity and economic growth has recently received considerable attention, partly because of the policy questions that it is related to (World Health Organization, 1999, 2001; Pan American Health Organization, 2001). Studies by Fogel (1991, 1994a,b) and Fogel and Wimmer (1992) established that nutrition and health have had an important historical impact, accounting for up to a *third* of economic growth. Arora (2001) finds that there is an exogenous component to the dynamics of health-related variables to which the dynamics of growth are sensitive and not vice versa, in a study using 62 health-related 100- to 125-year time series for nine advanced economies. The percentage of total growth attributed to these variables lies between 26 and 40 percent. Devlin and Hansen (2001) find Granger causality running in both directions between health and GDP in OECD countries. These economic history findings have been confirmed by macroeconomic empirical studies of economic growth along the lines set out in Barro and Sala-i-Martin (1995). Barro (1991), Barro and Lee (1994), Barro (1996), Easterly and Levine (1997), Gallup and Sachs (2000), Knowles and Owen (1995, 1997), Sachs and Warner (1995, 1997) and Mayer et al (2001) have found that health, measured usually as life expectancy or low mortality, has a significant, positive effect. Bhargava et al. (2001) find, addressing issues of endogeneity and reverse causality, that adult survival rates have a positive effect on GDP growth rates in low-income countries. Bloom, Canning and Sevilla (2001) carefully distinguish health from education and experience and find that it has a positive, sizable effect on aggregate output. This effect continues to be felt several decades into the future (Mayer 2001a,b, 2002a). In a study on the productivity associated to health, Gyimah-Brempong, K. and Wilson (1999) conduct two comparable dynamic panel studies on Subsaharan Africa and the OECD, each with more than twenty time observations, finding that health has considerable, significant, effects on the rate of economic growth. Weil (2001a) confirms Fogel's results for Britain, finds similar results for Korea over the period 1962-1995, and estimates that health accounts for about 17% of the variance in cross-country 1988 productivity levels. As mentioned above, Arcand (2001) shows that nutrition has substantial effects on economic growth, and finds evidence for the existence of a nutritional-related poverty trap.

At higher levels of income the effect of health on economic growth may be negligible or even negative (Van-Zon and Muysken, 2001).

An extensive series of microeconomic studies have used a human capital framework to measure the effects of health and eduacation on individual earnings and productivity (e.g. Schultz, 1992, 1997; Thomas, Schoeni and Strauss, 1997; Strauss and Thomas, 1998; Savedoff and Schultz, 2000; see Strauss and Thomas (1995) and Schultz, 1999, for surveys). However, by and large these studies have found smaller magnitudes for the effects of health, and none has been considered the possibility of a poverty trap.

One possible explanation for this discrepancy between the macro and micro results is the existence of health-related poverty traps. For suppose that there exist thresholds of health and well-being that lead to distinct equilibria at different levels of human capital. Then macroeconomic cross-country studies, whose samples cover considerable differences in wealth and health, will tend to span these equilibria and measure the health-related differences in economic performance.

On the other hand microeconomic studies will tend to measure marginal health effects reduced by the proximity to local equilibria.

At the individual level, a clear causal connection has been established running from differences in income to differences in health (Deaton, 1999a,b). In a study of 1.3 million deaths in the U.S., Rogot et al. (1992) show, for example, that in 1980 the life expectancy of men at age 25 in the bottom income group (those with less than $5,000 of family income) was 43.6 years while for men at the top (more than $50,000) it was 53.6 years. The analogous expectancies at age 45, 26.2 versus 39.0 bear a similar proportion. In a cross-country study, Bidani and Ravallion (1997) find that people with an income below US$2 per day have a life expectancy nine years shorter than those above this income level. This "mortality gradient" held in the last century as well. According to Dora and Steckel (1997) the distribution of health health diverged in the nineteenth century and converged in the twentieth in the U.S. Amongst the causes they cite are rising income inequality. It is also found that early-life health has a large impact on longevity. Analogously, in a study on the regions of Great Britain over the period 1861-1971, Lee (1991) finds the inequality of infant mortality rates diverged during the late nineteenth century to a peak inequality in 1921/31, converging since then towards equality, and relates these variations to the density of housing occupancy and industrialization. Ferrie

(2000) finds a strong and negative relationship between household wealth and mortality in the U.S. in 1860 and a somewhat weaker negative relationship between occupational status and mortality in 1850. Even when the U.S. population was largely rural and agricultural, changes in the distribution of income and wealth would have had a large impact on mortality rates and life expectancies.

The opposite causal connection, from health to income inequality, has not been addressed. Our model shows that health inequality may be a factor in the transmission and persistence of income inequality, explaining one channel through of such a causal connection. This theory finds some support in Dora (1998), who shows that health inequality was transmitted across generations, using data on maternal height for the first decades of the twentieth century. It suggests that some of the causes of the long-term changes in the distribution of income and health that occured for instance in the U.S. and Great Britain may run through health.

The model we propose focuses specifically on the effects of minimal health requirements for acquiring an education. Let us not forget that in the developing world, 790 million people do not have enough food to eat, while 1.3 billion people do not have access to safe drinking water (Weil, 2001b). The effects of health and nutrition on education in developing countries have been studied in some detail in an attempt to detect specific links which may be addressed cost-effectively (World Bank, 1993). As part of the effort to improve and extend basic education services and to universalize primary schooling conducted by the UNDP, UNESCO, UNICEF and the World Bank, survey studies have been undertaken on the consequences on education that low nutrition can have (Levinger, 1992[3]). The following obstacles that nutrition and health pose to the *achievement of child quality* (a reconceptualization of the objectives of education that echoes the essence of the concept of human capital formation) are documented. Temporary hunger is related to inattentiveness. Protein-energy malnutrition (especially in early childhood), often worsened by a child's parasite load, is significantly related to poorer cognitive and school performance indicators, and to worsened general conceptual ability, problem solving, mental agility and capacity. Micronutrient deficiency disorders also impair school performance. Iodine deficiencies are associated with reduced intelligence, psico-motor retardation, mental and neurologic damage, and cretinism. Iron deficiency anemia, which affects 1.3 billion people, of whom 210 million are school age children, has been associated with lower mental and motor development test scores. Vitamin A deficiencies are associated with eyesight problems and other conditions. Helminthic infection generates very high

[3] See web page http://www.edc.org/INT/NHEA/index.html.for the study and its references.

levels of morbidity associated with impaired cognitive function, absenteeism, under enrollement, and attrition. Untreated sensory impairment, such as vision or auditory problems constitute significant educational risk factors. 42.8% of the children under 5 in 21 Latin American countries[4] show moderate and severe stunting, a clear sign of malnutrition that is likely to be associated with poorer educational performance.

Levinger (*op. cit.*) notes that some of these problems may be overcome by relatively inexpensive interventions such as nutritional rehabilitation, medical care and cognitive stimulation. However, it is quite clear that this type of measure may be insufficient if it is not accompanied by a substantial rise in the satisfaction of basic needs in general, if children are to become succesful, productive individuals. Larrea, Freire and Lutter (1998) show that stunting due to malnutrition becomes established in the first 2 to 3 years of life. Supporting the hypothesis of a health threshold for education in the abscence of timely funding for nutrition. Programs supplementing nutrition in school may not reach children soon enough. Stunting has been shown to be cumulative and non-reversible and therefore provides an excellent measure of chronic malnutrition and its effects. A whole literature exists

[4] The countries are: Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

showing that malnutrition leads to lower longevity, chronic diseases and lower cognotive status (Schürch and Scrimshaw, 1987).

Our model thus assumes that a minimum level of health and well being — health, for short— is necessary during infancy and childhood to be able to obtain adequate returns for investment in education. Health affects the returns of education 1) by enabling the formation of child quality in the early years and throughout youth, bringing the efficiency of education to a viable level; 2) by raising skilled and unskilled labor efficiency and 3) through longevity, itself influenced by early health, by lengthening the time during which education will yield a return. Although health also affects the efficiency of unskilled labor, it does so to a lesser extent, because of the cognitive and mental dimensions involved in education, and because of the increased returns on investment implied by longevity, given a sufficient level of health. Thus it will not be feasible, or worthwhile, to choose to train for skilled instead of unskilled labor below some minimum level of health.

The presence of this threshold health level implies the possibility of multiple equilibria. For suppose that skilled work is a viable option. If, for example, unskilled laborers cannot in equilibrium provide their children with the minimum level of health necessary for succesful training, then if the satisfaction of these needs are not financed then the condition of unskilled labor will represent a low equilibrium (a poverty trap). In this situation, even if educational expenditures are financed, children will be trapped in low-wage, unskilled labor, remaining in the cycle of poverty.[5] Only policies financing basic needs and health as well as education will end this cycle. Note that this includes financing the satisfaction of needs closely associated with basic consumption. Public programs making food available for children in schools, are examples of policies extending credit for the satisfaction of basic needs, to be paid by the taxes of higher earning adults. Basic food subsidies, such as for the maize *tortilla* in Mexico are also examples, where similar principles have been extended to adults who may be trapped in poverty for a variety of reasons.[6] The simultaneous support of basic needs and education has been implemented in public programs. The nature of the nutrition and health thresholds involved implies that pre-school infants should also be aided, as in the Progresa program in Mexico.

Our model formalize this argument and implies that both income and health tend to polarize into a bimodal distribution, one mode poorer, less healthy and unskilled and the other richer, healthier and skilled. An immediate consequence is that the initial level and distribution of wealth matters for macroeconomic

[5]We make the supposition that skilled and unskilled labor are substitutes. Thus unskilled labor never becomes scarce. This is realistic at low skill levels.

[6]The *tortilla* plays a central role in the diet of the poor in Mexico. It is a bread equivalent originated in prehispanic culture.

performance, as in Galor and Zeira (1993), since it will determine the proportions of the population that are attracted to the skilled and unskilled equilibria, and this in turn will determine the aggregate level of human capital and the rate of economic growth. Our model therefore implies that policies promoting the satisfaction of basic needs and health can have an important impact on economic growth by unlocking the potential of the poor population. From the historical point of view, the replacement of physical with human capital accumulation can be shown to generate an inverted U Kuznets (1955) curve for the distribution of income, in the presence of credit constraints that slow the accumulation of human capital by the poor (Galor, 2000). Our model implies a) that poor health may play an important causal role in this process, by invigorating the credit constraint, making the acquisition of education more difficult, and lowering its rate of return, and b) that long-term distribution changes will also be reflected in the distribution of health itself. As mentioned before, Dora and Steckel (1997) and Lee (1991) show that the health distribution did in fact follow a Kuznets curve in the U.S. and Great Britain respectively, and Dora (1998) shows, further, that there was an intergenerational transmission of health inequality. The full extent to which health has contributed to the intergenerational transmission of wealth and to the persistence of inequality remain to be investigated.

It is remarkable that the prediction of a bimodal health distribution actually holds at the cross-country level for life expectancy. Figures 1 and 2 show the histograms of life expectancy for 159 countries in 1962 and 1997. These are clearly twin-peaked, although the size of the lower peak was considerably reduced in the period. The distributions are consistent with the presence of health-related poverty traps, and with convergence clubs (Mayer, 2002b). Disparities in wealth are numerically much larger than disparities in life expectancy. Thus per-capita income could mainly reflect the income of the skilled and the rich, capital owning, population. This may explain why a bimodal cross-country distribution is observed in health but not in income per capita. However, a long-term tendency towards the stratification of income at the cross-country level has been noted for the period 1961-1988 (Quah, 1997). Our model provides an important mechanism through which the initial health disparities already present in 1960 (see Figure 1) could have generated the subsequent income stratification, in an environment in which the premium to education increased and skills became ever more important as sources of both income and technological change.

Consistently with the model's implications, the descriptive data in Table 1 show a divergent pattern of economic growth between countries at different levels of health for the periods 1960-1980 and 1980-1998, whose causes remain to be fully unravelled. The non-concave, threshold effect we propose implies that market forces on their own are insufficient to promote the optimal accumulation of human capital. Empirical studies may thus need to go beyond the usual concavity and convergence assumptions to fully understand the impact of health on economic growth. Such empirical research will uncover the full extent to which non-concave health effects need to be taken into account in the formulation of policy for health, education and economic growth for the poor.

The next two sections contain the economic model and the conclusions of the paper.

2. The model

We consider an overlapping generations economy in which the inputs of production are capital and effective units of labor. Aggregate output Y is given by aggregate capital K and aggregate effective labor H (human capital) according to

$$Y = F(K, H), \tag{2.1}$$

where F is a neoclassical production function. The effective units of labor that each person commands will depend on her health and education. Let $y = Y/H$,

$k = K/H$ be output and capital per effective unit of labor, so that

$$y = f(k). \tag{2.2}$$

Here $f(k) = F(K/H, 1)$. We shall suppose that the economy is small and open, so that the interest rate r is fixed. Since $r = f'(k)$, it follows that k and w, the salary per effective unit of labor, are fixed at levels given by

$$k = f'^{-1}(r), w = f(k) - kf'(k). \tag{2.3}$$

Even though F is homogenous of degree one, we assume that there are decreasing returns to investment in human capital, so that in fact the economy does not sustain growth.

We now describe the household decisions. Each generation lives for two periods. In the first period of life (childhood) a person born at time t receives a bequest b_t from his parent and decides how much to spend on basic needs and health v_t (vitality), and whether to invest resources e_t on an education or to work as an unskilled laborer.[7] Prior to the application of any government policies, these

[7] It is perfectly consistent to think that some of the inheritance b_t is actually transmitted in the form of health v_t.

expenditures are subject to a credit restriction

$$0 \leq h_t + e_t \leq b_t. \tag{2.4}$$

In the second period of life (adulthood) each person will work, earn, and decideon consumption and bequest levels c_{t+1}, b_{t+1}.

Health and unskilled work

Second period health is a function of expenditures h_t on basic needs and health, including such consumption items as food, clothing, shelter, as well as specifically medical expenses, preventive or otherwise. Health, in turn, affects future productivity and longevity. In the case when the choice is unskilled work, we shall suppose that, once all of the effects of health are taken into account, second-period efficiency units (including a factor for the duration of the working life) take the form

$$E_L(h_t) = A_L h_t^{\xi}, \tag{2.5}$$

where $0 < \xi < 1$ is the elasticity of efficiency with respect to expenditure in health and basic needs. The subscript 'L' stands for 'labor' or unskilled, while 'E' will stand for 'educated' or skilled. Thus there are decreasing returns to health through productivity and longevity. If the child chooses unskilled work and does not invest in education, $e_t = 0$ and her second period income y_{t+1} is given by

$$y_L = \max_{h_t} \left[wE_L(h_t) + (b_t - h_t)(1+r) \right], \tag{2.6}$$

where $b_t - h_t$ is the portion of the bequest that is saved. In view of credit restriction (2.4), this income is

$$y_{L,t+1}(b_t) = \begin{cases} wA_L b_t^{\xi} & b_t \leq \tilde{b}_L, \\ y_L^0 + b_t(1+r) & b_t \geq \tilde{b}_L. \end{cases} \tag{2.7}$$

where the intercept

$$y_L^0 = (1-\xi)(w\xi^{\xi} A_L)^{\frac{1}{1-\xi}} (1+r)^{-\frac{\xi}{1-\xi}}. \tag{2.8}$$

Second period income is a concave function of bequests so long as these lie below the optimal level of investment in health for pursuing unskilled work, $\tilde{b}_L = \tilde{h}_L$, where

$$\tilde{h}_L = \left[\frac{w\xi A_L}{1+r} \right]^{\frac{1}{1-\xi}}.$$

Any bequests above this level are saved, yielding a linear portion of second period income, whose intercept is the gains of investment in health y_L^0 (see Figure 3).

Health and skilled work

Health has an additional set of effects in the case when the child decides to acquire an education. When basic and health needs are satisfied at too low a level, the productivity of education is too low to give any returns. In effect, a minimum level of health is required to successfully embark on a career as a skilled worker. Also, the effect of longevity is greater in the case of education, because it has an impact on the time available for training. This implies that the returns to education are more than proportional to longevity. Therefore the returns to expenditures on health are greater than in the unskilled case. We shall assume, keeping to simple functions as before, that second-period efficiency units (including a factor for the duration of the working life) take the form

$$E_E(h_t, e_t) = A_E(h_t - h_0)^\eta e_t^\varepsilon. \tag{2.9}$$

h_0 is the health threshold that is necessary to embark on an education. We assume that health and education have diminishing returns to health and education both singly and jointly, so $0 < \eta,\ \varepsilon,\ \eta + \varepsilon < 1$. Thus second-period income will be

$$y_{E,t+1} = \max_{h_t, e_t} \left[w E_E(h_t, e_t) + (b_t - h_t - e_t)(1 + r) \right], \tag{2.10}$$

where now $b_t - h_t - e_t$ is the portion of the bequest that is saved. In view of the credit restriction (2.4), the maximized income is

$$y_{E,t+1}(b_t) = \begin{cases} 0 & 0 \le b_t \le h_0, \\ w A_E \frac{\eta^\eta \varepsilon^\varepsilon}{(\eta+\varepsilon)^{\eta+\varepsilon}} (b_t - h_0)^{\eta+\varepsilon} & h_0 \le b_t \le \tilde{b}_E, \\ y_E^0 + b_t(1+r) & b_t \ge \tilde{b}_E. \end{cases} \tag{2.11}$$

where

$$y_E^0 = \left((1 - \eta - \varepsilon) \left[\frac{w \eta^\eta \varepsilon^\varepsilon A_E}{1 + r} \right]^{\frac{1}{1-\eta-\varepsilon}} - h_0 \right) (1 + r). \tag{2.12}$$

Above the threshold level of investment in health h_0, second period income is a concave function of bequests so long as bequests can pay for the threshold level of health h_0 but are insufficient to fund the optimal level $\tilde{b}_E = \tilde{h}_E + \tilde{e}_E$ of investment in health and education for pursuing skilled work, where

$$\tilde{h}_E = h_0 + \left[\frac{w \eta^{1-\varepsilon} \varepsilon^\varepsilon A_E}{1 + r} \right]^{\frac{1}{1-\eta-\varepsilon}}, \tag{2.13}$$

$$\tilde{e}_E = \left[\frac{w\eta^\eta \varepsilon^{1-\eta} A_E}{1+r}\right]^{\frac{1}{1-\eta-\varepsilon}}. \tag{2.14}$$

Any bequests above $\tilde{b}_E$ are saved, yielding the linear portion of second period income, whose intercept is y_E^0, the gains of investment to health and education.

The choice between skilled and unskilled work

We assume that any person whose bequest is large enough to invest the optimal amounts in health and education will prefer skilled to unskilled work. In other words, we suppose that $y_E(b_t) > y_L(b_t)$ for large enough b_t, a condition which is equivalent to

$$y_E^0 > y_L^0. \tag{2.15}$$

This states that the gains to investment in health and education to perform skilled work are larger than the gains to investment in health for performing unskilled work. Note that for bequests below h_0, investment in education is futile, so $y_L(b) > y_E(b) = 0$ for $b \leq h_0$. Hence there is some switching value $\hat{b} > h_0$ at which the second period incomes are equal,

$$y_E(\hat{b}) = y_L(\hat{b}). \tag{2.16}$$

We assume for simplicity that $\hat{b}$ is unique. This is the economically relevant case and is almost always the case for the functions we have chosen. Then we have the following Proposition (see Figure 3).

Proposition 2.1. *Given a bequest* b_t*, the child chooses to perform unskilled work in the second period if* $b_t \leq \hat{b}$ *and skilled work if* $b_t \geq \hat{b}$*. In the first case the amount* $\min\{\tilde{b}_L, b_t\}$ *will be invested in health, while in the second case the amount* $\min\{\tilde{b}_E, b_t\}$ *will be invested in health and education,* h_0 *being dedicated to health and the remaining amount being allocated between health and education according to* $\frac{e_t}{h_t - h_0} = \frac{\varepsilon}{\eta}$*. Any remaining resources will be saved.*

Preferences

In the second period a person divides her wealth between her personal consumption c_{t+1} and her bequest b_{t+1} to a single child, maximizing the utility function

$$u_{t+1} = c_{t+1}^{\gamma} b_{t+1}^{1-\gamma}. \tag{2.17}$$

The budget restriction is

$$c_{t+1} + b_{t+1} \leq y_{t+1}(b_t) = \max\{y_{L,t+1}(b_t), y_{E,t+1}(b_t)\}, \tag{2.18}$$

where $y(b_t)$ is second period income. Skilled or unskilled work is chosen so as to maximize income, because this will maximize utility. The Cobb-Douglass preferences imply the proportional allocation

$$c_{t+1} = \gamma y_{t+1}(b_t), \tag{2.19}$$

$$b_{t+1} = (1-\gamma) y_{t+1}(b_t). \tag{2.20}$$

Hence the resulting indirect utility is given by

$$u_{t+1} = \varkappa y_{t+1}(b_t). \tag{2.21}$$

where $\varkappa = \gamma^{\gamma}(1-\gamma)^{(1-\gamma)}$. Equation (2.20) for b_{t+1}, yields a dynamical system for bequests from which the dynamics of the remaining variables follow.

Bequest dynamics under the full credit constraint

We shall assume that the bequest dynamics that we are describing lead to stable equilibria. For this we need the condition

$$(1-\gamma)(1+r) < 1, \tag{2.22}$$

Otherwise what will be observed is permanent income growth through saving, independently of whether skilled or unskilled labor is chosen.

The bequest dynamics may have one equilibrium, which may be skilled or unskilled, or two equilibria, one of each. We shall assume that there exists a viable stable skilled equilibrium, in other words, some bequest level b_E^* for which.

$$b_E^* = (1-\gamma)y_E(b_E^*) \tag{2.23}$$

and $(1-\gamma)y_E'(b_E^*) < 1$, so that children choosing education leave their own children the same bequest.[8] There always exists a bequest level b_L^* when unskilled wages are too low for families to provide their children with these minimum levels of well-being, and these cannot be financed, at which the analogous statement holds for unskilled labor,

$$b_L^* = (1-\gamma)y_L(b_L^*). \tag{2.24}$$

We have the following Proposition (see Figure 4).

Proposition 2.2. *Suppose that unskilled and skilled labor equilibrium bequest*

[8] Generically, if the curve $(1-\gamma)z_E(b_t)$ intersects the 45° line it does so twice. The condition on the derivative excludes the non-generic case and also selects the stable equilibrium.

levels b_L^*, b_E^* *exist according to the definitions above, and that*

$$b_L^* < \hat{b} < b_E^*, \tag{2.25}$$

so that unskilled work is prefered at b_L^*, *while skilled work is prefered at* b_E^*. *Then the dynamical system (2.19) has two equilibria,* b_L^* *and* b_E^*. *At* b_L^*, *unskilled labor is chosen, no expenditure takes place on education, and expenditure on health is*

$$h_L^* = \min\{b_L^*, \tilde{h}_L\}. \tag{2.26}$$

At b_E^*, *skilled work is chosen. The equilibrium investments on health and education*

$$h_E^* = \min\{h_0 + \frac{\eta}{\eta+\varepsilon}(b_E^* - h_0), \tilde{h}_E\}, \tag{2.27}$$

$$e_E^* = \min\{\frac{\varepsilon}{\eta+\varepsilon}(b_E^* - h_0), \tilde{e}_E\}, \tag{2.28}$$

may be suboptimal, because of the credit restriction, in which case they will take up the full bequest. Bequests, expenditures on health and education, and second period income, are all less at the unskilled than at the skilled equilibrium.

It is worth noting that the returns to investment in health are locally concave at each equilibrium. Thus for example a regression performed on the income of a sample of countries or individuals located at one or at both equilibria, including some measure of health and its square as independent variables, would detect decreasing returns to health, even after taking account of endogeneity, as in Gyimah-Brempong and Wilson (1999). Detecting the threshold effects requires specific econometric methods.

Policies lifting the credit restriction

What happens if the credit restriction is partially lifted and an educational credit (EC) becomes available? The credit restriction now takes the form

$$0 \leq h_t \leq b_t \tag{2.29}$$

instead of (2.4). Maximization (2.10) therefore yields the following second period income for skilled work.

$$y_{E,t+1}^{EC}(b_t) = \begin{cases} 0 & 0 \leq b_t \leq h_0, \\ (1-\varepsilon)(\frac{\varepsilon}{1+r})^{\frac{\varepsilon}{1-\varepsilon}} \left[w A_E (h_t - h_0)^{\eta} \right]^{\frac{1}{1-\varepsilon}} & h_0 \leq b_t \leq \tilde{h}_E, \\ y_E^0 + b_t(1+r) & b_t \geq \tilde{b}_E. \end{cases} \tag{2.30}$$

The shape of $y_{E,t+1}^{EC}(b_t)$ is very similar to that of $y_{E,t+1}(b_t)$. It is zero below $b_t = h_0$

and rises as a concave function to reach the same linear function but somewhat sooner, at $b_t = \tilde{h}_E$ rather than $b_t = \tilde{h}_E + \tilde{e}_E$, because now $\tilde{e}_E$ can be borrowed. There is some new value $\hat{b}^{EC}$ between h_0 and $\hat{b}$ at which unskilled and skilled incomes are equal,

$$y^{EC}_{E,t+1}(\hat{b}^{EC}) = y_{L,t+1}(\hat{b}^{EC}). \tag{2.31}$$

We shall assume that in the presence of these constraints there exists a viable stable skilled equilibrium, whose existence may or not depend on the presence of the credits for education. In other words, some equilibrium bequest b^{EC}_E exists for which

$$b^{EC}_E = (1-\gamma)y^{EC}_{E,t+1}(b^{EC}_E) \tag{2.32}$$

and $(1-\gamma)y^{EC\prime}_E(b^{EC}_E) < 1$. A sufficient condition for the existence of this equilibrium is the existence of such an equilibrium b^*_E in the absence of educational credits.

If instead the credit restriction is lifted fully, then the full credit (FC) second period incomes are

$$y^{FC}_E(b_t) = y^0_E + b_t(1+r), \tag{2.33}$$

$$y^{FC}_L(b_t) = y^0_L + b_t(1+r). \tag{2.34}$$

In this case we let b^{FC} be the full credit equilibrium, defined by the intersection of $(1-\gamma)y_E^{FC}(b_t)$ with the 45° line,

$$b^{FC} = \frac{1-\gamma}{1-(1-\gamma)(1+r)} y_E^0. \tag{2.35}$$

The following Proposition describes the equilibria that hold when the credit restriction is partially or fully lifted (see Figure 5).

Proposition 2.3. *Suppose that the skilled equilibrium b^{FC} exists and that the unskilled equilibrium b_L^* satisfies*

$$b_L^* < \hat{b}^{EC}. \tag{2.36}$$

1) If credit becomes available for education but not health and there exists a skilled equilibrium b_E^{EC}, then the dynamical system (2.19) has two equilibria, b_E^{EC} and b_L^*, corresponding to skilled and unskilled work. At b_E^{EC}, skilled work is chosen. The equilibrium expenditures on health is

$$h_E^{EC} = \min\{b_E^{EC}, \tilde{h}_E\}, \tag{2.37}$$

which is suboptimal if $b_E^{EC} < \tilde{h}_E$. The equilibrium expense on education is

$$e_E^{EC} = \left[\frac{\varepsilon w A_E (h_E^{EC} - h_0)^\eta}{1+r} \right]^{\frac{1}{1-\varepsilon}}, \tag{2.38}$$

a second best equilibrium in which investment in education is optimal given the investment in health. Bequests, expenditures on health and education, and second period income, are greater than at the skilled equilibrium b_E^* if this exists.

2) If the credit restriction is fully relaxed, the skilled equilibrium b^{FC} becomes the unique equilibrium. The levels of investment on health and education are the optimal levels

$$h_E^{FC} = \tilde{h}_E, \tag{2.39}$$

$$e_E^{FC} = \tilde{e}_E. \tag{2.40}$$

3. Conclusions

We have given evidence that there are minimum levels of well-being and health below which the young cannot aspire to become skilled. When unskilled wages are too low for families to provide their children with these minimum levels of well-being, and these cannot be financed, a poverty trap exists in which the poor remain unskilled. In this situation, it may well happen that finance for education is not enough to break the cycle of poverty, and that provision must also be made for the satisfaction of basic needs and health. Even when people can choose to be skilled, and even when finance is available for education, financial restrictions for investment in health and well-being can lead to suboptimal levels of human capital investment in health and education.

It is worth noting that different threshold levels may exist for different levels of education. Although we have mainly discussed basic needs and basic education, it is probable that some higher minimum threshold of well-being and health is needed to meet the cognitive and other requirements of a higher education. Thus even an economy in which people have access to basic education may be trapped away from acquiring a full complement of professional level skills, an ever more pressing requirement of economic growth.

The credit constraints, or the lack of financing that exists for the satisfaction of basic needs and health are even more binding than those which exist for education, since they involve basic consumption. This, together with the critical role that health plays in the formation of human capital, strengthens the credit constraint explanation for the effects of distribution on economic growth. The close connection between basic consumption and investment in human capital implies that this market failure may only be dissolvable through direct public policy interventions.

Consistently with the predictions of our model, the cross-country distribution of life expectancy is twin-peaked. Thus the phenomenon we point to may operate on a widespread scale. Studies of the impact of children's health on income and economic growth must specificallly take into account the possibility of multiple equilibria, and explore whether health and nutrition are amongst the channels through which wealth —or poverty— are transmitted accross generations.

The link between health and education implies that a low level of satisfaction of basic needs can lead through its impact on education and skill acquisition to persistent income inequality. Thus health may play a causal role in the persistence of poverty and in secular changes in inequality. Conversely, the same link contributes to explain the important and long-term impact that health improvements have on economic growth. Nutrition and health are factors enabling the formation of skills which are essential both to productivity and technical change.

To achieve optimal human capital investment, policies promoting education must be carefully complemented with policies promoting the satisfaction of basic needs and health.

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Life Expectancy Histograms for a Sample of 101 Countries

Figure 1. 1960

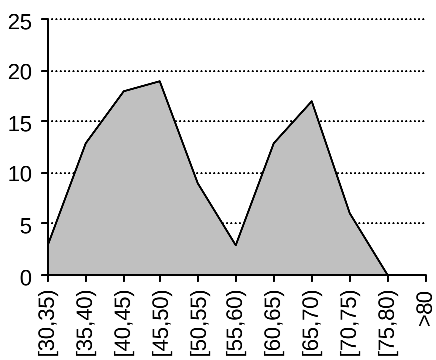

Figure 2. 1997

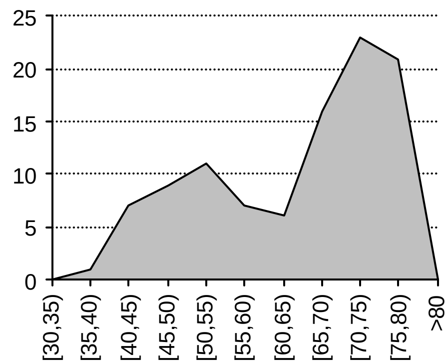

Table 1. Average Annual Economic Growth Rate According to Initial Life Expectancy Category

Initial Life Expectancy	[30, 40)	[40, 50)	[50, 60)	[60, 70)	[70, 80)
1960-1980 % Average Annual Growth	0.43	2.55	3.43	3.46	3.19
1960-1980 Observations	17	41	14	30	8
1980-1998 % Average Annual Growth	-2.21	-0.45	0.33	0.81	2.03
1980-1998 Observations	2	22	22	21	27

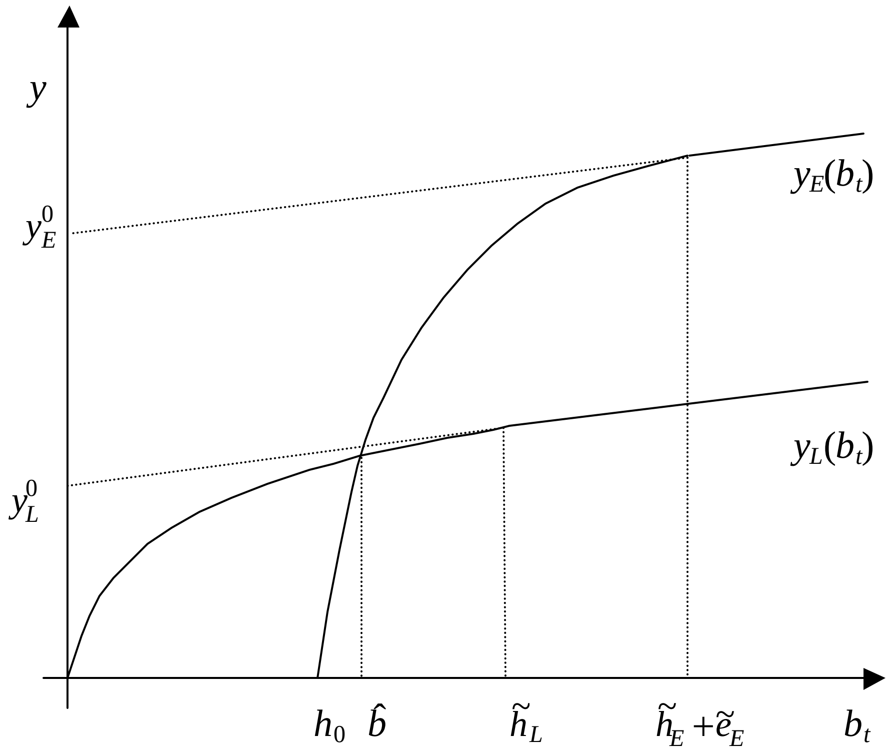

Figure 3. Second period income as a function of bequests.

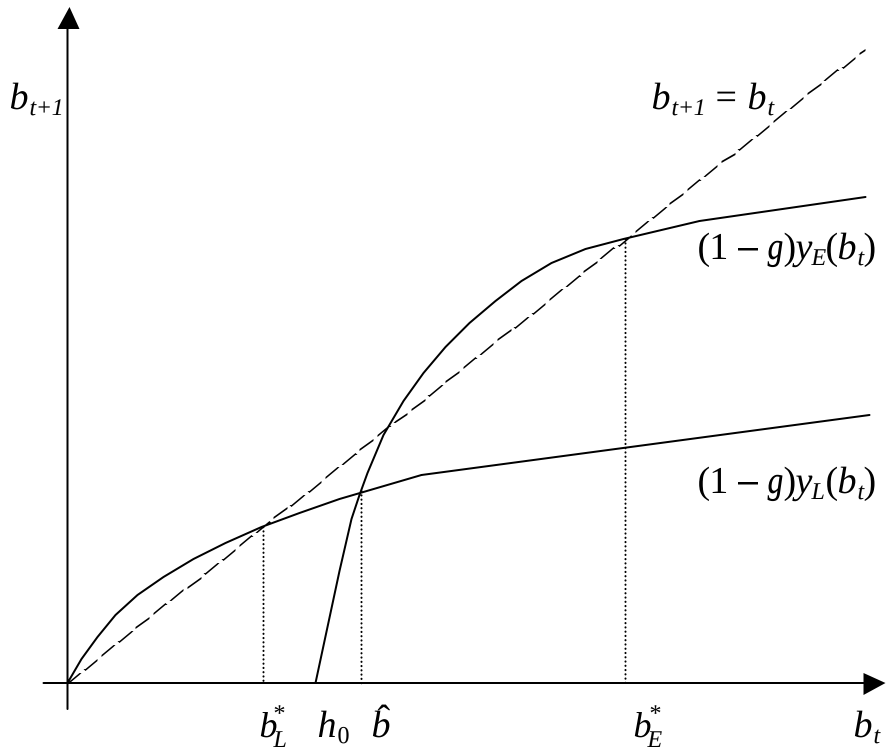

Figure 4. Multiple equilibria in the bequest dynamics.

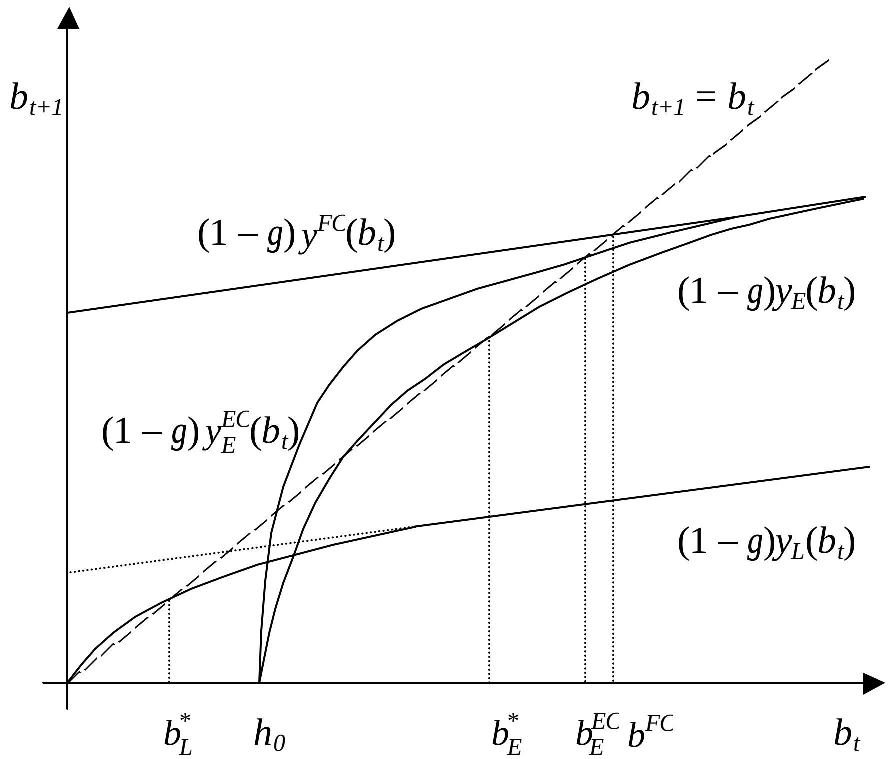

Figure 5. Example of multiple equilibria b_L^*, b_E^{EC} under a policy lifting the credit restriction through educational credit (EC) only. In this case a skilled equilibrium b_E^* exists without credit, although this need not be the case. The full credit (FC) equilibrium is b^{FC}.

More information on this and other papers related
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