Human capital and fertility: child vs adult survival

September 1, 2016

Abstract

In this paper, we investigate the impact of child and adult survival on human capital accumulation and fertility in a model in which parents face a trade-off between investment in education and child labour. We find that increases in adult longevity always have a positive effect on human capital accumulation. By contrast, the impact of child mortality depends on the initial levels of income; negative at low levels and positive when income is sufficiently high. At low levels of income, indeed, the rise in child survival by increasing the monetary returns of child labour, renders quantity more attractive than quality.

Keywords: Human capital accumulation, Child Labour, Fertility, Adult survival and child mortality.


1 Introduction

The theoretical literature on mortality and human capital accumulation has, in the main, either examined the impact of life expectancy, adult mortality and child mortality in distinct ways or it has treated these measures as interchangeable.

In particular, the literature focusing on the impact of life expectancy and adult survival on human capital accumulation is based on the argument, dating back to Ben-Porath (1967), that improvements in longevity promote human capital accumulation “because they increase the horizon over which benefits from investments in human capital can be enjoyed, therefore increasing the returns to education. This eventually raises educational attainment and increases the productivity of individuals in the labor market and in the household sector ” (Soares, 2005, p.581). In other words, higher longevity reduces the rate of depreciation of investment in education and increases its return (see, for example, De la Croix and Licandro, 1999, Boucekkine

On the other hand, the literature studying the link between child mortality and human capital accumulation is based on the quantity-quality trade-off. Kalemli-Ozcan (2003, 2008), for example, argues that in the presence of uncertain mortality, there is a precautionary demand for children so as to ensure a certain number of surviving children. Thus, lower child mortality decreases the uncertainty regarding the number of surviving children which, in turn, leads to a reduction in the demand for children and to an increase in educational investment.

However, Doepke (2005) and Azarnert (2006) show that lower child mortality may actually lead to a decrease in educational investment because it renders it more expensive to educate all surviving children. In other words a substitution effect occurs: as child mortality decreases, net fertility rises and investment in the human capital of each child decreases.  

Finally, Strulik (2003, 2004) shows that, when mortality is high (and there is no investment in education) the relationship between child mortality and fertility is negative and positive when the opposite is the case.

This paper is closer in thinking to Soares (2005) which is the only exception, to the best of our knowledge, that considers both the effect of child and adult survival on human capital accumulation and finds a positive effect. However, contrary to Soares (2005), we introduce child labour, whereby, in making education choices for their children, parents face the trade-off between human capital accumulation and child labour. The presence of child labour crucially affects the results, leading to a non-linear impact of child mortality on human capital accumulation. In fact, we find that while a rise in adult longevity always has a positive impact on human capital accumulation, the effect of child mortality reduction depends on the initial level of income. At the lowest levels of income, where parents choose zero or a very low level of education for their children, a decrease in child survival, increasing the monetary returns on children renders quantity more attractive than quality. In contrast, at a high level of income, the amount invested in education is sufficiently high to lead to an increase in the cost of having children as child survival increases. This leads parents to choose to have fewer children and therefore quality becomes more important than quantity.

Thus while gains in adult longevity always trigger the transition from an equilibrium without investments in human capital to an equilibrium with full investments in human capital, the impact of child survival, however, depends on the level of development. At low levels of development a rise in child survival, ceteris paribus, can affect negatively the investment in

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1Doepke (2005), analyzing England during the period 1861 – 1951, shows that, all things being equal, the reduction in child mortality should have lead to an increase in net fertility rates.
This paper is organised as follows: Section 2 presents the model; Section 3 analyzes the impact of adult and child survival on the dynamics of human capital; Section 4 concludes.

2 The Model

In every period, the economy produces a single material good, the price of which is normalised to 1. Production is conducted using both children who supply unskilled labour, i.e. $L^c_t$, and adults who supply skilled labour, i.e. $L_t h_t$, where $h_t$ is the human capital level. For simplicity, we propose a linear production function:

$$Y_t = w(\theta L^c_t + L_t h_t),$$

where $\theta < 1$ is the efficiency of child labour relative to adult labour and $w$ is the technological parameter which is assumed equal to unity.

Agents live for two periods: childhood and adulthood. All decisions are made in the adult period of life. Each agent, at time $t$, has an endowed level of human capital $h_t$, determined from previous generations decisions. Parents have $n_t$ children who face a probability of dying during early childhood before any investment in their education has taken place, i.e. $1 - \pi$. Each surviving child becomes, in turn, an adult who has a probability of dying during adulthood, i.e. $1 - p$.

Child and adult mortality are assumed to be exogenous, in agreement with an extensive literature in this area (see, among others, Preston, 1975; Easterlin, 2004; Livi Bacci, 2007 and Cutler et al., 2006).²

Adults derive utility from consumption, the number of children, i.e. quantity of children, and the income of surviving children in adulthood, $h_{t+1}$, i.e. the quality of children. The utility function of parents is therefore given by:

$$U_t = (1 - \beta) \log(c_t) + \beta[\log(n_t) + \pi p \log(h_{t+1})],$$

where, in agreement with Soares (2005), we assume that the effective discount rate applied to children’s human capital is endogenous and depends, in a linear way, on child and adult survival.

²In particular, these authors argue that income is not the sole factor affecting mortality. There are other contributing factors exogenous to the country’s level of income, such as the diffusion of health technology and new methods of preventing the transmission of disease. These include clean water supply and education in personal hygiene. For a detailed discussion of the literature on exogenous mortality see Fiaschi and Fioroni (2014).
probability. This implies that parents care not only about child mortality but also about the life expectancy that each child will enjoy as an adult, that is, the period during which they can take full advantage from the benefits of the investment in human capital (see Soares, 2005).

Parents allocate their income \( h_t \) across consumption \( c_t \), child rearing and education spending per child \( e_t \). In particular, raising each born child takes a fraction \( z \in (0, 1) \) of an adult’s income.\(^3\)

Parents choose the allocation of the time endowment of children between schooling \( e_t \in [0, 1] \) and labour force participation \( (1 - e_t) \in [0, 1] \) once child mortality has been realised (see for example Azarnert, 2006; Strulik, 2004; Kalemli-Ozcan, 2002).\(^4\) The direct education cost per child is indicated by \( d \).\(^5\) Thus the total cost of education, i.e. \( \theta + d \), is given by the opportunity cost that is the foregone earnings of the child and the direct cost of schooling. We assume that children do not consume. Parents face, therefore, the following budget constraints:

\[
\begin{align*}
  c_t &= h_t(1 - zn_t) + \theta \pi n_t(1 - e_t) - de_t \pi n_t, \\
  e_t &\in [0, 1], \\
  n_t &< \frac{1}{z}.
\end{align*}
\]

subject to the inequality constraints \( 0 \leq e_t \leq 1 \) and \( 0 < n_t \leq \frac{1}{z} \).

To ensure that parents have a finite number of children the net cost of children should be positive:

**Assumption 1**

\[
zh_t - \theta(1 - e_t)\pi + de_t \pi > 0,
\]

which imposes a lower bound on income, that is \( h_t > \theta \pi / z = h_{\text{MIN}} \).

Human capital of children \( h_{t+1} \) is an increasing, strictly concave function of the time devoted to school, that is:

\[
h_{t+1} = (b + e_t)^\gamma,
\]

where \( b \geq 0 \) and \( \gamma \in (0, 1) \). The presence of \( b \) implies that children are born with some basic human capital which can be increased by schooling (see for example Hazan and Berdugo, 2002).

Under assumption 1 the first order conditions for an interior solution are:

\[
\begin{align*}
\frac{(1 - \beta)}{c_t} [zh_t - \theta \pi + e_t \pi (\theta + d)] &= \frac{\beta}{n_t}, \\
\frac{(1 - \beta)}{c_t} \pi n_t (\theta + d) &= \frac{\beta \gamma \pi p}{b + e_t}.
\end{align*}
\]

\(^3\)Including the assumption that surviving children require an additional fraction of adult time does not change the main results of the paper.

\(^4\)We assume that survival from school age to adulthood is certain.

\(^5\)This cost could be given by the average human capital of teachers as in De la Croix and Doepke (2004) and Doepke (2004).
Equation (6) states that to maximize utility parents choose the number of children in such a way that the net marginal cost of an additional child, in terms of the loss of utility of consumption, equals the marginal benefit. In the same way, equation (7) shows that parents maximize their utility when the marginal cost of educating children equals the marginal benefit from the expected higher income of their children.

Equation (7) shows that there is a distinct difference in the way in which child and adult survival affect the educational optimal choice. Indeed, on the one hand, child survival positively affects both the marginal cost of education (since education choice concerns only surviving children) and the marginal utility from education (since higher child survival reduces the risk of investment in education). On the other hand, adult longevity has a positive impact only on the marginal utility of children’s human capital but it does not affect the marginal cost of education. This difference, as shown below, crucially affects the impact of child and adult survival on the dynamics of human capital accumulation.

Equations (6) and (7) can be explicitly solved for optimal fertility and education:

\[
 n_t = \frac{\beta h_t (1 - p\gamma\pi)}{z h_t - \theta\pi - b\pi(\theta + d)}, \tag{8}
\]

\[
e_t = \frac{p\gamma(z h_t - \theta\pi) - b(\theta + d)}{(\theta + d)(1 - p\gamma\pi)}. \tag{9}
\]

When income is sufficiently low, i.e. \( \hat{h} \leq h_t \leq \theta \pi z \rho = h_2 \), parents prefer their children to work, i.e. \( e_t = 0 \), and have a higher number of children, that is\(^6\):

\[
 n_t = \frac{\beta h_t}{z h_t - \theta\pi}. \tag{10}
\]

Finally when income is sufficiently high, i.e. \( h_t \geq \frac{\theta(1+b) + d(1-p\gamma\pi+b)}{z\rho\gamma} = h_3 \), children’s time is no longer allocated to sending them out to work, i.e. \( e_t = 1 \).

Let us first consider the effect of mortality reduction on parental optimal choices when parents do not invest in children’s education, i.e. \( h_t < h_2 \).

In this case an exogenous increase in adult survival probability lowers the threshold level \( h_2 \) at which parents start to invest in their children’s education. Indeed, the rise in adult longevity, by increasing the marginal benefit of the investment in children’s human capital, stimulates the investment in education even at lower income levels.

On the other hand, if child survival increases, the birth rate goes up and the threshold level of human capital \( h_2 \) increases. The reason for this is that when income is at its lowest level, we enter a vicious circle whereby an increase in child survival, by increasing the monetary returns

\(^6\)When \( h_{\text{min}} \leq h_t \leq \hat{h} = \frac{\theta\pi}{z(1-\gamma)} \) fertility reaches its upper bound, i.e. \( n_t = 1/z \).
of a child, lowers the cost of raising a child, i.e. \( z h_t - \theta \pi \), rendering a higher number of children relatively more desirable because of the presence of child labour which generates a potential increase in household income. In fact, if child labour were absent from the model, i.e. \( \theta = 0 \) (see Doepke and Zilibotti, 2005), as is evident from equation (10), the optimal number of children would not be affected by a reduction in child mortality.

At the interior solution, where \( h_2 < h_t < h_3 \), an increase in adult survival implies a reduction of fertility and child labour supply. Indeed, the increase in adult longevity increases the benefits of investing in education and thereby leads parents to choose fewer yet better educated children.

On the other hand, a decrease in child mortality has a nonlinear effect on parental optimal choices. In particular, there exists a threshold level of \( h_t \), i.e. \( h = \frac{\theta (1 + b) + db}{z \rho \gamma} \), such that if \( h_2 < h_t < h \) a rise in child survival negatively affects the investment in education.\(^7\)

The basic motivation behind this result is that when \( e_t > 0 \), the rise in child survival has two opposite effects on the net cost of having children. On the one hand, it has a negative effect because it increases the monetary returns of child labour. On the other hand, it has a positive effect because it increases the total cost of education. Thus, when the investment in education is sufficiently low, the first effect dominates the second, leading to an increase in both child labour supply and fertility. At this low level of income quantity is more essential than quality. In other words, the more numerous the children the higher the contribution to family income becomes and therefore parents increase child labour supply jointly with fertility. When income reaches a certain threshold, i.e. \( h_t > h \), the investment in the education of children is high enough to lead to an increase in the cost of having skilled children as child survival rises. Therefore parents choose to have fewer children and quality becomes more important than quantity.

Notice that if it were not for the presence of child labour this nonlinear effect would not exist. Indeed in the absence of child labour, that is \( \theta = 0 \), as can be seen from equation (9), an increase in child survival always leads to an increase in children’s education.

\(^7\)Simple calculations show that \( h_2 < h < h_3 \).
2.1 The dynamics of human capital

Figure 1: Adult versus child mortality and human capital accumulation

\[
\begin{align*}
h_{t+1} &= \begin{cases} 
  b^\gamma & \text{if } h_{\text{min}} \leq h_t \leq h_2, \\
  \left[ p\gamma(zh_t - \theta\pi) - p\gamma\pi(\theta + d)b \right]^{\gamma} / (\theta + d)(1 - p\gamma\pi) & \text{if } h_2 \leq h_t \leq h_3, \\
  (1 + b)^\gamma & \text{if } h_t \geq h_3;
\end{cases}
\end{align*}
\]

Fig.1 shows that different combinations of adult and child survival can lead to different scenarios.

When adult survival is sufficiently low, that is \( p < p_L = b(\theta + d) / \gamma(bz - \theta\pi) \), the economy shows a locally stable equilibrium with full-time child labour, and possibly one unstable and one stable equilibrium with \( 0 < e_t < 1 \). In this latter case, the initial level of human capital is fundamental as it establishes the features of the long-run equilibrium.

When adult survival is \( p_L < p < (\theta + d)(1 + b) / [z(1 + b) + ds] = p_H \), the economy shows one stable equilibrium where children are partially sent to school. \(^8\) Finally, when adult survival increases above the level \( p_H \) the economy always converges to the stable equilibrium \( h_H \) characterised by high income, low fertility rate and full investment in child quality.

In Fig. 1 we show some possible trajectories that an economy may follow.

\(^8\)We assume that \( bz > \theta \).
The points $J$, $S$, $K$ all illustrate the case of an economy with an initial low level of both adult and child survival but which then goes on to follow different paths.

The trajectory starting from point $J$ considers simultaneous improvements in adult and child survival rate, but with an overall prevalence of the advances in adult survival with respect to the ones in child survival rate. Along trajectory $J$ the economy transits from a zero to a full investment in education equilibrium.

Consider now an economy starting from point $S$ with both an increase in adult and child survival but with the increase in child survival higher than the increase in adult survival. In this case, however, the economy can stagnate in a low development trap. The negative effect on education, due to the increase in child survival, indeed, is only partially compensated by the positive effect due to the limited improvements in adult survival.

The trajectory starting from point $K$ considers the case of an economy characterised, in a first phase by the joint increase in adult and child survival which allows the transition from full-time child labour to partial school attendance. In a second phase, although child survival is still increasing, the decrease in adult survival pushes back the economy to a low equilibrium of stagnation.

Finally, the path starting from point $V$ shows an economy with relatively high initial adult and child survival, where the increase in child survival associated with a low improvement in adult survival may allow the transition from an equilibrium with partial work/school attendance to one with full investment in child education.

Policies aimed to reduce either the education cost ($d$), or to regulate child labour (i.e to decrease $\theta$), lower both $p_L$ and $p_H$ and favor, therefore, the transition to full investment in education even in the cases of the trajectories starting from points $K$ and $S$.

Although among developing countries there is considerable variation in the incidence of child labor and school attendance, the trajectories shown in Fig. 1 recall the path of adult and child survival followed by some developing countries.

In particular, Fig 2 illustrates the path of child and adult survival in selected developing countries during the period 1960 to 2010. Ethiopia (until 2000) and Nigeria, for example, are reminiscent of trajectory $S$. Both countries, in fact, in 2000 show a relatively low enrollment rate in primary education (40% in Ethiopia and 61% in Nigeria) and high child employment (56% in Ethiopia in 2005 and 41% in Nigeria in 2007$^9$).

Tanzania and the Central African Republic show a path similar to that described by the

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$^9$The data is not available for every year. The data are from World Development Indicators, 2015. As measure of primary enrollment rate we use the net enrollment rate that is the ratio of children of official school age who are enrolled in school to the population of the corresponding official school age.
trajectory starting from point $K$. In Tanzania the decreasing adult survival rate (from 0.62 in 1970 to 0.55 in 2000) combined with increasing child survival (from 0.78 in 1970 to 0.86 in 2000) is associated with the decrease in primary school enrollment (it starts to decline from 1980, in which it is about 70%, reaching 49% in 1999). The same occurs in the Central African Republic where the enrollment rate increases between 1970 and 1985 (from about 50% in 1970 to 61% in 1985) and then starts to decline reaching 49% in 2005. Moreover, both countries show a relatively high level of child labour in 2000 (40% in Tanzania and 67% in the Central African Republic) 10.

Benin, Guatemala and Nicaragua may represent an example of the trajectory from point $J$. Each of these countries, indeed, shows a considerable increase in the enrollment rate from the Seventies to 2010 (from about 50% to over 90%).

Finally, the path followed by Morocco can reflect trajectory $V$. Morocco, in 1970 shows a low school attendance (about 50%) and relatively high adult survival (0.70%). The increase in child survival, higher than that of adult survival (0.21 and 0.17 respectively), is associated to

10Fortson (2011) provides a detailed empirical analysis showing that areas with higher levels of HIV experienced relatively larger declines in schooling. He points out: “Children in areas with higher levels of HIV fare worse along a number of dimensions: they are less likely to attend school, less likely to complete primary school, and progress more slowly through school.”.
a large increase in school enrollment (reaching 93% in 2010).

3 Conclusions

This paper contributes to the literature by analyzing the different effects of adult and child survival on human capital accumulation and fertility in a model that takes into account the trade-off between investment in education and child labour.

We find that the relationship between investment in education and adult longevity is always positive. In contrast, the relationship between education and child survival can be negative at the lowest levels of income and positive when income is sufficiently high. The basic intuition behind this result is that the rise in child survival increases the monetary returns of child labour, thereby rendering, at the lowest levels of income, quantity more attractive than quality.

To sum up, our model suggests that policies aimed at increasing adult longevity can be an important contributing factor to the reduction of child labour (see, for example, Chakraborty and Das, 2005; Cipriani, 2015).

On the other hand, the rise in child survival alone at low levels of development may be insufficient in stimulating fertility reduction and full investment in education, if it is not associated to policies aimed at either reducing the cost of schooling or regulating child labour.
References


