The Effect of Social Environment at Birth on Economic Development※

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This study distinguishes between neonatal and post-neonatal child mortality and examines the effect of improvements in mortalities, which arise due to medical and epidemiological progress, on economic development. If neonatal survival improves because of improvement in social environment at birth, which increases survival among more vulnerable babies (pre-term, etc.), it results in foster economic development. However, when improvement in social environment at birth is achieved by better method for preventing infectious disease, it impedes economic development.

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1. Introduction

This paper analyzes the effect of social environment at birth on economic development by employing overlapping generations (OLG) model featuring the quality-quantity tradeoff in children. Neonatal mortality is explicitly included in this model, which improves with social environment at birth. Here, we define improvements in social environments for survival as an improvement of health conditions, such as provision of water (including well-digging), sanitation, nutrition, disease prevention technology, healthcare systems and services. Furthermore, post-neonatal child mortality is affected by social environments during fetal and neonatal periods. We show that economic development is promoted when neonatal mortality improves because of improvement in treatment methods on preterm delivery. On the other hand, when neonatal mortality improves because of better method for preventing infectious disease, economic development is impeded.

There are two features, based on empirical findings, which distinguish our paper from the existing literature. First, our model incorporates neonatal mortality, which appears to have been previously neglected. As shown in Figure 1, the speed of decrease in mortality rate differs between a neonate and a child, and the pace at which neonatal mortality decreases is much slower compared to child mortality.

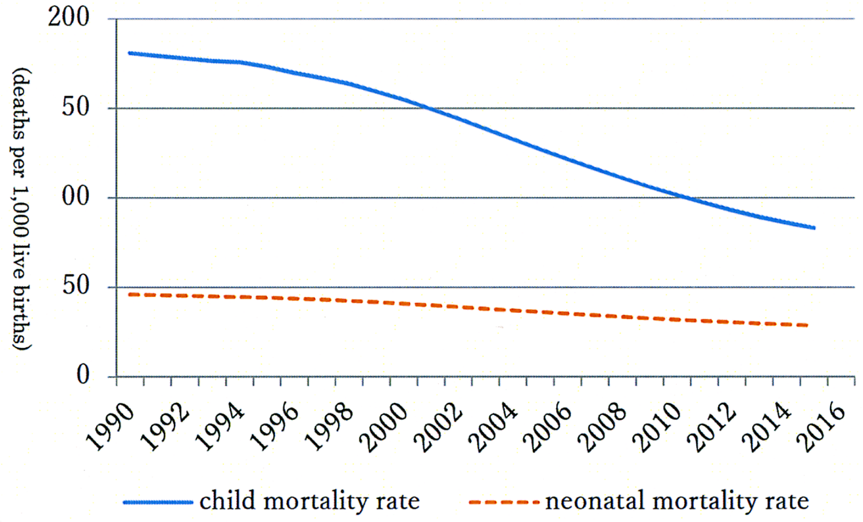

Figure 1. Neonatal and Child Mortality in Sub-Saharan Africa
Source: World Bank data, 1990-2015: number of neonatal deaths and under-five deaths.

Second, we consider that social environments during fetal and neonatal periods alter both neonatal mortality and mortality in subsequent post-neonatal period. The fetal and neonatal environments, such as prevalence of breastfeeding and neonatal care, affect neonatal and post-neonatal child survival (Blencowe et al., 2010; Vennemann et al., 2009; Hartz et al., 1977). Thus, this study considers the effects of improvements in these environments on mortalities.

Economic development has been extensively investigated, as evidenced by its large body of literature. We, too, follow this tradition. Our work is primarily related to literature on the effect of mortality in childhood on fertility-education decisions. In this vein, Becker and Barro (1988) include child mortality in their pioneering quantity-quality trade-off model. Fioroni (2010) also introduces child mortality and investigates the relationship between income and economic development. His study explores the effect of exogenous shocks, which is improvements in health conditions, on fertility, human capital accumulation, and economic development. He shows that, while these shocks reduce child mortality, their effect on economic development is dependent on the educational system.

Azarnart (2006), on the other hand, divides the childhood period into two sub-periods: early childhood and school age. He assumes that parents must allocate time to raise their children throughout the childhood period, and thus, investigates the effect of child mortality on human capital accumulation and economic development (see also Strulik, 2004; Kalemli-Ozcan, 2008; Nakamura, 2015; Hirota, 2016).

The second body of literature related to our study deals with the effect of social environments on mortality. Chakraborty et al. (2010) investigate the effect of infectious disease on adult mortality and morbidity, and thereby, economic development (see Momota et al., 2005; Aksan and Chakraborty, 2014).[1] They assume that infectious diseases are transmitted to young people by their contact with infected older people. Considering public health investment, Chakraborty (2004) examines how a decline in adult mortality affects economic development.[2] Here, the improvement in social environments includes the eradication of infection disease, improved nutrition intake, or vaccinations. As per most extant literature, improvements in the social environment lead to an intended decline in mortality. In addition to this effect, we consider that these improvements could also possibly lead to unintended effects on post-neonatal child mortality.

As noted above, social environments include various health improvement methods, such as infection prevention, and health investment. We especially focus our attention on social environment during fetal and neonatal periods to investigate its effect on economic growth.

The remainder of this paper is structured as follows. Section 2 outlines the model. Section 3 analyzes the impact of exogenous changes. We conclude the paper in section 4 with some policy implications.

2. Model

We use an OLG model in which each individual lives through three periods: childhood, adulthood, and old age. We further divide childhood into two sub-periods: early childhood and school age. Furthermore, children may face the risk of death twice through their life, once at the beginning of early childhood and once at the beginning of school age. We define the former as neonatal mortality and the latter as post-neonatal child mortality (Figure 2).

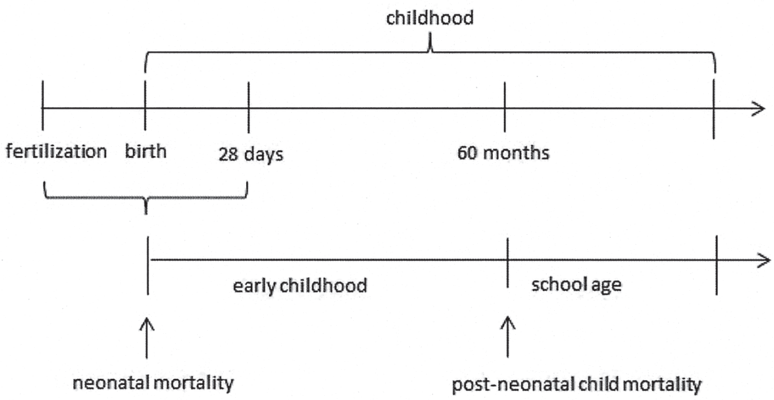

Figure 2. Chronological Relation between Neonatal and Child Mortality

We assume that only a fraction p_a of neonates can reach early childhood, and a fraction p_b of them reach school age. Then, $p_a p_b$ of children may reach adulthood period. We define neonatal mortality as $1-p_a$. An

[1] Wilson (2013) finds empirical support for mother-child transmission of health conditions.

[2] See also Chakraborty and Das (2005) and Nakamura and Mihara (2016) on health investment; see Peter Lorentzen et al. (2008) and Aksan and Chakraborty (2013) on literature on disease.

increase in survival ratio parallels a decline in mortality.

Key feature of our model relates the social environment during fetal and neonatal periods to future mortality. Hereafter, we refer to social environment during fetal and neonatal periods as social environment at birth or SEB. We consider SEB to affect neonatal and post-neonatal child survival. X denotes SEB, then we have:

$$p_a = p_a(X) \quad p_b = p_b(X),$$

where p_a and p_b denote neonatal and post-neonatal child survival ratio, respectively, and $0 < p_a, p_b < 1$.

Many previous studies assume that $p_a = 1, 0 < p_b < 1, p_b'(X) = 0$. However, we assume:

$$\frac{\mathrm{d}p_a}{\mathrm{d}X} > 0,$$

$$\frac{\mathrm{d}(p_a p_b)}{\mathrm{d}X} > 0.$$

Improvements in the SEB lower neonatal mortality, but their effect on post-neonatal child survival is ambiguous. $p_b' < 0$ refers to cases in which the neonatal survival improves because of technology that increases survival among more vulnerable babies (pre-term, etc.), then morbidity increases leading to lower survival in the post-neonatal period. $p_b' > 0$ means, conversely, that neonatal survival improves because of increased prevalence of exclusive breastfeeding, then morbidity declines and so post-neonatal survival improves.[3] [4] $p_b' = 0$ means that an improved SEB raises neonatal survival but has no effect on post-neonatal survival.

Next, we assume that parents decide whether to educate their surviving children. We also assume that the human capital of generation t is produced as follows:

$$h_{t+1} = (1 + \gamma e_t)^{\delta}, \tag{1}$$

where $\gamma > 0, 0 < \delta < 1, h_{t+1}$ is human capital stock level in period $t+1$, e_t is the education received in period t. We assume individuals have basic human capital naturally.

In adulthood, each individual supplies labor, decides the number of children to have, and how much education to give to the surviving children. In old age, an individual receives a transfer from their surviving children, eventually dying at the end of the old age period.

The life time utility of an individual born at the period $t-1$ is assumed to be a log- linear function:

$$U_t \equiv \beta \ln c_t^{t-1} + (1 - \beta) \ln c_{t+1}^{t-1}, \tag{2}$$

where $0 < \beta < 1, c_t^{t-1}$ is the consumption during adulthood and c_{t+1}^{t-1} is the consumption during old age. Each adulthood is endowed one unit of time and sells h_t units of labor at a real wage w, receiving labor income wh_t. Following Tamura (2000) and Strulik (2003), we assume the custom of transferring a certain fraction of income to parents, and distributing the remainder to oneself and their surviving child.[5] Let α be the fraction of adulthood labor income given to the parent, αwh_t, and z be the fraction of adulthood labor income given to the surviving

[3] Colostrum is breast milk produced during the first week after a baby is born. It contains elevated levels of antibodies and growth factors.

[4] Vennemann et al. (2009) show that breastfeeding reduces risk of infant death.

[5] Tamura (2000) and Strulik (2003) make a similar assumption, they assume the proportion of income transferred to parents is fixed and the remainder is allocated to oneself or children. Ehrlich and Lui (1991), Chakraborty and Das (2005a), and Morand (1999) also assume that a part of the children's earnings is transferred to parents, and Chen (2005) assumes that the proportion is fixed.

neonates time for feeding and raising children. Then, adults allocate the remaining disposable income, $wh_t - zp_a n_t wh_t - \alpha wh_t$, between their own consumption and investment in education for surviving child (rearing cost). Thus, the budget constraint during adulthood is:

$$c_t^{t-1} = [1 - \alpha - zp_a n_t] h_t w - e_t p_a p_b n_t, \tag{3}$$

where n_t is the number of (conceived)children. In old age, income transfers from surviving children occur, and thus, the budget constraint during this period is:

$$c_{t+1}^{t-1} = \alpha h_{t+1} w p_a p_b n_t. \tag{4}$$

The utility maximization problem of an individual born in period $t-1$ is as follows:

$$\begin{aligned} \underset{c_t^{t-1}, c_{t+1}^{t-1}, e_t, n_t}{\text{Max}} \quad & U_t \equiv \beta \ln c_t^{t-1} + (1-\beta) \ln c_{t+1}^{t-1}, \\ \text{s.t.} \quad & c_t^{t-1} = [1 - \alpha - zp_a n_t] h_t w - p_a p_b n_t e_t, \\ & c_{t+1}^{t-1} = \alpha h_{t+1} w p_a p_b n_t. \end{aligned}$$

If the following condition holds, parents make educational investments for their children:

$$NN(h_t) \equiv \delta \gamma z \frac{1}{p_b} h_t w - 1 > 0. \tag{5}$$

Eq. (5) is a non-negativity constraint on education levels. Let $\hat{h}$ be the threshold for human capital level h_t, at which educational investment commence or does not. The level of $\hat{h}$ is given as:

$$h_t = \left[\delta \gamma z \frac{1}{p_b} w \right]^{-1} \equiv \hat{h}.$$

If Eq. (5) does not hold, then parents choose $e_t = 0$, and the optimal choice would be:

$$c_t^{t-1} = \beta (1-\alpha) h_t w,$$

$$c_{t+1}^{t-1} = \frac{\alpha w (1-\beta)(1-\alpha)}{z \frac{1}{p_b}},$$

$$n_t = \frac{(1-\beta)(1-\alpha)}{z p_a}.$$

When Eq. (5) holds ($h_t > \hat{h}$), and parents invest in children's education, their optimal choices are:

$$c_t^{t-1} = \beta(1-\alpha)h_t w,$$

$$c_{t+1}^{t-1} = \frac{\gamma\delta^\delta(1-\delta)^{1-\delta}\alpha w(1-\beta)(1-\alpha)h_t w}{\left[\gamma z \frac{1}{p_b} h_t w - 1\right]^{1-\delta}},$$

$$n_t = \frac{(1-\delta)(1-\beta)(1-\alpha)}{z p_a - \frac{p_a p_b}{\gamma h_t w}},$$

$$e_t = \frac{\delta}{1-\delta} z \frac{1}{p_b} h_t w - \frac{1}{(1-\delta)\gamma}. \tag{6}$$

Thus proposition 1 summarizes the result of the effect of the improvement in neonatal and child mortality on individual decisions.

Proposition 1. *Neonatal mortality affects only replacement effect, while post-neonatal mortality has effects on the quantity-quality tradeoff.*

The fertility rate depends negatively on neonatal survival. This means that a higher neonatal mortality result in higher fertility rate; the replacement effect. On the other hand, child survival positively affects the fertility rate but negatively affects educational investment.

Using Eqs. (1) and (6), the dynamics of human capital accumulation is:

$$h_{t+1} = \begin{cases} 1, & \text{if } h_t < \hat{h}, \\ \left(\frac{\delta}{1-\delta}\right)^\delta \left[\gamma z \frac{1}{p_b} h_t w - 1\right]^\delta \equiv \eta(h_t), & \text{if } h_t \geq \hat{h}, \end{cases} \tag{7}$$

where $\eta'(h_t) > 0$ and $\eta''(h_t) < 0$. As shown in Figure 3, there are two steady state equilibria. While a low-level steady state represented by h^{**} is unstable, a high-level one represented by h^* is stable[6]. Since educational investment is not affected by p_a, children's human capital also remains unchanged. Conversely, the human capital of children decreases when the child survival ratio negatively relates to education investment.

[6] In Figure 3, human capital $\eta'(h_t) = 1$ is depicted as $h_t = \tilde{h}$ such that $\tilde{h} < \eta(\tilde{h})$; that is, the following condition must be fulfilled:

$$(1-\delta)\gamma z \frac{1}{p_b} \tilde{h} w - 1 > 0.$$

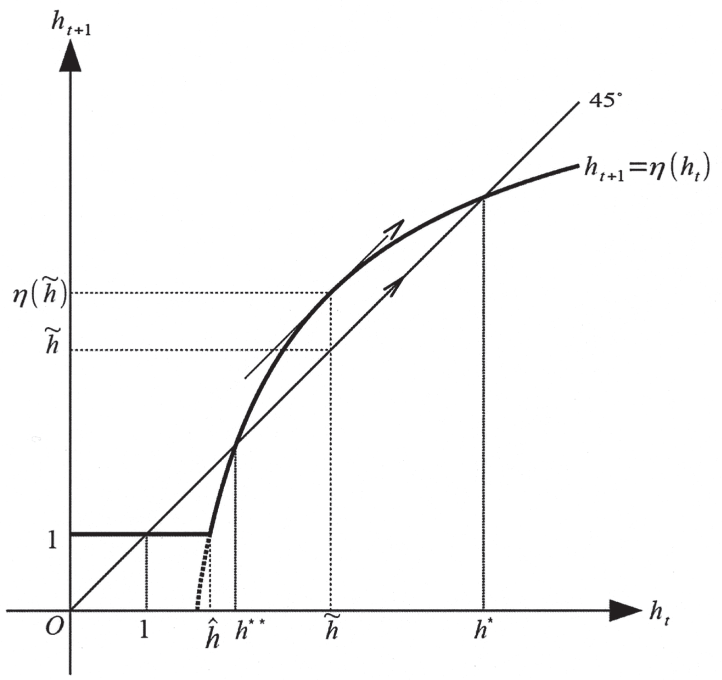

Figure 3. Human Capital Accumulation

3. Effects of improving social environment at birth on economic development

In this section, we consider the impact of SEB improvements on economic development.

When the economy is caught in a poverty trap, that is, $h_0 = 1, NN(1) < 0$, and the social environment, X, is improving, we derive the following lemma using Eq. (7):

Lemma 1. *When the economy is caught in a poverty trap, we obtain:*

$$\frac{\partial \hat{h}}{\partial X} \begin{cases} < 0, & if \quad p_b'(X) < 0, \\ = 0, & if \quad p_b'(X) = 0, \\ > 0, & if \quad p_b'(X) > 0. \end{cases}$$

When $p_b'(X) = 0$ holds, a permanent SEB improvement has no effect on the threshold of the education investment. However, a permanent SEB improvement decreases (increases) the threshold of the education investment when $p_b'(X) < 0$ ($p_b'(X) > 0$).

When the economy has escaped the poverty trap, and the social environment, X, is improving, we derive the following lemma using Eq. (7):

Lemma 2. *When the economy has escaped a poverty trap, we obtain:*

$$\frac{\partial h^*}{\partial X} \begin{cases} > 0, & if \quad p_b'(X) < 0, \\ = 0, & if \quad p_b'(X) = 0, \\ < 0, & if \quad p_b'(X) > 0. \end{cases}$$

Proof. In the neighborhood of low-level steady state, h^*, Eq. (7) is defined as:

$$H(h^* : X) \equiv h^* - \eta(h^* : X).$$

This implies that:

$$\frac{\partial h^*}{\partial X} = -\frac{\partial H/\partial X}{\partial H/\partial h^*}.$$

We have:

$$\frac{\partial H}{\partial X} = -\frac{\partial \eta}{\partial X} = -\eta \frac{\gamma z_a \frac{1}{p_b(X)} h_t w}{\gamma z_a \frac{1}{p_b(X)} h_t w - 1} \frac{p_b'(X)}{p_b(X)}$$

Meanwhile, we obtain:

$$\frac{\partial H}{\partial h^*} = 1 - \frac{\partial \eta(h^* : X)}{\partial h^*}$$

In the neighborhood of high-level steady state equilibrium h^*, $0 < \partial\eta(h^* : X)/\partial h^* < 1$, thus $\partial H(h^* : X)/\partial h^* < 0$. Accordingly, we obtain $\partial h^*/\partial X = 0$ when $p_b'(X) = 0$, $\partial h^*/\partial X > 0$ when $p_b'(X) < 0$, and $\partial h^*/\partial X < 0$ when $p_b'(X) > 0$. [Q.E.D.]

A permanent SEB improvement has no effect on long-run human capital accumulation when $p_b'(X) = 0$; although, it increases (decreases) the long run human capital accumulation when $p_b'(X) < 0$ ($p_b'(X) > 0$).

Accordingly, we derive at the following proposition:

Proposition 2. *When SEB improvements do not affect child survival, there is no impact on economic development. When neonatal mortality improves because of improvement in treatment methods of preterm delivery, economic development is promoted. On the other hand, when neonatal mortality improves because of a new method for preventing infectious disease, economic development is impeded.*
Proof. As per lemma 1 and 2. [Q.E.D.]

In case of $p_b'(X) < 0$, improvement in X increases e_t. Thus, parents invest more in education because a higher survival ratio during early childhood reduces its marginal cost at given h_t. This results in lower threshold for educational investment, and promotes economic development. However in case of $p_b'(X) > 0$, improvement in X declines e_t. Thus, a higher survival ratio during early childhood induces parents to reduce educational investment. This results in higher threshold for educational investment, and impedes economic development. If the education level is enough to exceed h^{**}, the human capital level monotonically converges to the high-level steady state as shown in Figure3. A permanent improvement in SEB does not affect long-run human capital accumulation when improved SEB does not alter child survival, although it increases (decreases) the long-run human capital accumulation when improved SEB negatively (positively) affects child survival.

4. Conclusions

This paper analyzes the effect of social environment at birth on economic development by assuming that households choose the number of children they have and education investment to their children. We extend a three-period OLG model by dividing childhood into early childhood and school age, and distinguish between neonatal mortality and post-neonatal child mortality. We also assume that the social environment at birth affects both neonatal mortality and subsequent post-neonatal child mortality. Furthermore we then assume that improving social environment at birth would reduce neonatal mortality, while its effect on mortality during early childhood period is ambiguous.

We thus obtain the following results. Improving the social environment at birth may foster economic development by increasing educational investment. This would be the case when children who survived due to improved social environment at birth face a high risk of death during early childhood. On the other hand, social environment at birth improvements may impede economic development if it reduces the risk of infection and disease during early childhood.

The results of our study have several policy implications. For example, if the government promotes breastfeeding to combat poverty, an educational policy must be implemented simultaneously to support economic development. In addition, if the government establishes or improves the perinatal care system, it should simultaneously allocate public expenditure to reduce the risk of death among children with disabilities or born prematurely.

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