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# Does Reduction in Child Mortality Repress Economic Growth?

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Abstract: The theoretical literature shows that an exogenous decrease in child mortality leads to a decline in education , and thus delays economic growth. By considering a deep parameter, which represents the nutritional and health status of children, we examine that a decline in child mortality is compatible with a rise in educational investment per capita. An improvement of the nutritional and health levels increases not only the survival rate of children but also marginal productivity of educational investment. When the nutrition and health level is sufficiently high, the latter effect dominates the former; the educational investment per capita increases with the decline in child mortality. Even if the effect on child mortality adversely dominates the effect on educational efficiency, it is possible that an improvement in nutrition and health promotes economic growth because the latter effect directly raises the economic growth rate. Moreover, the improvement in nutritional and health status reduces fertility through a rise in the efficiency of educational investment.

Keywords: Child mortality, Nutrition and health, Educational outcomes, Economic growth

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# 1 Introduction

In a seminal study of child mortality, Azarnert (2006), shows that the timing of mortality relative to education is crucial to economic growth. The study finds that if child mortality is realized before education starts, an exogenous reduction in child mortality leads to a decline in education.[1] Since the reduction of educational investment delays economic growth, this result implies that a decrease in child mortality is harmful for economic growth. This is not only morally inconvenient but also inconsistent with the facts of demographic transition.

Several studies attempt to overcome this theoretical result. Kalemli-Ozcan (2008) proposes a two-step model, wherein parents decide on their fertility before the uncertainty about child survival is realized, but they choose ex post investment only in the human capital of their surviving children. The model indicates a negative relationship between mortality and educational investment. Fioroni (2010) finds that under a private education system, an exogenous shock that lower child mortality are detrimental for economic growth due to a reduction in educational investment. On the other hand, under the public education regime, health improvement shocks are no longer detrimental for growth because the government decides on the level of educational investment. Although these studies are successful in avoiding inconsistent results by using convictive setups, several questions remain. First, the two-step model requires complex calculations; by using a simpler model, is it possible to provide an intuitive explanation why a decline in child mortality is compatible with the rise in educational investment? Second, even if the public education regime can avoid the inconvenient result, is a decrease in child mortality detrimental to economic growth in the private education regime?

In this paper, we provide an alternative explanation to why such an inconvenient equilibrium is scarcely observed in the real world. We consider that a cause of the result is the decreasing returns-to-scale technology for human capital formulation. An exogenous decline in child mortality increases the total educational spending in a household budget. As total educational spending consists of the number of surviving children's educational expenditure per capita, parents have an incentive to reduce either fertility or educational investment for each surviving child. If human capital is formulated by a concave technology, the reduction in education per capita increases the marginal productivity of education. Thus, an exogenous decline in child mortality leads to a decline in education per capita.[2]

Introducing a deep parameter such as the nutritional and health status of children, we focus on the relationship between an exogenous improvement in child mortality and a marginal productivity in educational investment. By an accumulation of knowledge of epidemiology, it is common sense that

[1] Azarnert mentions that if child mortality is realized after education starts, on the other hand, an exogenous decline in child mortality increases education and thus promotes economic growth. Developing this model by introducing an extra sub-period into the period of childhood, Hirota (2016) formally shows that the mortality decline after the school age promotes human capital accumulation.

[2] In Strulik (2004)'s model, which considers non-decreasing returns-to-scale technology, an improvement of child survival rate increases educational expenditure for each surviving child.

nutrition and health conclusively affect the child mortality rate.[3] Moreover, we focus on the empirical evidences of educational economics; a considerable amount of literature reports that improvement of the nutrition and health status of a child makes education more efficient. In a survey paper, Glewwe and Miguel (2008), conclude that despite the difficulties associated with omitted variable bias, attenuation bias, and differences in data comparison among studies, "most of the best recent studies using cross-sectional data, panel data, or data from randomized evaluations have found sizeable and statistically significant positive impacts of child health on education outcomes (p. 3602, l.28)." [4]

We propose a model that an improvement in the nutritional and health status increases both the survival rate and marginal productivity for human capital accumulation. While the first effect decreases educational investment for each survival child, the same as the literature, the second effect increases educational investment per capita. If the latter effect dominates the former, a decline in child mortality and a rise in educational investment are compatible through an improvement of the nutritional and health status. Moreover, as the second effect directly makes human capital formulation more efficient, economic growth is promoted with a decrease in child mortality.

The remainder of this paper is organized as follows. Section 2 provides a simple model. Section 3 presents the equilibrium and shows that a decline in child mortality and economic growth are consistent. Section 4 concludes.

## 2 The model

We consider an overlapping generations economy where time is denoted as $t = 0,1,2,\cdots$. The economy has a single homogenous good produced by a linear technology using human capital $h_t$ alone. The representative individual lives for two periods, namely childhood and adulthood, and the period of childhood consists of two sub-periods: early childhood and school age. In adulthood, the individual has one unit of time and allocates it to working and raising children. The parent faces the exogenous mortality risk of their children during the early childhood period. The survival rate of children is given by $\pi(\chi_t)$,

[3] UNICEF (2006) reports that, for example, "it is estimated that undernutrition contributes to the deaths of about 5.6 million children under the age of five (p.1, l.5)." Lopez (2004) concludes that undernutrition and micronutrient deficiencies caused about 6 million deaths in 2000, and suggests that at least half of all child deaths could be prevented if undernutrition and associated micronutrient disorders could be eliminated.

[4] With the accumulation of long-term data and the progress of social experiment, this is a burgeoning area of research and empirical evidences are rapidly accrued. For example, Maluccio et al. (2009) examine the effect of an early childhood nutritional intervention on adult educational outcomes by using a longitudinal survey from rural Guatemala and find that improving the nutrient intakes of very young children can have substantial, long term, educational consequences. Miguel and Kremer (2004) evaluate a Kenyan project in which school-based mass treatment with deworming drugs was randomly phased into the schools and show that treatment for parasitic worm infections can increases school attendance dramatically. Currie (2009) and Glewwe and Muralidharan (2016) also provide surveys in this field.

i.e., even if the parent has $n_t$ children, the number of survivors is $\pi(\chi_t)n_t$, and $\chi_t > 0$ represents the nutritional and health levels of society. We assume that $\pi'(\chi_t) > 0$, $\lim_{\chi_t \to 0} \pi(\chi_t) = 0$, and $\lim_{\chi_t \to \infty} \pi(\chi_t) = 1$.[5]

The representative individual has an altruistic motive for rearing children; he/she gains utility from the total income of children. The utility function of the altruistic individual born in the period $t-1$ is

$$U_t = \alpha \log c_t + (1-\alpha)\log \pi(\chi_t) n_t w h_{t+1}, \tag{1}$$

where $\alpha \in (0,1)$, $c_t$ is consumption in adulthood, $w$ is wage rate per efficiency unit of labor, and $h_{t+1}$ is the offspring's human capital, i.e., $wh_{t+1}$ is the future income of each surviving child. We ignore the consumption in childhood for simplicity. The individual's budget constraint is given by

$$(1 - zn_t)wh_t = c_t + \pi(\chi_t)n_t e_t, \tag{2}$$

where $z \in (0,1)$ is the fixed parental care time for every child born, and $e_t$ is the amount of educational investment for each surviving child in school age.

Human capital is formulated by educational investment. An individual born in period $t$ achieves human capital in the adulthood period according to the following function:

$$h_{t+1} = B e_t^{\beta(\chi_t)}, \tag{3}$$

where $B > 0$. Because of $\frac{\partial h_{t+1}}{\partial e_t}\frac{e_t}{h_{t+1}} = \beta(\chi_t)$, $\beta(\chi_t)$ implies the educational investment elasticity of human capital, and thus a high $\beta(\chi_t)$ implies that educational investment is more efficient. Following the empirical evidence mentioned in the introduction (Section 1), we assume that $\beta(\chi_t)$ depends on the nutritional and health status, and $\beta'(\chi_t) > 0$, $\lim_{\chi_t \to 0} \beta(\chi_t) = 0$ and $\lim_{\chi_t \to \infty} \beta(\chi_t) = 1$ are also assumed.

## 3 Equilibrium

The parent decides consumption $c_t$, fertility $n_t$, and educational investment $e_t$ by maximizing (1) subject to (2) and (3). By the optimization, we have

$$c_t = \alpha w h_t, \tag{4}$$

$$n_t = \frac{(1-\alpha)[1-\beta(\chi_t)]}{z}, \tag{5}$$

[5] Fioroni (2010) assumes that the child survival rate depends on the human capital level of parents; human capital is considered as a surrogate variable of the health conditions of children. In contrast, we directly assume that the survival rate is a function of the nutritional and health status.

$$e_t = \frac{\beta(\chi_t)zwh_t}{[1-\beta(\chi_t)]\pi(\chi_t)}. \quad (6)$$

First, we consider a benchmark case that the survival rate $\pi$ is independent of the nutritional and health status $\chi_t$. In this case, (6) directly yields the following result:

$$\frac{\partial e_t}{\partial \pi} = -\frac{\beta(\chi_t)zwh_t}{[1-\beta(\chi_t)]\pi^2} < 0. \quad (7)$$

**Proposition 1** Suppose that the survival probability $\pi$ does not depend on the nutritional and health status $\chi_t$. An exogenous increase in the survival probability has a negative effect on the educational investment $e_t$.

Essentially, this result is identical to Azarnert (2006); if child mortality is realized before education starts, an exogenous decrease in child mortality leads to a decline in education. The mechanism underlying our model is straightforward. An exogenous rise in $\pi$ increases the total amount of educational spending, which is shown by the second term on the right hand side of (2). The per capita child-raising cost is constant as $z$. Moreover, from (3) human capital is formulated by a decreasing returns-to-scale technology. The parent attempts to restrain educational costs by reducing educational investment per capita $e_t$ because the reduction of educational investment increases marginal productivity. Declining investment in education delays human capital accumulation; therefore, it may be concluded that a decline in child mortality is harmful for economic growth.

However, if the decline in child mortality stems from an improvement of the nutritional and health level $\chi_t$, the result of proposition 1 changes drastically. From (6), we have

$$\frac{\partial e_t}{\partial \chi_t} = \frac{\beta(\chi_t)zwh_t}{[1-\beta(\chi_t)]^2\pi(\chi_t)\chi_t}\left[\varepsilon_\beta - [1-\beta(\chi_t)]\varepsilon_\pi\right], \quad (8)$$

where $\varepsilon_\beta \equiv \frac{\partial\beta(\chi_t)}{\partial\chi_t}\frac{\chi_t}{\beta(\chi_t)}$ and $\varepsilon_\pi \equiv \frac{\partial\pi(\chi_t)}{\partial\chi_t}\frac{\chi_t}{\pi(\chi_t)}$. Assuming the following condition:

$$\varepsilon_\beta > [1-\beta(\chi_t)]\varepsilon_\pi, \quad (9)$$

we have the following proposition:

**Proposition 2** Suppose that (9) is valid. An improvement of the nutritional and health levels leads to both a rise in the survival rate of children $\pi(\chi_t)$ and an increase in the amount invested in the education for each surviving child, i.e., $\frac{\partial e_t}{\partial \chi_t} > 0$.

Proposition 2 claims that a decline in child mortality is compatible with a rise in educational investment. The rise in survival rate has a negative effect on educational investment as shown in Proposition 1. However, if marginal productivity increases with nutrition and health levels, education becomes a good investment for the parent. The effect on marginal productivity dominates the negative effect if (9) is satisfied.

If (9) is not valid, an improvement in nutrition and health adversely decreases educational investment. From (9), it occurs when $\beta(\chi_t)$ is small, the nutritional and health status of children is too poor to acquire sufficient educational outcomes. In this case, as education is not a good investment for parents, a small improvement in the nutritional and health status reduces education adversely. However, with a high level of nutrition and health, $\beta(\chi_t)$ closes to 1; therefore, (9) must hold. Thus, considerable improvement in the nutritional and health status could promote educational investment even in such an economy.[6]

Next, we focus on the effects of nutritional level on fertility. From (5), we have the following proposition:

**Proposition 3** Improving the nutritional and health level reduces fertility through a rise in the productivity for human capital formulation, i.e., $\dfrac{\partial n_t}{\partial \beta(\chi_t)} \dfrac{\partial \beta(\chi_t)}{\partial \chi_t} < 0$.

Fertility decreases with economic development due to the quantity-quality tradeoff, which is usually explained by a rise in the opportunity cost of child rearing. On the other hand, proposition 2 and 3 imply that the promotion of educational efficiency leads to the quantity-quality tradeoff.[7]

Finally, we consider the effect on economic growth. Substituting (3) into (6), we have $h_{t+1} = Be_t^{\beta(\chi_t)} = B\left[\dfrac{\beta(\chi_t)zw}{[1-\beta(\chi_t)]\pi(\chi_t)} h_t\right]^{\beta(\chi_t)}$. We define the gross growth rate per capita as $G_t = \dfrac{h_{t+1}}{h_t}$. Because $\dfrac{\partial G_t}{\partial \chi_t} = \dfrac{\partial h_{t+1}}{\partial \chi_t} h_t^{-1}$, we have

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[6] Kalemli-Ozcan (2008) proposes a convictive model in which parents decide on their fertility before the uncertainty is realized, but they choose to invest in human capital for only the surviving children. In this model, a negative relationship between mortality and educational investment is possible if $\beta$ closes to 1 leads to the negative relationship. In this sense, our condition, which is implied by (9), is consistent with Kalemli-Ozcan.

[7] The effect of the nutritional and health level on the number of survivors $\pi(\chi_t)n(\chi_t)$ is ambiguous because the rise in $\chi_t$ decreases $n(\chi_t)$, but increases $\pi(\chi_t)$.

$$\frac{\partial G_t}{\partial \chi_t} = G_t \left[ \frac{\partial \beta(\chi_t)}{\partial \chi_t} \log e_t + \frac{\beta(\chi_t)}{e(\chi_t)} \frac{\partial e_t}{\partial \chi_t} \right]. \tag{10}$$

The first term in (10) is the direct effect; an improvement of the nutritional level directly makes the productivity of human capital more efficient. The second term is the indirect effect through educational investment, which is ambiguous. However, from proposition 2, the indirect effect is also positive, if (9) holds. By using (6) and (8), (10) is rewritten as

$$\frac{\partial G_t}{\partial \chi_t} = \frac{\beta(\chi_t) G_t}{\chi_t} \left[ \{\log e_t + (1-\beta(\chi_t))^{-1}\} \varepsilon_\beta - \varepsilon_\pi \right]. \tag{11}$$

We have $\frac{\partial G_t}{\partial \chi_t} > 0$ if the following inequality holds:

$$\{\log e_t + (1-\beta(\chi_t))^{-1}\} \varepsilon_\beta > \varepsilon_\pi . \tag{12}$$

Obviously, (9) sufficiently implies (12). The results yield the following proposition:

**Proposition 4** Suppose that (12) is valid. An improvement of the nutritional and health status increases the economic growth rate per capita with a decrease in child mortality.

## 4 Conclusions

In the theoretical literature, a reduction of child mortality represses economic growth through a reduction in educational investment for each surviving child. Alternatively, by introducing a deep parameter such as the nutritional and health status, we can avoid the inconvenient result. Although an improvement in the nutrition and health level decreases educational investment, same as the literature, it also increases the marginal productivity of educational investment. If the latter effect dominates the former, a decline in child mortality and an increase in educational investment per capita are compatible. Moreover, the latter effect directly promotes economic growth, and the decrease in child mortality will accelerate economy development.

Our result suggests a policy implication. When the nutritional and health status is poor in a less-developed country, a small improvement in both may repress economic growth through a reduction in education investment per capita. In contrast, a big improvement in the nutritional and health status can promote educational investment through increasing educational productivity. Therefore, policies for improving the nutritional and health status possess the potential of achieving promotion of educational investment and a decline in child mortality.

A reduction of child mortality mostly stems from an improvement in the nutritional and health status in developing countries. If this improvement in nutrition and health represses educational investment, the inconvenient result may lead to reluctance to improve the nutritional and health levels. However, empirical evidence shows that the improvement in the nutritional and health levels makes education more efficient. Therefore, it is possible that a decrease in child mortality rate improves human capital accumulation.

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