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TIMING OF CHILDBEARING, FAMILY SIZE AND ECONOMIC GROWTH

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Abstract

This paper incorporates the timing of childbearing into a growth model with endogenous fertility. It analyzes a model in which individuals' human capital stock depends positively on their education and parental human capital and in which producing and raising children and acquiring human capital are time intensive. The model highlights how changes in the human capital stock interact with individuals' timing of childbearing in affecting the evolution of the economy. It shows that, if the complementarity between parental human capital and education in determining individuals' human capital is relatively large, then increases in the human capital stock raise the opportunity cost of having children while young and induce individuals to delay childbearing. That, in turn, accelerates human capital accumulation in the future. The model also demonstrates that early childbearing may lead to a development trap with low human capital.

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1. Introduction

The link between economic development, educational attainment and fertility yields one of the most well-documented empirical regularities in economics and demographics: As economies develop, fertility rates fall, the level of educational attainment and the average age of childbearing increase[2]. The economics literature has provided some explanations for why fertility is negatively related to human capital accumulation. So far, however, it has neglected to adress how timing of childbearing relates to economic development. This paper incorporates the timing of childbearing–as part of individuals' fertility decisions–into an economic growth model. In doing so, it demonstrates the mutually reenforcing effects of economic growth on delayed childbearing and delayed childbearing on growth.

In the nineteenth century, Thomas Malthus made the pioneering theoretical contribution on fertility and economic growth. His model predicts that death rates fall and fertility rises when incomes exceed the equilibrium per capita income. However, empirical evidence has revealed that fertility rates and economic development were negatively related during the past century and a half. It has also provided strong support for

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[2]The historical experience of industrialized countries, as well as cross-country studies, confirm these trends. In the U.S. and most other developed countries, studies show that working women are more educated and bear fewer children later than their counterparts two decades ago. The *1993 Handbook on Women Workers: Trends and Issues* (1994) states that in the United States, ". . . many women delay marriage, and when they do marry, they have fewer children than mothers had in previous generations. In the mid-seventies a trend began toward delayed childbearing and births among women in their later childbearing years rose markedly in the 1980's. Between 1980 and 1988, births among women aged 30 to 34 increased from 35 to 45 per 1,000 women . . . During the 1980's the proportion of . . . women workers completing 4 or more years of college increased steadily. In 1989, 24 percent of women workers had completed 4 years of college or more (up from 17.6 percent in 1979) . . ."

educational investment as a determinant of economic growth [See, for example, Barro (1991) and Mankiw, Romer and Weil (1992)]. Accordingly, economists have developed theoretical models that incorporate the interactions among fertility, educational investment and economic growth. Becker and Barro (1988) construct a model with a dynastic utility function in which parents with more children discount the future consumption of each offspring more. According to their model, technological progress leads to lower fertility and higher consumption. Becker, Murphy and Tamura (1990) consider a model in which human capital investment exhibits increasing returns, at least to a point, and individuals' discount rate of future generations' utility is identical to the one developed in Becker and Barro (1988). They demonstrate that families have fewer children and educate each child more in economies with higher human capital levels. They also show that high fertility leads to slower economic growth. The important feature of these models is the specific nature in which the discount factor of parents depends on the number of their offspring. Sundstrom and David (1988) and Azariadis and Drazen (1990) explain the negative relation between fertility and economic development by individuals' desire to provide for their old age. In these models, increases in the wage rate improve the bargaining power of children with their parents and reduce parents' perceived value of having children. Galor and Weil (1996) present a model in which household fertility is determined by the relative wages of men and women. They consider a production function where capital is more complementary to women's labor input than it is to men's. Thus, increases in capital per worker raise women's relative wages and reduce fertility by increasing the cost of children more than household income. Iyigun (1995) considers a model in which having and rearing children take away time from human capital investment, and shows that the trade-off between education and childrearing leads to the negative relation between fertility and economic development.

This paper differs from existing related work in three main aspects: First, it provides an explanation for the well-documented empirical relation between economic development and timing of childbearing. In existing work, this relation arises implicitly and only as a by-product of individuals' fertility decisions. (i.e. In any given period, if individuals face a trade-off between work and producing and rearing children, the fact that they have fewer children due to a higher opportunity cost implies that they also delay childbearing provided that individuals allocate the latter part of the period to producing and rearing children.) Second, unlike existing work that has mostly emphasized time taken away from employment as the main opportunity cost of having children [See, Birdsall (1988) for a review], this paper includes time diverted from education as well as employment as part of the opportunity cost. Thus, it shows that both lower fertility and delayed childbearing are consequences of the higher opportunity cost associated with time taken away from education *relative* to that associated with time taken away from employment. And third, the model presented below highlights how the human capital stock interacts with individuals' timing of childbearing in determining the evolution of the economy. It demonstrates that human capital accumulation raises the cost of having children while young relative to lifetime wage income. As a result, individuals delay childbearing and spend more time acquiring education when they are young. Since delayed childbearing, in turn, leads to higher future human capital levels, the model identifies the importance of the positive feedback between human capital accumulation and delayed childbearing in economic development.

In what follows, a three period over-lapping generations model–in which individuals receive utility from consumption in the last period and from the total number of their offspring–is considered. In the model, individuals acquire a minimum mandatory level of education in the first period; they devote time to education and producing and rearing children in the second period; and they work, consume and produce and rear children in the last period. By assumption, accumulating human capital and producing and rearing children are time intensive. An important feature of the model is that human capital accumulation depends positively on the time spent on education and the parental human capital stock, which are assumed to be complements in human capital formation. The role parental human capital plays in human capital formation has been explored both theoretically and empirically. For the empirical significance of parental human capital, see for example, Coleman et al. (1966), Becker and Tomes (1986) and Fuchs and Reklis (1994).

In this setup, individuals' most productive time in acquiring human capital and having children coincide. Therefore, when individuals are young, they face a trade-off between getting educated and having children. Moreover, if the degree of complementarity between parental human capital and education in determining individuals' human capital is sufficiently large, then producing and rearing children in the second period becomes more costly with increases in parental human capital. In response, individuals devote more time to education and delay having children. Thus, as parental human capital increases, the fertility rate of young women declines while that of older women who are in the labor force increases. Nonetheless, since the effect of substitution of time to education from childrearing in the second period (due to higher parental human capital) always dominates the effect of higher income on the number of children individuals choose to have in the last period, total fertility declines as the economy evolves.

The model described below also shows that multiple steady-state equilibria, where the initial stock of human capital of each country will determine the evolution of its economy, may exist. More specifically, countries that start out with a low initial human capital stock will converge to a development trap in which individuals are less educated and bear more children early. In contrast, those countries that start with a higher value of the initial human capital stock will converge to a steady-state in which individuals are more educated and have fewer children later.

The remainder of the paper is organized as follows: The next section describes the technology of production and the behavior of individuals. Section three discusses the evolution of the economy. And, section four offers some concluding remarks.

2. The Model

2.1. Production

Consider a small open economy that operates in a perfectly competitive world in which economic activity extends over an infinite discrete time. The output of the economy is a single homogeneous good produced by a CRS production function that uses physical and human capital as input. The output produced at time t, Y_t, is given by

$$Y_t = F(K_t,\ H_t) = H_t\ f(k_t); \qquad\qquad k_t \equiv K_t/H_t \tag{1}$$

where K_t and H_t respectively denote the quantities of physical and human capital employed in production at time t. The production function f: $R_+ \to R_+$ satisfies the standard neoclassical assumptions. Namely, $f'(k_t) > 0$, $f''(k_t) < 0$, $\lim_{k_t \to 0} f'(k_t) = \infty$ and $\lim_{k_t \to \infty} f'(k_t) = 0$, $\forall\ k_t \geq 0$.

Competitive markets imply that both factors earn their marginal products:

$$r_t = f'(k_t) \qquad \text{and} \qquad w_t = f(k_t) - f'(k_t)k_t \tag{2}$$

where r_t and w_t respectively denote the interest rate on physical capital and the wage rate paid to human capital.

Suppose that the world interest rate is constant at $\bar{r}$. Since the small open economy permits unrestricted physical capital mobility, its interest rate is constant at $\bar{r}$ as well. This implies that the ratio of physical capital to human capital, k_t, and the wage rate paid to human capital, w_t, are also constant:

$$r_t = \bar{r} = f'(k_t) \quad \Rightarrow \quad k_t = \bar{k} = f'^{-1}(\bar{r}) \tag{3}$$

and,

$$w_t = f(\bar{k}) - f'(\bar{k})\bar{k} = \bar{w} \tag{4}$$

2.2. Individuals

Individuals live for three periods in overlapping generations and they are endowed with one unit of time in every period. In the first period, they acquire a minimum level of education, $\underline{e}$, mandated by law. In the second period, they get educated if investing in human capital is feasible, and they produce and rear children. In the third and final period, individuals work, consume and produce and rear children. Thus, in this model, individuals endogenously decide what portion of their lifetime to devote to child rearing[3].

In the second period, individuals born at time $t-1$ invest in human capital. The acquisition of human capital requires time. An individual of generation $t-1$, who is born to a parent with h_t units of human capital, invests i_t, $i_t \epsilon [0,1]$, units of time to acquiring h_{t+1} units of human capital. These h_{t+1} units constitute the individuals labor supply in the last period of life.

$$h_{t+1} = \phi(h_t,\ e_t) = A.[h_t^{\rho}\ +\ e_t^{\rho}]^{\frac{1}{\rho}} \tag{5}$$

where $A > 0$, $-\infty \leq \rho < 1$ and where e_t, $e_t = \underline{e} + i_t$, denotes the total amount of education that the individiual accumulates throughout her lifetime. For the remainder of the discussion, we will follow the conventional notation that $\phi_1 = \frac{\partial h_{t+1}}{\partial h_t}$, $\phi_2 = \frac{\partial h_{t+1}}{\partial e_t}$, $\phi_{11} = \frac{\partial^2 h_{t+1}}{\partial h_t^2}$, $\phi_{22} = \frac{\partial^2 h_{t+1}}{\partial e_t^2}$ and $\phi_{12} = \frac{\partial^2 h_{t+1}}{\partial h_t \partial e_t} = \phi_{21} = \frac{\partial^2 h_{t+1}}{\partial e_t \partial h_t}$.

Let n_t and n_{t+1} respectively denote the number of children that the individual chooses to have in the second and third periods. Since, in the second period, individuals

[3] This setup, without loss of generality, can be extended to include second period consumption. The crucial component of the model is not that individuals allocate their time between education and having children in the second period of life. Rather, it is that producing and rearing children take away some time from individuals' human capital investment. Including in the analysis the assumption that individuals work in the second period as well will not alter the qualitative nature of the results. Similarly, the results of the model are not dependent on the assumption that the time costs of rearing children do not spillover in to the last period of life.

allocate their one unit of time between acquiring human capital and having and raising children, it follows that

$$i_t \quad + \quad zn_t \quad \leq 1, \tag{6}$$

where z, $z > 0$, is the time cost of producing and raising one child.

Similarly, since individuals allocate their one unit of time endowment between work and producing and rearing children in the last period of life,

$$l_{t+1} + zn_{t+1} \leq 1, \tag{7}$$

where l_{t+1} denotes the amount of time individuals allocate to work in the third period.

Individuals receive utility from consumption and the total number of their children. There is no uncertainty and bequest motive. The utility of an individual of generation $t-1$ is

$$u_{t-1} = u(n_T, c_{t+1}) = \quad a\ ln(n_T) \ + \ (1-a)\ ln(c_{t+1}) \tag{8}$$

where $0 < a < 1$, n_T, $n_T = n_t + n_{t+1}$, denotes the total number of children the individual chooses to have and where c_{t+1} denotes the consumption of the individual in the last period.

Individuals maximize their utility as given by equation (8), subject to equations (6), (7) and the following budget constraint:

$$c_{t+1} \quad \leq \ \bar{w}\ h_{t+1} l_{t+1}. \tag{9}$$

Therefore, the number of children that the individuals choose to have in the second and third periods, n_t, n_{t+1}, respectively satisfy the following first order conditions:

$$\frac{a}{n_t + n_{t+1}} - \frac{z(1-a)\phi_2}{\phi(.)} = \frac{a}{n_t + n_{t+1}} - \frac{z(1-a)}{e_t^{1-\rho}[h_t^\rho \ + \ e_t^\rho]} \geq 0 \tag{10}$$

$$\frac{a}{n_t + n_{t+1}} - \frac{z(1-a)}{(1 - zn_{t+1})} \leq 0 \tag{11}$$

Let $\tilde{h}$ denote the level of parental human capital that makes the individuals indifferent to acquiring education. From equation (10), we derive that

$$\frac{\partial i_t}{\partial h_t} = \frac{e_t}{h_t^{1-\rho}} \left\{ \frac{z(1-\rho)(1-a)n_T - ae_t^{1-\rho}[h_t^\rho \ + \ e_t^\rho]}{z(1-\rho)(1-a)n_T h_t^\rho + e_t[h_t^\rho \ + \ e_t^\rho]} \right\} \qquad \forall h_t > \tilde{h}. \tag{12}$$

Thus, the optimal amount of time devoted to education by an individual born in period $t-1$, i_t, is strictly monotonic and non-vanishing $\forall h_t > \tilde{h}$, if $\underline{e} \geq \frac{2(1-a)(1-\rho)}{a-\rho}$ and the complementarity between the parental human capital stock and education in determining individuals' human capital level is sufficiently large (i.e. the parameter ρ is relatively small[4]). In that case, equation (12) is strictly positive $\forall h_t > \tilde{h}$, and, there exists a differentiable and invertable function, $i(h_t)$, that determines the optimal amount of time individuals allocate to acquiring education, i_t, and to producing and raising children in the second period, n_t :

$$i_t = \gamma(h_t) = \begin{cases} 0 & for \quad h_t \leq \tilde{h} \\ i(h_t) < 1 & for \quad h_t > \tilde{h} \end{cases}, \tag{13}$$

$$e_t = \underline{e} + \gamma(h_t) \equiv e(h_t), \tag{14}$$

[4]A necessary but not sufficient condition is for ρ to be strictly less than zero. Therefore, ρ is assumed to be strictly negative for the remainder of the discussion.

and

$$n_t = \frac{1-i_t}{z} = \frac{1-\gamma(h_t)}{z}. \tag{15}$$

From equations (10) and (11), we also conclude that there exists a threshold parental human capital level, h^*, that equates the marginal costs of having and raising children in the second and third periods [i.e. when $h_t = h^*$, $\phi_2(1-zn_{t+1}) = \phi(.)$]. When the parental human capital is less than or equal to h^*, the marginal cost of having and rearing children in the second period is strictly lower than that in the third period. If as stated previously, $\underline{e} \geq \frac{2(1-a)(1-\rho)}{a-\rho}$, increases in the parental human capital stock raise the marginal cost of having children in the second period relative to that in the third. Consequently,

$$n_{t+1} = \zeta(h_t) = \begin{cases} \max\left[0,\ \frac{2a-1}{z}\right] & for \quad h_t \leq h^* \\ \frac{1}{z}\frac{\phi_2[h_t,\, e(h_t)]-\phi[h_t,\, e(h_t)]}{\phi_2[h_t,\, e(h_t)]} = \frac{1}{z}\frac{h_t^{-\rho}(1-e_t)-e_t^{1-\rho}}{h_t^{-\rho}} & for \quad h_t > h^* \end{cases} \tag{16}$$

and,

$$\frac{\partial n_{t+1}}{\partial h_t} = [e_t^{1-\rho}h_t^{\rho} \ + \ e_t]\{(a-\rho)e_t - z(1-a)(1-\rho)n_T\} > 0 \qquad if \quad \underline{e} \geq \frac{2(1-a)(1-\rho)}{a-\rho}. \tag{17}$$

Equations (13)-(16) imply the following about the behavior of individuals: When the stock of parental human capital, h_t, is less than or equal to the threshold level of human capital, $\tilde{h}$, individuals do not find it optimal to invest time in education, i_t, in order to enhance their human capital stock in the following period, h_{t+1}. As a result, they choose to devote all of their time endowment in the second period to producing and rearing children. In addition, depending on the value that individuals place on having children, which depends positively on the parameter a, individuals may devote part of their third period endowment to producing and raising children as well. Specifically, if $a \leq \frac{1}{2}$, individuals choose not to get educated and have $\frac{1}{z}$ children in the second period, and, no children in the last period. And if $a > \frac{1}{2}$, individuals choose not to get educated and have $\frac{1}{z}$ children in the second period, and $\frac{2a-1}{z}$ children in the third period. When the parental human capital stock, h_t, exceeds the threshold level, $\tilde{h}$, individuals find it optimal to allocate a positive amount of time to education. Since $i_t = 1 - zn_t$, this implies that they choose to have fewer children in the second period.

Note also that equations (10) and (11) imply $\tilde{h} < h^*$ if $a \leq \frac{1}{2}$, and $\tilde{h} = h^*$ if $a > \frac{1}{2}$. Hence, if $a \leq \frac{1}{2}$ and when $\tilde{h} < h_t \leq h^*$, individuals choose to have fewer children in the second period and they continue to have no children in the last period in response to increases in the parental human capital stock. In this case, individuals put relatively little emphasis on the total number of children compared to consumption that the amount of time that they devote to producing and rearing children in the second period is sufficient for them to have the optimal number of total children. Moreover, it is still optimal for them to have all of their children when they are young since the opportunity cost of doing so is still lower than that in the third period (or, alternatively because $h_t \leq h^*$). Only when parental human capital reaches a level such that $h_t > h^*$, do individuals choose to have more children in the third period and continue to have fewer children in response to increases in the parental human capital stock. In contrast, if $a > \frac{1}{2}$ and when $\tilde{h} = h^* < h_t$, individuals choose to have fewer children in the second period and more children in the third period in response to increases in parental human capital. In this case, individuals put relatively more emphasis on the total number of children compared to consumption that they need to devote some fraction of their time to producing and rearing children in the last period. Unlike the previous case, however, increased time devoted to education in the second period immediately leads to delayed childbearing and an increase in the number of children that individuals choose to have in the third period, $\forall\ h_t > \tilde{h}$. In sum, without examining whether human capital accumulation leads to lower fertility, we can conclude that individuals choose to delay childbearing in response to increases in parental human capital[5] . The intuition behind this conclusion is straighforward: increases in the stock of parental human capital raise the cost of childbearing in the second period relative to that in the last period and make not acquiring education in the second period "too costly".

Finally, we can easily establish that, when $h_t > \tilde{h}$, individuals choose to have fewer children in total as the parental stock of human capital increases. Equation (11) implies that, when $h_t > h^*$, $n_T = \frac{a}{1-a}\frac{1-zn_{t+1}}{z}$. Thus, $\frac{\partial n_T}{\partial h_t} = -\frac{a}{1-a}\frac{\partial n_{t+1}}{\partial h_t} < 0$, $\forall\ h_t > h^*$. In addition, if $a \leq \frac{1}{2}$ and $\tilde{h} < h_t \leq h^*$, then $n_T{=}n_t$ and $\frac{\partial n_T}{\partial h_t} = -\frac{1}{z}\frac{\partial i_t}{\partial h_t} < 0$. When $h_t > \tilde{h}$, total fertility declines as the return to education increases simply because the effect of the substitution of time devoted to education from childrearing in the second period always dominates the effect of higher income on the number of children individuals choose to have in the last period. Figures 1 and 2 summarize the above discussion.

3. The Evolution of the Economy

The evolution of this economy, and, in particular, the evolution of the stock of human capital, $\{h_t\}_{t=0}^{\infty}$, is governed by an autonomous, non-linear, first-order difference equation. The evolution of the human capital stock, $\{h_t\}_{t=0}^{\infty}$, in turn, determines the evolutions of the amount of time allocated to education, $\{e_t\}_{t=0}^{\infty}$, the number of children individuals choose to have in the second and third periods and in total, $\{n_t\}_{t=0}^{\infty}$, $\{n_{t+1}\}_{t=0}^{\infty}$, $n_T = n_t + n_{t+1}$, and of per capita income, $\{y_t\}_{t=0}^{\infty}$. We derive equation (18) by combining equations (5) and (14):

[5]Note that, in the context of the model presented here, delayed childbearing arises because the average age of childbearing increases (as the fertility rate of young women declines while that of older women who are in the labor force rises with increases in the human capital stock) and not so much because individuals choose to have fewer children in the second period. Put differently, delayed childbearing is not strictly a consequence of the order of activities in the second period as the model does not rely on the assumption that, in the second period, individuals first get educated and then they produce and rear children.

$$h_{t+1} = \psi(h_t) = \begin{cases} A.[h_t^\rho \ + \ \underline{e}^\rho]^{\frac{1}{\rho}} & \text{if} \ \ h_t \leq \tilde{h} \\ \\ A.[h_t^\rho \ + \ e(h_t)^\rho]^{\frac{1}{\rho}} & \text{if} \ \ h_t > \tilde{h} \end{cases} \tag{18}$$

where the initial stock of human capital, h_0, is historically given.

Along the dynamic path, h_t, evolves monotonically. Namely,

$$\frac{\partial h_{t+1}}{\partial h_t} = \psi'(h_t) = \begin{cases} A.[1 \ + \ \underline{e}^\rho h_t^{-\rho}]^{\frac{1-\rho}{\rho}} > 0 & \text{if} \ \ h_t \leq \tilde{h} \\ \\ A.[1 \ + \ e(h_t)^\rho h_t^{-\rho}]^{\frac{1-\rho}{\rho}} + A.[1 \ + \ e(h_t)^{-\rho} h_t^\rho]^{\frac{1-\rho}{\rho}} \frac{\partial e_t}{\partial h_t} > 0 & \text{if} \ \ h_t > \tilde{h} \end{cases} \tag{19}$$

$$\frac{\partial^2 h_{t+1}}{\partial h_t^2} = \psi''(h_t) = \begin{cases} A.(\rho-1)[h_t^\rho \ + \ \underline{e}^\rho]^{\frac{1-2\rho}{\rho}} \underline{e}^\rho \ h_t^{\rho-2} < 0 & \text{if} \ \ h_t \leq \tilde{h} \\ \\ A.(\rho-1)[h_t^\rho \ + \ e(h_t)^\rho]^{\frac{1-2\rho}{\rho}} \left\{ e_t^\rho h_t^{\rho-2} + h_t^\rho e(h_t)^{\rho-2} \frac{\partial^2 e_t}{\partial h_t^2} \right\} & \text{if} \ \ h_t > \tilde{h} \\ \\ +A.[h_t^\rho \ + \ e(h_t)^\rho]^{\frac{1-2\rho}{\rho}} h_t^{\rho-1} e(h_t)^{\rho-1} \frac{\partial e_t}{\partial h_t} & \end{cases} \tag{20}$$

Furthermore, as obtained from equations (18) and (19)

$$\psi(0) = 0 \tag{21}$$

and,

$$\lim_{h_t \to 0} \psi'(h_t) = A > 0 \tag{22}$$

$$\lim_{h_t \to \tilde{h}^+} \psi'(h_t) = \ A.[1 \ + \ \underline{e}^\rho h_t^{-\rho}]^{\frac{1-\rho}{\rho}} + A.[1 \ + \ \underline{e}^{-\rho} h_t^\rho]^{\frac{1-\rho}{\rho}} \frac{\partial e_t}{\partial h_t} \qquad > \tag{23}$$

$$\lim_{h_t \to \tilde{h}^-} \psi'(h_t) \quad = \quad A.[1 + \underline{e}^{\rho} h_t^{-\rho}]^{\frac{1-\rho}{\rho}}$$

$$\lim_{h_t \to \infty} \psi'(h_t) = 0 \tag{24}$$

A steady-state equilibrium is defined as a stationary stock of human capital, $\bar{h}$ such that

$$\bar{h} = \psi(\bar{h}). \tag{25}$$

Once the stock of human capital is in its steady-state, $\bar{h}$, per capita income, the total number of children individuals have and the amount of time individuals allocate to education reach their steady-state levels, respectively denoted by $\bar{y}$, $\bar{n}_T, \bar{e}$ as well.

Given equations (21)-(24) and $\psi(h_t)$ is a continuous function of the human capital stock, h_t, we are able to establish that a non-trivial stable steady-state exists if $A > 1$. In addition, multiple steady state equilibria may exist under certain parameter restrictions. Since $\lim_{h_t \to 0} \psi'(h_t) = A$, $\psi''(h_t) < 0 \; \forall \; h_t \leq \tilde{h}$, and $\tilde{h}$ depends positively on the minimum level of required education, $\underline{e}$, non-trivial multiple steady-state equilibria exist if $\tilde{h} > 0$, $\psi(\tilde{h}) < \tilde{h}$, $\exists \; h_t > \tilde{h}$ such that $\psi(h_t) > h_t$ and $\lim_{h_t \to \infty} \psi'(h_t) < 1$. From equations (18)-(24), it follows that the above conditions are satisfied if $A > 1$ and the complementarity between parental human capital and education is sufficiently large for a given set of other parameter values (i.e. for relatively small values of ρ). Note also that, as can be verified from equation (23), the slope of the dynamical system in a close neighborhood to the right of $\tilde{h}$ is larger than that in a close neighborhood to the left of it. Figures 3 and 4, respectively illustrate the dynamical evolution of the system with unique and multiple steady state equilibria.

4. Conclusion

In providing an explanation for the well-documented negative relation between human capital accumulation and fertility, existing work in the economics literature emphasizes time diverted from employment as the main opportunity cost of having children, and stresses that increases in the return to human capital make more educated individuals' time too valuable to care for children. In doing so, however, it ignores how individuals' most productive periods in having children and acquiring human capital coincide, and, how timing of childbearing is inextricably linked to the fertility decision.

The model presented above, incorporates the timing of childbearing into an economic growth model. The results highlight the importance of the feedback mechanism between the return to education (via the existing human capital stock) and timing of childbearing on economic growth: Increases in the human capital stock raise the opportunity cost of bearing children while young and induce individuals to delay childbearing. That, in turn, accelerates human capital accumulation in the future as younger generations devote relatively more time to education.

The key feature of the preceeding analysis is the interdependence of parental human capital and education in determining individuals' human capital stock. The model reveals that, if the complementarity between these variables in human capital formation is relatively large, in response to higher returns to education individuals delay childbearing until they join the labor force. This leads to the possibility of multiple steady-state equilibria: For countries with a low initial human capital stock, the interaction between human capital and timing of childbearing creates a development trap in which individuals are less educated and bear more children early. In contrast, countries with higher initial human capital stock converge to a steady-state in which individuals are more educated and have fewer children later. Moreover, the same interaction between timing of childbearing and human capital that leads to a development trap for other countries stimulates economic growth in these countries. The results also demonstrate that lower fertility as well as delayed childbearing are consequences of the higher opportunity cost associated with time taken away from education *relative* to that associated with time taken away from employment.

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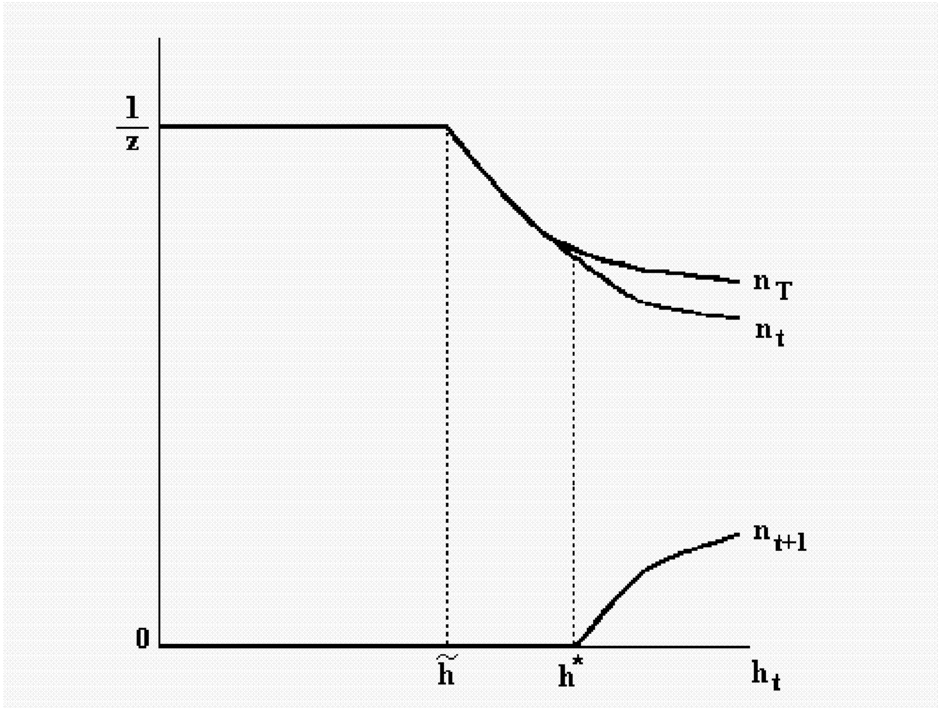

Figure 1:

The evolution of fertility by period and total fertility when $a \leq \frac{1}{2}$

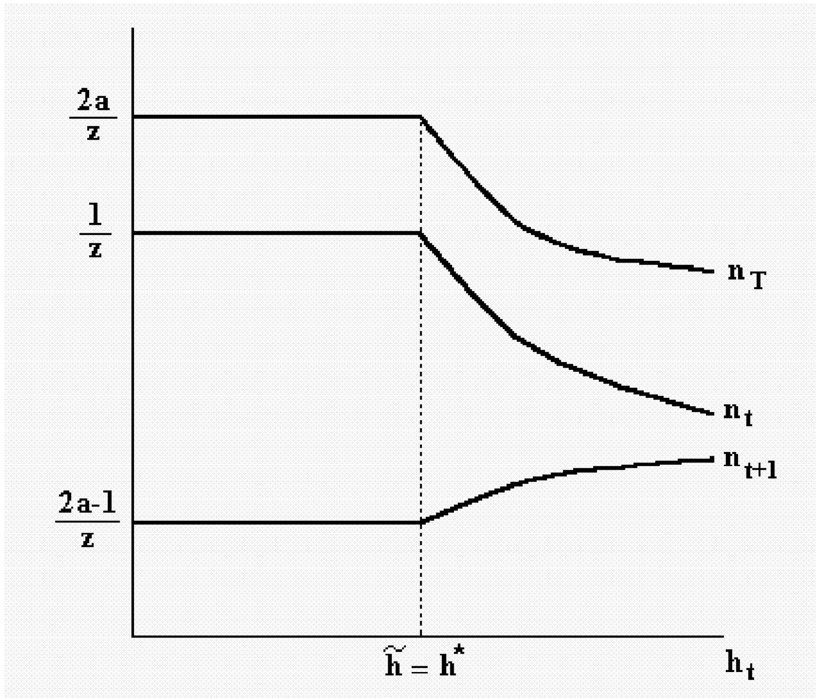

Figure 2:

The evolution of fertility by period and total fertility when $a > \frac{1}{2}$

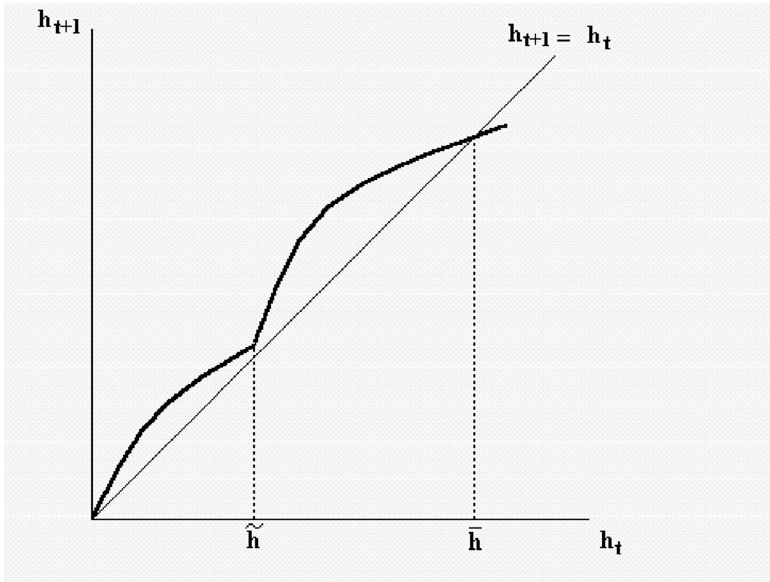

Figure 3:

A globally stable, unique steady-state equilibrium

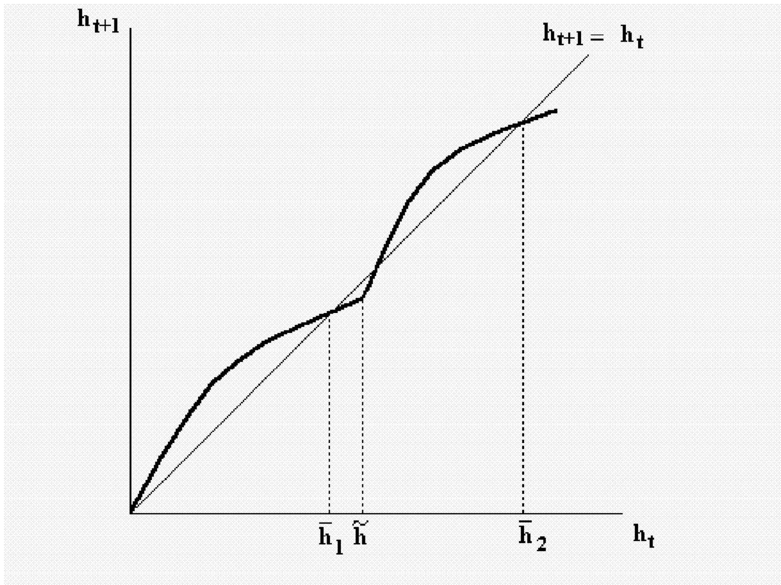

Figure 4:

Locally stable, multiple steady-state equilibria