E C O N O M I C S   B U L L E T I N

Social norms, inequality and fertility

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Abstract

We explore the short-run and long-run effects on fertility of inequality with regard to human capital when the individual's fertility decision is influenced by average fertility in the economy. We find simple conditions under which a mean-preserving spread in the distribution of human capital helps decrease fertility and increase future average human capital.

I wish to thank Ravi Kanbur and Nancy Chau; this paper has greatly benefited from their detailed comments and suggestions on the first chapter of my dissertation, wherein a type of norm that does not change regardless of the amount of norm violation in the economy is considered. The usual disclaimer applies.
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1. INTRODUCTION

The literature on the effects of inequality on fertility has assumed that there is no social norm that influences fertility decisions. On the contrary, existing theoretical work on the relationship between social norms and fertility assumes homogeneous individuals in terms of human capital. The objective of this paper is to explore the effects on the average levels of fertility and human capital of inequality in human capital when an individual's fertility decision is influenced by social norms, namely, average fertility rates in an economy.

There exists much empirical evidence on the important role that fertility behavior of one's cohorts plays in fertility decisions. For example, based on two sets of research studies that cover most developing countries, namely, the World Fertility Survey and the Princeton European Fertility Project, Coale and Watkins (Eds.)(1986) and Cleland and Hobcraft (Eds.)(1985) find that region and culture are important in determining fertility levels. In addition, Freedman et al. (1965) indicate that social norms about family size control fertility behavior of American couples. Moreover, Montgomery and Chung (1999), Rosero-Bixby and Casterline (1994), and Montgomery and Casterline (1993) provide statistical evidence on the contribution of social interaction to fertility in Republic of Korea, Costa Rica and Taiwan, respectively.[1] However, theoretical investigation on how the existence of social norms affects fertility has been scattered. A few exceptions include Munshi and Myaux (2006), Palivos (2001), and Crook (1978), but the relationship between inequality in terms of human capital and fertility is not considered.

This paper is also related to those that explore the relationship between inequality and fertility. Galor and Zang (1997) investigate the impact of inequality on fertility, human capital and growth under borrowing constraints. Morand (1999) has a model of inequality and fertility in which fertility decisions are motivated by old-age support. Croix and Doepke (2003) have a model of inequality and growth in which fertility and education decisions depend on, among other things, the level of one's human capital. Moav (2005) presents a model of fertility and child educational choice, which explains the persistence of poverty trap. Social norms, however, are not considered in their models.

In the following section, we introduce the model. Section 3 presents results on the short-run and long-run effects of distributional shifts on fertility and human capital. Section 4 concludes the paper.

2. THE MODEL

2.1 Description

Consider overlapping generations of individuals who live for two periods: youth and old age. Each individual is endowed with one unit of time per period. We follow Palivos (2001) in that, when young, the individual decides how much time to devote to her own education, and how much to raising children. When old, the individual works full-time regardless of wages, and her consumption depends on the level of human capital:

$$c_{t+1} = w_{t+1}h_{t+1}, \tag{1}$$

[1] For more evidence, see Palivos (2001).

where w_{t+1} is a wage rate in period $t+1$ and h_{t+1} is the level of human capital when old, the latter depending on the amount of education attained when young.

If the individual in period t spends $e_t \in [0,1]$ on education, her human capital in the next period is given by

$$h_{t+1} = B(\theta + e_t h_t)^\gamma, \tag{2}$$

where h_t is the level of human capital of the individual's parent, and $B, \theta > 0$ and $\gamma \in (0,1)$ are constant parameters. The parameter θ captures the level of human capital when no education was attained when young.

Given e_t, the remainder of the time endowment is spent on raising children. We assume that raising one child takes $1/\delta$ hours. Thus the number of children, or the fertility rate, n_t, is given by

$$n_t = \delta(1 - e_t) \tag{3}$$

The utility function of an individual born at time t is of the form

$$U_t = u(n_t, \bar{n}_t) + \beta \ln c_{t+1}, \tag{4}$$

where u is utility from having children and $\bar{n}_t$ denotes the average fertility rate in period t. Thus the individual's utility depends not only on the number of her own children but also on the average fertility behavior of the other individuals in the economy. We assume $u_1 \equiv \partial u/\partial n_t > 0$, $u_2 \equiv \partial u/\partial \bar{n}_t > 0$, $u_{11} \equiv \partial^2 u/\partial n_t^2 \leq 0$ and $u_{12} \equiv \partial^2 u/\partial \bar{n}_t \partial n_t \geq 0$. Given $\bar{n}_t$, the individual in period t maximizes (4) subject to (1), (2) and (3).

The production of a representative firm exhibits constant returns to scale:

$$y_{t+1} = A h_{t+1}, \tag{5}$$

where $A > 0$ is a parameter.

Human capital is distributed between h_t^{min} and h_t^{max} according to the distribution function $F_t(h_t)$. Total population P_t evolves according to

$$P_{t+1} = P_t \int_{h_t^{min}}^{h_t^{max}} n_t \, dF(h_t) \tag{6}$$

The distribution of human capital evolves according to

$$F_{t+1}(h) = \frac{P_t}{P_{t+1}} \int_{h_t^{min}}^{h_t^{max}} n_t I(h_{t+1} \leq h) \, dF(h_t), \tag{7}$$

where $I(\cdot)$ is an indicator function. Last, average human capital $\hat{h}_t$ is given by

$$\hat{h}_t = \int_{h_t^{min}}^{h_t^{max}} h_t \, dF(h_t) \tag{8}$$

2.2 Equilibrium

An equilibrium for the economy is defined as follows:

Definition: Given an initial distribution of human capital $F_0(h_0)$ and an initial population size P_0, an equilibrium consists of a set of sequences $\{n_t\}_{t=0}^{\infty}$, $\{e_t\}_{t=0}^{\infty}$, $\{h_{t+1}\}_{t=0}^{\infty}$, $\{c_{t+1}\}_{t=0}^{\infty}$, $\{y_{t+1}\}_{t=0}^{\infty}$, $\{w_{t+1}\}_{t=0}^{\infty}$, $\{P_{t+1}\}_{t=0}^{\infty}$ and $\{F_{t+1}(h_{t+1})\}_{t=0}^{\infty}$ such that (i) each individual's utility function is maximized, (ii) total population evolves according to (6), (iii) the distribution of human capital evolves according to (7), (iv) the labor market clears, i.e., $w_{t+1} = A$ holds, (v) the goods market clears, i.e., $y_{t+1} = c_{t+1}$ holds, and (vi) the expectation of $\bar{n}_t$ coincides with the resulting average fertility rate given the expectation (Figure 1):

$$\bar{n}_t = \int_{h_t^{min}}^{h_t^{max}} n_t(h_t, \bar{n}_t)\ dF(h_t) \tag{9}$$

We restrict attention to stable equilibria, wherein the derivative of the right-hand side of (9) with respect to $\bar{n}_t$ evaluated at an equilibrium fertility rate is strictly less than 1. In Figure 1, the right-hand side of (9) as the function of $\bar{n}_t$ is denoted by $RHS(\bar{n}_t)$. $\bar{n}^*_{t,1}$ and $\bar{n}^*_{t,3}$ are stable while $\bar{n}^*_{t,2}$ is not.[2] Note that, if an equilibrium is stable, a slight downward shift of RHS induces a lower equilibrium fertility rate.

By the first-order condition, $e_t(h_t, \bar{n}_t)$ is determined by[3]

$$\delta u_1(\delta(1-e_t), \bar{n}_t) = \frac{\beta\gamma h_t}{\theta + e_t h_t} \tag{10}$$

if $\underline{\mathrm{h}}_t \leq h_t \leq \bar{h}_t$, where $\underline{\mathrm{h}}_t$ and $\bar{h}_t$ are respectively determined by

$$\delta u_1(\delta, \bar{n}_t) = \frac{\beta\gamma \underline{\mathrm{h}}_t}{\theta} \tag{11}$$

and

$$\delta u_1(0, \bar{n}_t) = \frac{\beta\gamma \bar{h}_t}{\theta + \bar{h}_t} \tag{12}$$

Otherwise,

$$e_t(h_t, \bar{n}_t) = \begin{cases} 0 & \text{if} \quad h_t^{min} \leq h_t \leq \underline{\mathrm{h}}_t \\ 1 & \text{if} \quad \bar{h}_t \leq h_t \leq h_t^{max} \end{cases} \tag{13}$$

It should be noted that both $\underline{\mathrm{h}}_t$ and $\bar{h}_t$ are increasing in $\bar{n}_t$.

By differentiating (10) with respect to h_t, we have:

$$\frac{\partial e_t}{\partial h_t} = \frac{\beta\gamma\theta}{\beta\gamma h_t^2 - \delta^2 u_{11}(\delta(1-e_t), \bar{n}_t)(\theta + e_h h_t)^2} > 0 \tag{14}$$

Thus investment in human capital increases as the parent's human capital increases. Also, by differentiating (10) with respect to $\bar{n}_t$, we get

$$\frac{\partial e_t}{\partial \bar{n}_t} \leq 0, \tag{15}$$

[2] The occurance of multiple equilibria is not our focus. Palivos (2001) investigates issues related to multiple equilibria in the case of homogeneous individuals.

[3] The second-order condition for a maximum is satisfied.

which means that education decreases as the expectation of the average fertility rate in the economy increases.

From (3) and $e_t(h_t, \bar{n}_t)$ obtained above, fertility rate is given by

$$n_t(h_t, \bar{n}_t) = \begin{cases} \delta & \text{if} \quad h_t^{min} \leq h_t \leq \underline{h}_t \\ \delta(1 - e_t(h_t, \bar{n}_t)) & \text{if} \quad \underline{h}_t \leq h_t \leq \bar{h}_t \\ 0 & \text{if} \quad \bar{h}_t \leq h_t \leq h_t^{max} \end{cases} \tag{16}$$

In contrast to education, from (3) and (14), we find that fertility rate falls as the parent's human capital rises (when $\underline{h}_t < h_t < \bar{h}_t$):

$$\frac{\partial n_t}{\partial h_t} < 0 \tag{17}$$

From (2) and $e_t(h_t, \bar{n}_t)$, human capital in period $t+1$ is given by

$$h_{t+1}(h_t, \bar{n}_t) = \begin{cases} B\theta^\gamma & \text{if} \quad h_t^{min} \leq h_t \leq \underline{h}_t \\ B(\theta + e_t(h_t, \bar{n}_t)h_t)^\gamma & \text{if} \quad \underline{h}_t \leq h_t \leq \bar{h}_t \\ B(\theta + h_t)^\gamma & \text{if} \quad \bar{h}_t \leq h_t \leq h_t^{max} \end{cases}, \tag{18}$$

which is depicted in Figure 2. Note that h_{t+1} does not depend on $\bar{n}_t$ for $h_t \leq \underline{h}_t$ and $h_t \geq \bar{h}_t$, where $\underline{h}_t$ and $\bar{h}_t$ are the functions of $\bar{n}_t$.

It is seen that there are two extreme cases. First, if all h_t is small enough to satisfy

$$\delta u_1(\delta, \delta) \geq \frac{\beta\gamma h_t^{max}}{\theta},$$

every individual does not invest in human capital at all and has δ children. Second, if all h_t is large enough for

$$\delta u_1(0, 0) \leq \frac{\beta\gamma h_t^{min}}{\theta + h_t^{min}}$$

to hold, every individual devotes the whole time endowment to education and has no child.

In what follows, we consider the case where $h_t^{min} < \underline{h}_t < \bar{h}_t < h_t^{max}$ hold.

3. DISTRIBUTIONAL SHIFTS AND FERTILITY

In this section, we explore how the equilibrium fertility rate changes as the distribution of human capital changes. We first study the short-run effects. An investigation of the long-run effects follows.

3.1 Short-run Effects

Let us begin with the impact on fertility rates of first-order stochastically dominating shifts in h_t. With this kind of shifts, all individuals' human capital increases. We have the following result, as is to be expected:

Proposition 1. *With first-order stochastically dominating shifts in the distribution of human capital in period t, the equilibrium average fertility rate (in period t) falls and the average human capital (in period $t+1$) rises.*
Proof: See Appendix.

The effect of inequality on fertility is less obvious. Let us first consider the case of a uniform distribution. In this case, we have the following result:

Proposition 2. *Suppose h_t is distributed uniformly along $[m-k, m+k]$, where m is the (fixed) average level of human capital and $k \in (0, m]$ is a parameter describing the extent of inequality. Then as k increases,*
(i) the equilibrium fertility rate falls if $\bar{n}_t > \delta/2$,
(ii) the equilibrium fertility rate rises if $\bar{n}_t < \delta/2$.
Proof: The equilibrium fertility rate is determined by

$$\bar{n}_t(k) = \frac{1}{2k}\left\{\delta[\underline{h}_t(\bar{n}_t(k)) - (m-k)] + \int_{\underline{h}_t(\bar{n}_t(k))}^{\bar{h}_t(\bar{n}_t(k))} n_t(h_t, \bar{n}_t)\ dh_t\right\} \tag{19}$$

Differentiating and rearranging (19) gives

$$\frac{\partial \bar{n}_t}{\partial k} = \frac{-\frac{1}{k}\left(\bar{n}_t - \frac{\delta}{2}\right)}{1 - \frac{1}{2k}\int_{\underline{h}_t}^{\bar{h}_t} \frac{\partial n_t}{\partial \bar{n}_t}\ dh_t} \tag{20}$$

In stable equilibria, $\partial RHS/\partial \bar{n}_t = \frac{1}{2k}\int_{m-k}^{m+k} \frac{\partial n_t}{\partial \bar{n}_t}\ dh_t < 1$. Since $\frac{1}{2k}\int_{\underline{h}_t}^{\bar{h}_t} \frac{\partial n_t}{\partial \bar{n}_t}\ dh_t \leq \frac{1}{2k}\int_{m-k}^{m+k} \frac{\partial n_t}{\partial \bar{n}_t}\ dh_t$, the denominator of (20) is positive. Therefore we have the result. □

The above result states that if fertility is already high in the first place, a more *unequal* distribution helps decrease average fertility.

The intuition behind this is as follows. Suppose for a moment that the (equilibrium) expectation of $\bar{n}_t$ is unchanged. As k increases, the value of the density function $f(h_t, k) = 1/2k$ decreases. So the average fertility rate of the individuals with $h_t \in [\underline{h}_t, \bar{h}_t]$, which is $\frac{1}{2k}\int_{\underline{h}_t}^{\bar{h}_t} n_t(h_t, \bar{n}_t)\ dh_t$, decreases. Next, from $\bar{n}_t > \delta/2$, $\underline{h}_t$ must satisfy

$$\int_{\underline{h}_t}^{\bar{h}_t} n_t(h_t, \bar{n}_t)\ dh_t > \delta(m - \underline{h}_t) \tag{21}$$

If $\underline{h}_t > m$, the average fertility rate of the individuals with $h_t \in [m-k, \underline{h}_t]$, which is $F_t(\underline{h}_t, k) = \frac{\delta}{2k}[\underline{h}_t - (m-k)]$, also decreases, because $\partial F_t/\partial k < 0$ for $h_t > m$. Thus the average fertility rate of the economy falls. On the other hand, if $\underline{h}_t \leq m$, the average fertility rate of the individuals with $h_t \in [m-k, \underline{h}_t]$ changes by $\frac{\delta}{2k^2}(m - \underline{h}_t)$ while that of the individuals with $h_t \in [\underline{h}_t, \bar{h}_t]$ changes by $-\frac{1}{2k^2}\int_{\underline{h}_t}^{\bar{h}_t} n_t(h_t, \bar{n}_t)\ dh_t$. Although the former is positive, from (21), the total change is negative. Thus, in any case, fertility decreases with an increase in k, with the expectation of $\bar{n}_t$ held constant. As fertility declines, the right-hand side of (19) shifts downwards, which leads to a lower equilibrium fertility rate. Therefore, an increase in the extent of inequality helps decrease the average fertility rate of the economy if $\bar{n}_t > \delta/2$.

In the case of a general distribution function, we have the following results:

Proposition 3. *Let $F(h_t, k)$ be the distribution function of human capital, where k is a mean-preserving spread parameter. That is, if $k' > k$, $F(h_t, k')$ is a mean-preserving spread of $F(h_t, k)$. Then as k increases,*

(i) the average fertility rate falls if $\partial F(h_t, k)/\partial k < 0$ for $h_t \in (\underline{h}_t, \bar{h}_t)$,
(ii) the average fertility rate rises if $\partial F(h_t, k)/\partial k > 0$ for $h_t \in (\underline{h}_t, \bar{h}_t)$.
Proof: Follows directly from (A-3) by letting $s = k$.

Thus distributional shifts only in $h_t \in (\underline{h}_t, \bar{h}_t)$ affect fertility.

3.2 Long-run Effects

Next, we analyze the long-run effects of inequality on fertility and the average level of human capital.

Let us first consider the case where the 45-degree line crosses $h_{t+1} = h_{t+1}(h_t, \bar{n}_t)$ once (from below). The following three cases could occur:

Case 1:

Suppose that there exists t' such that the following conditions hold for $\forall t \geq t'$: (i) the 45-degree line crosses $h_{t+1} = h_{t+1}(h_t, \bar{n}_t)$ at some $h_t \in [min\{h_t^{min}, B\theta^\gamma\}, \underline{h}_t]$, (ii) $h_{t+1}(\underline{h}_t) < \underline{h}_{t+1}$, and (iii) $h_{t+1}(\bar{h}_t) < \bar{h}_{t+1}$ (Figure 3). Then all individuals' human capital converges to $h^* = B\theta^\gamma$, and the (average) fertility rate in this steady state is $n^* = \delta$.

Case 2:

Suppose that there exists t' such that the following conditions hold for $\forall t \geq t'$: (i) the 45-degree line crosses $h_{t+1} = h_{t+1}(h_t, \bar{n}_t)$ at some $h_t \geq \bar{h}_t$, (ii) $h_{t+1}(\underline{h}_t) > \underline{h}_{t+1}$, and (iii) $h_{t+1}(\bar{h}_t) > \bar{h}_{t+1}$. Then all individuals' human capital converges to h^*, which is determined by $B(\theta + h^*)^\gamma = h^*$. The fertility rate in this case is $n^* = 0$.

Case 3:

Suppose that there exists n^* such that $\bar{n}_t$ converges to n^*, and that there exists t' such that the following conditions hold for $\forall t \geq t'$: (i) the 45-degree line crosses h_{t+1} at some $h_t \in [\underline{h}_t, \bar{h}_t]$, (ii) $h_{t+1}(\underline{h}_t) > \underline{h}_{t+1}$, and (iii) $h_{t+1}(\bar{h}_t) < \bar{h}_{t+1}$. Then h^* and n^* are determined by $B(\theta + e_t(h^*, n^*)h^*)^\gamma = h^*$ and $n^* = \delta(1 - e_t(h^*, n^*))$.

Note that in cases 1 and 2, as long as the conditions are satisfied, changes in the distribution of human capital do not affect the average levels of fertility and human capital.

In order to see clearly that there exists a case in which inequality affects fertility and human capital, let us consider the following case:

Case 4:

Suppose that there exists t' such that $\bar{n}_t = n^*$ for $\forall t \geq t'$, and that the 45-degree line crosses $h_{t+1} = h_{t+1}(h_t, \bar{n}_t)$ three times at $h_1^* \in [B\theta^\gamma, \underline{h}(n^*)]$, $h_2^* \in (\underline{h}(n^*), \bar{h}(n^*))$ and $h_3^* \geq \bar{h}(n^*)$ (Figure 4). Then the fertility rate in the steady state is determined by

$$n^* = \delta F_{t'}(h_2^*)$$

Thus if $\partial F_{t'}(h_{t'},k)/\partial k > 0$ (respectively, $\partial F_{t'}(h_{t'},k)/\partial k < 0$) for $h_{t'} \in (\underline{h}(n^*), \bar{h}(n^*))$, the fertility rate rises (respectively, falls), which means that Proposition 3 holds true in the long-run too.

Also it should be noted that the average level of human capital in the steady state is given by

$$\hat{h}^* = B\theta^\gamma F_{t'}(h_2^*) + h_3^*(1 - F_{t'}(h_2^*))$$

Therefore if $\partial F_{t'}(h_{t'},k)/\partial k > 0$ ($\partial F_{t'}(h_{t'},k)/\partial k < 0$) for $h_{t'} \in (\underline{h}(n^*), \bar{h}(n^*))$, the average human capital decreases (increases).

Suppose a mean-preserving spread is such that $\partial F_{t'}(h_{t'},k)/\partial k > 0$ for $h_{t'} < \hat{h}^*$ and $\partial F_{t'}(h_{t'},k)/\partial k < 0$ for $h_{t'} > \hat{h}^*$, as in the case of a uniform distribution. Then it is seen that average human capital decreases if $h_2^* < \hat{h}^*$, increases if $h_2^* > \hat{h}^*$.

The other cases can be analyzed in a similar way.

4. CONCLUSION

When the individual's fertility decision is influenced not only by economic incentives but also by fertility behavior of her cohorts, how do the average levels of fertility and human capital change if the inequality of human capital changes? We find that, in the short-run, if fertility is already high in the first place in the case of a uniform distribution, an increase in inequality helps reduce fertility. In the case of a general distribution, we show that distributional shifts only in a certain range affect average fertility rates. More precisely, if the distribution function shifts downwards (upwards) for the levels of human capital with which individuals have a positive, but smaller than the maximum, number of children, average fertility falls (rises). We find that there exists a case wherein the same result holds in the long-run. In such a case, when fertility falls (rises), the average level of human capital in a steady state rises (falls). We also find that, in the long-run, there exist cases in which the limiting distribution is degenerate and so changes in inequality do not affect fertility and human capital.

APPENDIX: PROOF OF PROPOSITION 1

From (9) and (16), an equilibrium average fertility rate is determined by

$$\bar{n}_t(s) = \delta F(\underline{h}_t(\bar{n}_t(s)), s) + \int_{\underline{h}_t(\bar{n}_t(s))}^{\bar{h}_t(\bar{n}_t(s))} n_t(h_t, \bar{n}_t(s))\; dF(h_t, s), \tag{A-1}$$

where $F(h_t, s)$ satisfies $\partial F/\partial s \leq 0$ for $\forall\ h_t$. Thus F with a larger s first-order stochastically dominates those with smaller s.

By differentiating and rearranging (A-1), we have

$$\frac{\partial \bar{n}_t}{\partial s} = -\frac{\int_{\underline{h}_t}^{\bar{h}_t} \frac{\partial n_t(h_t,\bar{n}_t)}{\partial h_t} \frac{\partial F(h_t,s)}{\partial s}\; dh_t}{1 - \int_{\underline{h}_t}^{\bar{h}_t} \frac{\partial n_t(h_t,\bar{n}_t)}{\partial \bar{n}_t} f(h_t, s)\; dh_t} \tag{A-2}$$

Since $\int_{\underline{h}_t}^{\bar{h}_t} \frac{\partial n_t(h_t,\bar{n}_t)}{\partial \bar{n}_t} f(h_t,s)\ dh_t < \int_{h_t^{min}}^{h_t^{max}} \frac{\partial n_t(h_t,\bar{n}_t)}{\partial \bar{n}_t} f(h_t,s)$, and since $\int_{h_t^{min}}^{h_t^{max}} \frac{\partial n_t(h_t,\bar{n}_t)}{\partial \bar{n}_t} f(h_t,s) < 1$ in stable equilibria, the denominator is positive. Thus

$$sign\ \frac{\partial \bar{n}_t}{\partial s} = sign\ \left(- \int_{\underline{h}_t}^{\bar{h}_t} \frac{\partial n_t(h_t,\bar{n}_t)}{\partial h_t} \frac{\partial F(h_t,s)}{\partial s}\ dh_t \right) \tag{A-3}$$

From $\partial n_t/\partial h_t < 0$ for $h_t \in (\underline{h}_t, \bar{h}_t)$ and $\partial F/\partial s \leq 0$, we have $\partial \bar{n}_t/\partial s \leq 0$.

Next, from (8) and (18), the average human capital in period $t+1$ is given by

$$\hat{h}_{t+1} = B\theta^{\gamma} F(\underline{h}_t, s) + \int_{\underline{h}_t}^{h^{max}} h_{t+1}(h_t,\bar{n}_t)\ dF(h_t,s), \tag{A-4}$$

where h^{max} is large enough for $F(h^{max},s) = 1$ to be satisfied for $\forall s$. So $\partial F(h^{max},s)/\partial s = 0$.

Differentiating (A-4) with respect to s offers

$$\frac{\partial \hat{h}_{t+1}}{\partial s} = \int_{\underline{h}_t}^{h^{max}} \frac{\partial h_{t+1}}{\partial \bar{n}_t} \frac{\partial \bar{n}_t}{\partial s} f(h_t,s)\ dh_t - \int_{\underline{h}_t}^{h^{max}} \frac{\partial h_{t+1}}{\partial h_t} \frac{\partial F}{\partial s}\ dh_t$$

From (15) and (18), $\partial h_{t+1}/\partial \bar{n}_t$ is negative. Besides, $\partial h_{t+1}/\partial h_t$ is positive. Therefore, we have $\partial \hat{h}_{t+1}/\partial s \geq 0$.

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Figure 1: Equilibrium Fertility Rates

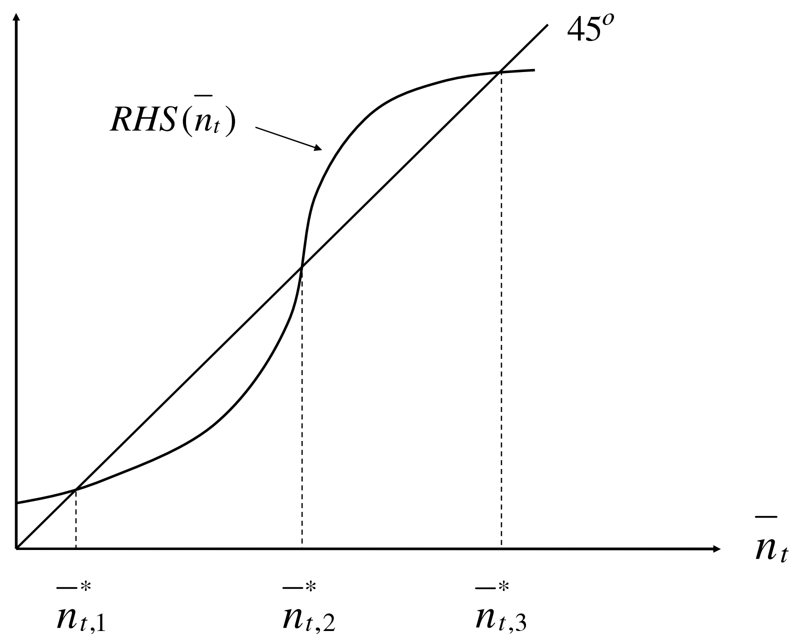

Figure 2: Distribution of human capital

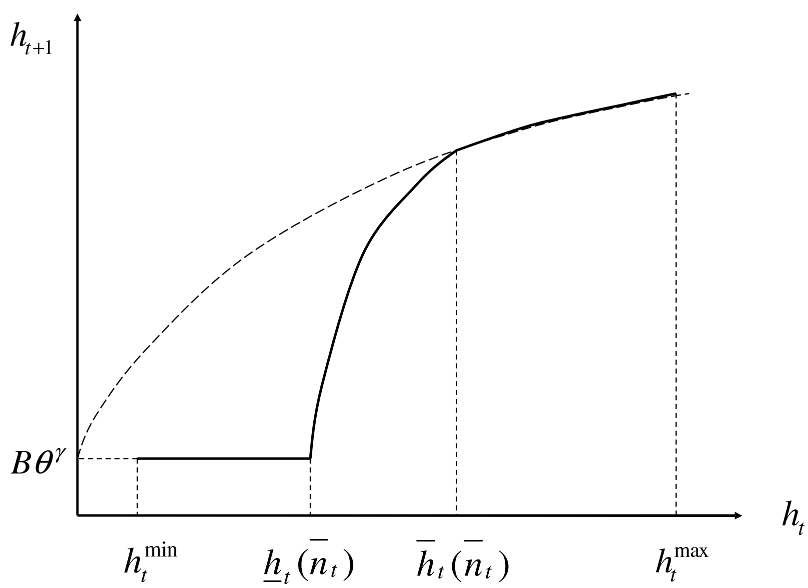

Figure 3: Equilibrium growth path when $B\theta^{\gamma} < \underline{h}_{t+1}$ and $h_{t+1}(\bar{h}_t) < \bar{h}_{t+1}$

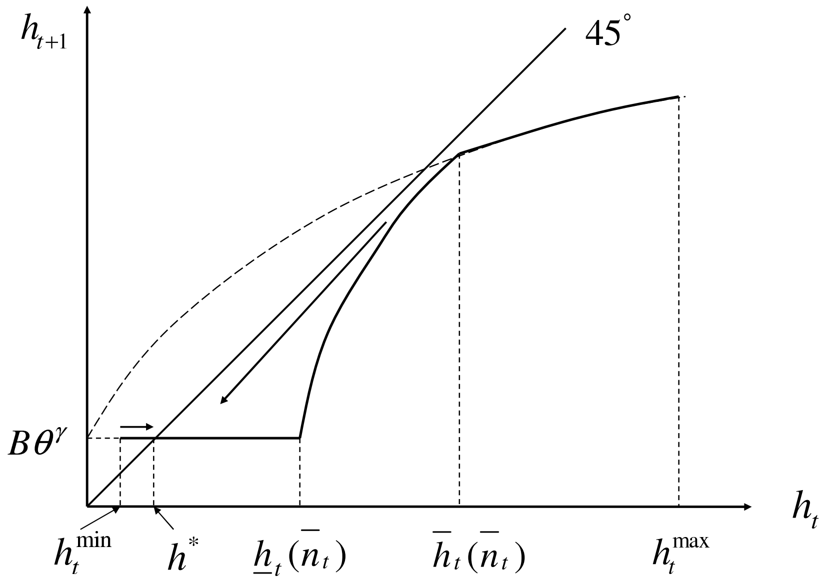

Figure 4: Equilibrium growth path when $B\theta^{\gamma} < \underline{h}_{t+1}$ and $h_{t+1}(\bar{h}_t) > \bar{h}_{t+1}$