Growth and Parental Preference for Education

Chu, Angus C. and Furukawa, Yuichi and Zhu, Dongming

University of Liverpool, Chukyo University, Shanghai University of Finance and Economics

September 2015

Growth and Parental Preference for Education

Angus C. Chu Yuichi Furukawa Dongming Zhu

January 2016

Abstract

This study explores the implications of parental preference for education in an innovation-driven growth model that features an interaction between endogenous technological progress and human capital accumulation. Parents invest in children's education partly due to the preference for their children to be educated. We consider a preference parameter that measures the degree of this parental preference for education. We find that a higher degree of parental preference for education increases human capital, which is conducive to innovation, but the increase in education investment also crowds out resources for R&D investment. As a result, a stronger parental preference for education has an inverted-U effect on the steady-state equilibrium growth rate. We also analytically derive the complete transitional path of the equilibrium growth rate and find that an increase in the degree of education preference has an initial negative effect on growth. Furthermore, we explore the robustness of our results in a scale-invariant extension of the model and find that although the steady-state equilibrium growth rate becomes monotonically increasing in the degree of education preference, it continues to have an initial negative effect on the transitional growth rate.

JEL classification: O30, O40
Keywords: education, endogenous growth, human capital, innovation

Angus C. Chu: angusccc@gmail.com. Department of Economics, Finance and Accounting, Management School, University of Liverpool, Liverpool, United Kingdom. Yuichi Furukawa: you.furukawa@gmail.com. School of Economics, Chukyo University, Nagoya, Japan. Dongming Zhu: zhu.dongming@mail.shufe.edu.cn. School of Economics, Shanghai University of Finance and Economics, Shanghai, China.

1 Introduction

Some societies place a relatively high value on education. Here we consider the Chinese society as an example. In China's Song Dynasty, Emperor Zhenzong (968-1022) wrote his famous *Urge to Study Poem* in which an often quoted verse is "in books one finds golden mansions and maidens as beautiful as jade." Also in the Song Dynasty, a poet, Wang Zhu, wrote in his famous *Child Prodigy Poem*, "all pursuits are of low value; only studying the books is high." This emphasis on education can be traced back to Confucianism, which emphasizes the importance of education. Studying the origins of this strong preference for education in China, Kipnis (2011) notes that education "invokes a system of prestige in which those with educational accomplishments are marked as superior to the non-educated." Even in the case of Chinese families in the US, this parental preference for education still exerts influences on parents' involvement in children's education. For example, from their survey data, Chen and Uttal (1988) find that Chinese parents have higher expectations on their children's academic achievement and spend more time working with children on their homework than American parents. Furthermore, Chen and Uttal (1988) argue that these different behaviors can be explained by differences in cultural values.[1] However, is a strong parental preference for education necessarily good for the economy? A BBC News article[2] discusses the costs of this "education fever" in China as well as South Korea, which also shares the Confucian values, and reports that in South Korea, "the government believes 'education obsession' is damaging society".

In this study, we use a growth-theoretic framework to explore the macroeconomic implications of a strong parental preference for education. The growth-theoretic framework is an innovation-driven growth model that features an interaction between endogenous technological progress and human capital accumulation. Parents invest in their children's human capital due to the subjective utility that they derive from their children's education. We consider a preference parameter that measures the degree of this parental preference for education. We find that a higher degree of parental preference for education increases the accumulation of human capital, which is conducive to innovation, but the increase in education investment also crowds out resources for R&D investment. As a result, a stronger parental preference for education has an inverted-U effect on the steady-state equilibrium growth rate. Furthermore, if the degree of parental preference for education is sufficiently low or high, the economy would be trapped in a stagnant equilibrium with zero economic growth in the long run.

We also analytically derive the complete transitional path of the equilibrium growth rate from the initial steady state to the new steady state when the degree of parental preference for education increases. We find that an increase in the degree of education preference has an initial negative effect on the equilibrium growth rate due to the crowding-out effect of education investment on R&D investment. However, as the level of human capital increases, the equilibrium growth rate also increases due to the positive effect of human capital on innovation. The new steady-state equilibrium growth rate may be higher or lower than the initial growth rate, depending on the relative magnitude of the negative crowding-out effect

[1] See also Huang and Gove (2012) for a discussion of Confucianism's influence on the Chinese culture and educational practice of Chinese families in the United States.

[2] "Asia's Parents Suffering 'Education Fever'". BBC News, 22 October 2013.

of education investment and the positive effect of human capital on innovation and growth.

Furthermore, we explore the robustness of our results in a scale-invariant extension of the model and find that although the steady-state equilibrium growth rate becomes monotonically increasing in the degree of education preference, it continues to have an initial negative effect on the transitional growth rate. Therefore, in both versions of the model, an increase in the degree of parental preference for education indeed has a certain "damaging" effect on the society by temporarily slowing down the growth rate of the economy. The underlying assumption behind this negative effect is that parents investing more of their time in their children's education carries an opportunity cost that crowds out other productive activities. For example, a recent SCMP News article[3] describes a growing trend of educated parents in China quitting their careers to educate their children. However, this negative short-run effect on economic growth can be offset by a positive long-run effect of accumulating more human capital. Therefore, policymakers should take into consideration both the negative short-run effect and the positive long-run effect.

This study contributes to the literature on R&D-driven innovation and economic growth.[4] Early studies in this literature do not consider human capital accumulation. More recent studies, such as Eicher (1996), Zeng (1997, 2003), Strulik (2005, 2007), Strulik *et al.* (2013), Chu *et al.* (2013), Hashimoto and Tabata (2016) and Prettner and Strulik (2016), explore human capital accumulation and its interaction with endogenous technological progress in the R&D-based growth model. However, these studies either do not explore the effects of parental preference for education or they find an unambiguously positive effect of education preference on growth. By analytically deriving the transitional dynamics, we show that although an increase in the degree of parental preference for education can have a positive effect on the steady-state equilibrium growth rate, it also has a negative effect on the transitional growth rate due to the negative crowding-out effect of education.

The rest of this study is organized as follows. Section 2 presents the benchmark model. Section 3 explores the implications of parental preference for education. Section 4 analyzes a scale-invariant extension of the model. The final section concludes.

2 The benchmark model

We consider a discrete-time version of the seminal R&D-based growth model in Romer (1990). We extend the Romer model by considering a simple structure of overlapping generations and human capital accumulation. Each individual is endowed with one unit of time to be allocated between leisure, work and the education of her child.[5] We follow previous

[3] "Home Freer: Chinese Mothers Quit Jobs to Care for the Kids". South China Morning Post, 9 November 2015.

[4] See Romer (1990), Segerstrom *et al.* (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992) for seminal studies in this literature.

[5] In this study, we do not consider endogenous fertility; see for example Chu *et al.* (2013), Strulik *et al.* (2013), Prettner and Strulik (2016) and Hashimoto and Tabata (2016) for an analysis of human capital accumulation and endogenous fertility in the R&D-based growth model. In the case of China, the number of children was not freely chosen by most parents due to the one-child policy, which has been recently changed to a two-child policy.

studies[6] to assume that individuals derive utility from their children's education. Furthermore, they supply labor that is embodied with human capital to earn a wage income. For simplicity, we follow previous studies to assume that individuals only consume goods when they are old. In this case, they save all of their wage income when they are young and consume their asset income when they are old.

2.1 Individuals

In each generation, there is a unit continuum of individuals. An individual who works at time t has the following utility function indexed by a superscript t:

$$U^t = u(l_t, C_{t+1}, H_{t+1}) = \eta \ln l_t + \ln C_{t+1} + \gamma \ln H_{t+1}. \tag{1}$$

l_t denotes the individual's leisure at time t, and the parameter $\eta \geq 0$ captures leisure preference.[7] C_{t+1} denotes the individual's consumption at time $t+1$. H_{t+1} denotes the level of human capital possessed by the individual's child. The parameter $\gamma > 0$ measures the degree of parental preference for education (i.e., γ is the utility weight that an individual places on her child's human capital). The amount of time e_t a parent invests in her child's education determines her level of human capital according to the following equation:

$$H_{t+1} = \phi e_t + (1-\delta)H_t, \tag{2}$$

where $\phi > 0$ is an education efficiency parameter and $\delta \in (0,1)$ is the depreciation rate of human capital that the parent passes onto her child.[8] Following previous studies, we assume for simplicity that education is the only form of bequest.

Individuals use their remaining time endowment $1 - l_t - e_t$ combined with their human capital H_t to earn a wage income $w_t(1 - l_t - e_t)H_t$. Given that individuals consume only when they are old, their consumption at time $t+1$ is given by

$$C_{t+1} = (1 + r_{t+1})w_t(1 - l_t - e_t)H_t, \tag{3}$$

where r_{t+1} is the real interest rate. Substituting (2) and (3) into (1), we can express an individual's optimization problem as follows.

$$\max_{e_t,\, l_t} U^t = \eta \ln l_t + \ln[(1 + r_{t+1})w_t(1 - l_t - e_t)H_t] + \gamma \ln[\phi e_t + (1-\delta)H_t],$$

taking $\{r_{t+1}, w_t, H_t\}$ as given. The utility-maximizing levels of l_t and e_t are respectively

$$l_t = \eta \frac{\phi + (1-\delta)H_t}{\phi(1 + \eta + \gamma)}, \tag{4}$$

[6] See for example Glomm and Ravikumar (1992) and Futagami and Yanagihara (2008). In this literature on parental investment in human capital and economic growth, studies focus on human capital accumulation as the sole engine of economic growth. The present study complements these studies by exploring parental investment in human capital as well as its interaction with endogenous technological progress.

[7] We consider endogenous leisure to allow individuals to choose between reducing their time spent on leisure and work when they want to increase their time spent on their children's education. Our results are robust to the absence of endogenous leisure (i.e., $\eta = 0$).

[8] Our results are robust to $\delta \to 1$ (i.e., parents' human capital does not transfer to their children).

$$e_t = \frac{\phi\gamma - (1+\eta)(1-\delta)H_t}{\phi\,(1+\eta+\gamma)}. \tag{5}$$

Substituting (5) into (2) yields the level of human capital at time $t+1$ as

$$H_{t+1} = \frac{\gamma}{1+\eta+\gamma}\left[\phi + (1-\delta)H_t\right], \tag{6}$$

which is the accumulation equation of human capital and shows that the dynamics of H_t is stable. Therefore, given any initial H_0, H_t always converges to its steady state.

In the steady state, the level of leisure is $l^* = \eta/(1+\eta+\delta\gamma)$, which is decreasing in γ, whereas the level of education is $e^* = \delta\gamma/(1+\eta+\delta\gamma)$, which is increasing in γ. The steady-state level of human capital is $H^* = \phi\gamma/(1+\eta+\delta\gamma)$, which is also increasing in γ. However, the steady-state level of human-capital-embodied labor supply is

$$(1-l^*-e^*)H^* = \frac{\phi\gamma}{(1+\eta+\delta\gamma)^2}, \tag{7}$$

which is an inverted-U function of γ. The negative effect of γ on human-capital-embodied labor supply is due to the crowding-out effect of education, which is captured by $1-l^*-e^* = 1/(1+\eta+\delta\gamma)$. Intuitively, an increase in γ causes parents to devote more time to their children's education e^*. As a result, they have to devote less of their time to other productive activities. Although they also reduce leisure l^*, the reduction in l^* only partly offsets the increase in e^*, resulting into an overall decrease in $1-l^*-e^*$.

2.2 Final goods

Final goods Y_t are produced by competitive firms using the following production function:

$$Y_t = H_{Y,t}^{1-\alpha}\sum_{i=1}^{N_t} X_t^{\alpha}(i), \tag{8}$$

where $H_{Y,t}$ is human-capital-embodied labor devoted to production and $X_t(i)$ is intermediate good $i \in [1, N_t]$. The firms take as given the output price (normalized to unity) and input prices w_t and $p_t(i)$. The familiar conditional demand functions for $H_{Y,t}$ and $X_t(i)$ are respectively

$$w_t = (1-\alpha)Y_t/H_{Y,t}, \tag{9}$$

$$p_t(i) = \alpha\left[H_{Y,t}/X_t(i)\right]^{1-\alpha}. \tag{10}$$

2.3 Intermediate goods

There is a number of differentiated intermediate goods $i \in [1, N_t]$. We consider the following simple production process that is commonly used in the literature. Specifically, we assume that one unit of intermediate goods is produced by one unit of final goods. In this case, the profit function is given by

$$\pi_t(i) = p_t(i)X_t(i) - X_t(i). \tag{11}$$

The familiar unconstrained profit-maximizing price is $p_t(i) = 1/\alpha$. Here we follow Goh and Olivier (2002) and Iwaisako and Futagami (2013) to introduce patent breadth $\mu > 1$ as a policy variable,[9] such that

$$p_t(i) = \min\{\mu, 1/\alpha\}. \tag{12}$$

We focus on the more realistic case in which $\mu < 1/\alpha$.[10] Substituting $p_t(i) = \mu$ into (10) shows that $X_t(i) = X_t$ for all $i \in [1, N_t]$. In this case, (11) becomes

$$\pi_t = (\mu - 1)X_t = (\mu - 1)\left(\frac{\alpha}{\mu}\right)^{1/(1-\alpha)} H_{Y,t}, \tag{13}$$

where the second equality follows from (10).

2.4 R&D

Denote v_t as the value of an intermediate good invented at time t. The value of v_t is equal to the present value of future profits given by[11]

$$v_t = \sum_{s=t+1}^{\infty} \left[\pi_s / \prod_{\tau=t+1}^{s} (1 + r_\tau)\right]. \tag{14}$$

Competitive entrepreneurs employ human-capital-embodied labor $H_{R,t}$ for R&D. The innovation process is

$$\Delta N_t = \theta N_t H_{R,t}, \tag{15}$$

where $\Delta N_t \equiv N_{t+1} - N_t$. The parameter $\theta > 0$ denotes an R&D productivity parameter, and N_t captures intertemporal knowledge spillovers as in Romer (1990). The zero-profit condition is given by

$$\Delta N_t v_t = w_t H_{R,t} \Leftrightarrow \theta N_t v_t = w_t. \tag{16}$$

2.5 Aggregation

Substituting $X_t = (\alpha/\mu)^{1/(1-\alpha)} H_{Y,t}$ into $Y_t = H_{Y,t}^{1-\alpha} N_t X_t^{\alpha}$ yields the aggregate production function given by

$$Y_t = \left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)} N_t H_{Y,t} \tag{17}$$

[9] The presence of monopolistic profits attracts potential imitation; therefore, stronger patent protection allows monopolistic producers to charge a higher markup without losing their markets to potential imitators. This formulation of patent breadth captures Gilbert and Shapiro's (1990) seminal insight on "breadth as the ability of the patentee to raise price".

[10] Given a labor share $1 - \alpha$ of roughly two-thirds, the unconstrained markup ratio is $1/\alpha = 3$, which is unrealistically large. However, all our results are robust to the case of $p_t(i) = 1/\alpha$.

[11] A new variety invented at time t will only start generating profits in the next period.

and the amount of intermediate goods given by $N_t X_t = \alpha Y_t/\mu$. The resource constraint on final goods is

$$C_t = Y_t - N_t X_t = \left(1 - \frac{\alpha}{\mu}\right) Y_t. \tag{18}$$

The resource constraint on human-capital-embodied labor input is

$$(1 - l_t - e_t)H_t = H_{Y,t} + H_{R,t}. \tag{19}$$

2.6 Equilibrium

The equilibrium is a sequence of allocations $\{X_t(i), Y_t, C_t, H_{Y,t}, H_{R,t}, H_t, e_t, l_t\}$ and prices $\{p_t(i), w_t, r_t, v_t\}$ such that the following conditions are satisfied:

- individuals choose $\{e_t, l_t\}$ to maximize utility taking $\{r_{t+1}, w_t, H_t\}$ as given;
- competitive final goods firms choose $\{X_t(i), H_{Y,t}\}$ to maximize profit taking $\{p_t(i), w_t\}$ as given;
- monopolistic intermediate goods firms choose $\{p_t(i), X_t(i)\}$ to maximize profit (11) taking (10) as given;
- competitive entrepreneurs in the R&D sector employ $\{H_{R,t}\}$ to maximize profit taking $\{w_t, v_t\}$ as given;
- the resource constraint on final goods holds such that $Y_t = N_t X_t + C_t$;
- the resource constraint on human-capital-embodied labor holds such that $H_{Y,t} + H_{R,t} = (1 - l_t - e_t)H_t$;
- the amount of saving equals the value of assets such that $w_t(1 - l_t - e_t)H_t = N_{t+1} v_t$.

3 Parental preference for education

In this section, we explore the implications of parental preference for education on economic growth. Section 3.1 focuses on the balanced growth path. Section 3.2 considers the transitional paths of human capital and the equilibrium growth rate.

3.1 Balanced growth path

Human-capital-embodied labor allocations $\{H_{Y,t}, H_{R,t}\}$ are stationary in the steady state. Then, (13) implies that π_t is also stationary in the steady state. As a result, the steady-state version of (14) simplifies to $v = \pi/r$. Substituting this condition into the R&D zero-profit condition in (16), we have $\theta N_t \pi/r = w_t$, where $N_t\pi = \alpha Y_t(\mu - 1)/\mu$ and w_t is given by (9). Solving these conditions yields

$$H_Y = \frac{\mu}{\mu - 1}\left(\frac{1-\alpha}{\alpha}\right)\frac{r}{\theta}. \tag{20}$$

The next step is to determine the steady-state equilibrium interest rate r. Wage income at time t is $w_t(1 - l_t - e_t)H_t = w_t(H_{Y,t} + H_{R,t})$, which is also the total amount of saving in the economy at time t. The total value of assets in the economy at the end of time t is $N_{t+1}v_t$, which includes the new varieties created at time t. Given the overlapping-generation structure of the economy, the amount of saving must equal the value of assets such that

$$w_t(1 - l_t - e_t)H_t = N_{t+1}v_t \Leftrightarrow w_t(H_Y + H_R) = (1 + \theta H_R)N_t\pi/r, \tag{21}$$

where $N_t\pi = \alpha Y_t(\mu - 1)/\mu$ and w_t is given by (9). Solving these conditions, we obtain

$$\frac{(1-\alpha)(H_Y + H_R)}{H_Y} = \frac{\alpha(1 + \theta H_R)}{r}\left(\frac{\mu - 1}{\mu}\right), \tag{22}$$

which determines the equilibrium interest rate that equates the amount of saving to the value of assets in the economy.

Solving (7), (19), (20) and (22) yields the steady-state equilibrium values of $\{r^*, H_Y^*, H_R^*\}$.

$$r^* = \frac{\alpha}{1-\alpha}\left(\frac{\mu - 1}{\mu}\right), \tag{23}$$

$$H_Y^* = \frac{1}{\theta}, \tag{24}$$

$$H_R^* = \frac{\phi\gamma}{(1 + \eta + \delta\gamma)^2} - \frac{1}{\theta}, \tag{25}$$

which shows that H_R^* is an inverted-U function of γ. From (15) and (25), the steady-state equilibrium growth rate of technology (and also output) is given by

$$g^* \equiv \frac{\Delta N_t}{N_t} = \theta H_R^* = \frac{\theta\phi\gamma}{(1 + \eta + \delta\gamma)^2} - 1 \geq 0, \tag{26}$$

which is also an inverted-U function of γ. Specifically, the growth-maximizing value of γ is given by $(1 + \eta)/\delta > 0$. Intuitively, a higher depreciation rate δ of human capital leads to a higher steady-state level of education e^* that mitigates the negative effect on human capital H^*, and hence, a weaker education preference γ is needed to reach the level of education that maximizes the level of human-capital-embodied labor $(1 - l^* - e^*)H^*$. In contrast, a stronger preference η for leisure reduces e^* and requires a stronger education preference γ to reach the

level of education that maximizes $(1-l^*-e^*)H^*$. To ensure that there exists an intermediate range of γ in which the steady-state equilibrium growth rate g^* is positive, we impose the following parameter restriction: $\theta\phi > 4(1+\eta)\delta$. Under this parameter restriction, there still exists a lower bound value $\underline{\gamma}$ of γ below which $g^* = 0$, and there also exists an upper bound value $\overline{\gamma}$ of γ above which $g^* = 0$. In other words, if $\gamma = \underline{\gamma}$ or $\gamma = \overline{\gamma}$, then $H_R^* = 0$. Solving the quadratic function $\theta\phi\gamma = (1+\eta+\delta\gamma)^2$, we derive the values of $\{\underline{\gamma}, \overline{\gamma}\}$ given by

$$\{\underline{\gamma}, \overline{\gamma}\} = \frac{\theta\phi - 2(1+\eta)\delta \pm \sqrt{[\theta\phi - 4(1+\eta)\delta]\,\theta\phi}}{2\delta^2}. \tag{27}$$

We summarize these results in Proposition 1 and plot g^* as a function of γ in Figure 1.

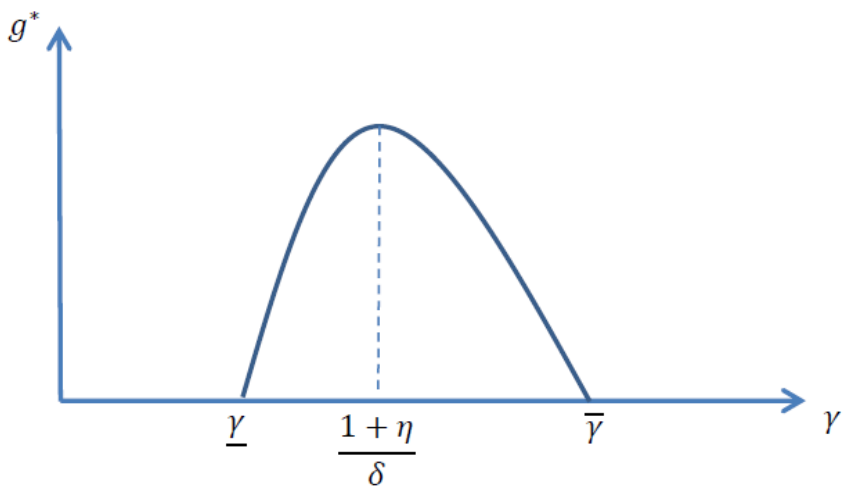

Figure 1: Steady-state effect of education preference on growth

Proposition 1 *The degree of parental preference for education has an inverted-U effect on the steady-state equilibrium growth rate. Under a sufficiently low or high degree of parental preference for education, the economy is trapped in a zero-growth equilibrium.*

The intuition of the above results can be explained as follows. An increase in the degree of parental preference for education increases education investment and human capital accumulation. However, it also crowds out productive resources for R&D. Specifically, if $\gamma > (1+\eta)/\delta$, then any further increase in γ would lead to a decrease in human-capital-embodied labor supply, which in turn reduces the amount of resources available for innovation. In this case, a stronger degree of parental preference for education is detrimental to economic growth. Furthermore, in the R&D-based growth model, the market size needs to be sufficiently large in order for R&D investment to be profitable. Therefore, when the degree of parental preference takes on a sufficiently high or low value, the market size measured by $(1-l-e)H$ becomes so small that there is no incentive for entrepreneurs to invest in R&D. In this case, the economy is trapped in a stagnant equilibrium with zero economic growth.

3.2 Transition dynamics

In this subsection, we derive the transitional dynamics of the economy. Substituting (17) into (9) yields the following expression for the equilibrium wage rate:

$$w_t = (1-\alpha)\left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)} N_t. \tag{28}$$

Substituting (28) into (16) yields the following expression for the value of an invention:

$$v_t = \frac{1-\alpha}{\theta}\left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)}, \tag{29}$$

which is stationary both on and off the balanced growth path. Substituting (28) and (29) into (21) yields

$$w_t(1-l_t-e_t)H_t = N_{t+1}v_t \Leftrightarrow N_{t+1} = \theta N_t(1-l_t-e_t)H_t. \tag{30}$$

Substituting (4) and (5) into (30) yields the growth rate of technology given by

$$g_t \equiv \frac{N_{t+1}}{N_t} - 1 = \frac{\theta}{\phi(1+\eta+\gamma)}\left[\phi H_t + (1-\delta)(H_t)^2\right] - 1, \tag{31}$$

which is decreasing in γ for a given H_t due to the crowding-out effect of education investment but is increasing in H_t due to the positive effect of human capital on innovation. Equation (31) shows that the dynamics of g_t is completely determined by the dynamics of H_t given by (6).

We next determine the transitional path of output. Substituting (15) and (19) into (30) yields

$$\frac{N_{t+1}}{N_t} = \theta(1-l_t-e_t)H_t \Leftrightarrow 1+\theta H_{R,t} = \theta(H_{Y,t}+H_{R,t}), \tag{32}$$

which shows that $H_{Y,t} = 1/\theta$ even when the economy is off the balanced growth path. As a result, the level of output in (17) simplifies to

$$Y_t = \frac{1}{\theta}\left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)} N_t, \tag{33}$$

which shows that $Y_{t+1}/Y_t = N_{t+1}/N_t$ at any point in time.

We are now ready to examine the transitional effects of a change in parental preference for education when the degree of education preference γ changes from an initial value γ_0 to a new value γ_1. Suppose at time $t=0$ the economy is at an initial steady state with $\gamma=\gamma_0$. In this case, the initial value of human capital is $H_0 = \phi\gamma_0/(1+\eta+\delta\gamma_0)$, and the initial steady-state equilibrium growth rate is $g_0|_{\gamma=\gamma_0} = \theta\phi\gamma_0/(1+\eta+\delta\gamma_0)^2 - 1$. From (31), we see that when γ increases at time 0 from γ_0 to $\gamma_1 > \gamma_0$, the growth rate at time 0 immediately falls to

$$g_0|_{\gamma=\gamma_1} = \frac{\theta}{\phi(1+\eta+\gamma_1)}\left[\phi H_0 + (1-\delta)(H_0)^2\right] - 1 = \underbrace{\frac{1+\eta+\gamma_0}{1+\eta+\gamma_1}}_{<1}\frac{\theta\phi\gamma_0}{(1+\eta+\delta\gamma_0)^2} - 1 \tag{34}$$

given that H_0 is predetermined. Therefore, a stronger education preference has an initial negative impact on growth. Then, at time $t = 1$, the level of human capital increases to

$$H_1 = \frac{\gamma_1}{1+\eta+\gamma_1}[\phi + (1-\delta)H_0] = \underbrace{\frac{1+\eta+\gamma_0}{\gamma_0}\frac{\gamma_1}{1+\eta+\gamma_1}}_{>1}\frac{\phi\gamma_0}{1+\eta+\delta\gamma_0} > H_0, \tag{35}$$

which determines the equilibrium growth rate at time $t = 1$ given by

$$g_1 = \frac{\theta}{\phi(1+\eta+\gamma_1)}\left[\phi H_1 + (1-\delta)(H_1)^2\right] - 1 > g_0|_{\gamma=\gamma_1}, \tag{36}$$

where H_1 is given by (35). After the initial decrease, the equilibrium growth rate gradually increases until it reaches the new steady state given by $g^* = \theta\phi\gamma_1/(1+\eta+\delta\gamma_1)^2 - 1$, which may be higher or lower than the initial steady-state growth rate given that g^* is an inverted-U function in γ as demonstrated in (26) and Proposition 1. We summarize these results in Proposition 2 and plot in Figure 2 the transitional paths of g_t when γ increases at time 0 from γ_0 to γ_1.

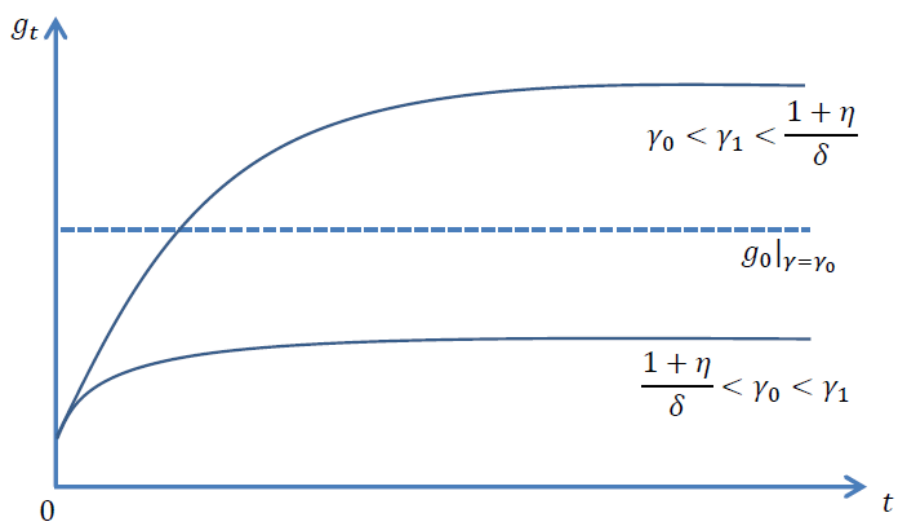

Figure 2: Transitional effect of education preference on growth

Proposition 2 *An increase in the degree of parental preference for education has an initial negative effect on the equilibrium growth rate and a gradual positive effect on the level of human capital. As the level of human capital increases, the equilibrium growth rate also increases. The new steady-state equilibrium growth rate may be higher or lower than the initial steady-state equilibrium growth rate.*

Using (31) and the transitional path of human capital in (6), we can also derive a closed-form solution for the complete transitional path of the equilibrium growth rate from the

initial steady state to the new steady state when γ increases at time 0 from γ_0 to γ_1. From (6), the equilibrium level of human capital at time $t+s$ for any $s \geq 1$ is given by

$$H_{t+s} = \frac{\phi\gamma_1}{1+\eta+\delta\gamma_1}\left\{1-\left[\frac{(1-\delta)\gamma_1}{1+\eta+\gamma_1}\right]^s\right\} + \left[\frac{(1-\delta)\gamma_1}{1+\eta+\gamma_1}\right]^s H_t, \tag{37}$$

where at time $t=0$, $H_t = H_0 = \phi\gamma_0/(1+\eta+\delta\gamma_0)$. Then, the equilibrium growth rate at time $t+s$ for any $s \geq 1$ is given by

$$g_{t+s} = \frac{\theta}{\phi(1+\eta+\gamma_1)}\left[\phi H_{t+s} + (1-\delta)(H_{t+s})^2\right] - 1, \tag{38}$$

where H_{t+s} is given in (37).

4 A scale-invariant extension of the model

In this section, we explore the robustness of our results by allowing for growth in human capital and removing a scale effect from the specification for technological progress.[12] To begin, we allow for growth in human capital by modifying (2) as follows.

$$H_{t+1} = \phi H_t e_t + (1-\delta)H_t, \tag{39}$$

where ϕH_t can be interpreted as an intertemporal externality effect of human capital H_t on the productivity of education e_t. In this case, the growth rate of human capital is given by

$$\frac{H_{t+1}-H_t}{H_t} = \phi e_t - \delta. \tag{40}$$

Therefore, the growth rate of human capital is now increasing in the level of education e_t. The rest of the individuals' optimization problem is the same as before. Solving the individuals' optimization problem, the equilibrium levels of education e_t and leisure l_t at any time t are given by

$$e_t = \frac{\gamma - (1+\eta)(1-\delta)/\phi}{1+\eta+\gamma}, \tag{41}$$

$$l_t = \eta\left[\frac{1+(1-\delta)/\phi}{1+\eta+\gamma}\right]. \tag{42}$$

Substituting (41) into (40) yields the following constant growth rate of human capital at any time t:[13]

$$\frac{H_{t+1}-H_t}{H_t} = \frac{\gamma(\phi+1-\delta)}{1+\eta+\gamma} - 1 \equiv g_H, \tag{43}$$

which is increasing in the degree γ of parental preference for education. We impose parameter restriction to ensure $g_H > 0$.

[12] See Jones (1999) for a discussion of the scale effect in the R&D-based growth model. Here a scale-invariant model means that the steady-steady equilibrium growth rate of technology is constant despite a growing human-capital-embodied labor supply.

[13] This condition holds regardless of whether or not the rest of the economy is on a balanced growth path.

To remove the scale effect from the specification for technological progress, we modify (15) as follows:[14]

$$\Delta N_t = \theta H_{R,t}. \tag{44}$$

The rest of the model is the same as before. In this case, the growth rate of technology N_t is given by

$$\frac{\Delta N_t}{N_t} = \theta \frac{H_{R,t}}{N_t}. \tag{45}$$

On the balanced growth path, R&D labor $H_{R,t}$ is proportional to the stock of human capital H_t. Therefore, a constant steady-state technology growth rate $\Delta N_t/N_t$ in (45) implies that the human-capital-technology ratio H_t/N_t must be constant in the long run. Therefore, the steady-state equilibrium growth rate of technology is given by

$$g_N^* = g_H = \frac{\gamma\left(\phi + 1 - \delta\right)}{1 + \eta + \gamma} - 1, \tag{46}$$

which is monotonically increasing in the degree γ of parental preference for education. Proposition 3 summarizes this result. This long-run implication of education preference on the steady-state equilibrium growth rate is different from the benchmark model because in the scale-invariant model the long-run growth rate of technology is determined by the growth rate of human capital. However, as we will show in the next subsection, a stronger preference for education continues to have a negative effect on the transitional growth rate in the scale-invariant model.

Proposition 3 *In the scale-invariant version of the model, the degree of parental preference for education has a positive effect on the steady-state equilibrium growth rate of technology and human capital.*

4.1 Transition dynamics of the scale-invariant model

We now explore the transition dynamics of the scale-invariant model and show that the economy converges to the balanced growth path. Substituting (44) into the zero-profit condition of R&D in (16) yields

$$\Delta N_t v_t = w_t H_{R,t} \Leftrightarrow \theta v_t = w_t. \tag{47}$$

Then, substituting (47) into the saving-asset equation in (21) yields

$$w_t(1 - l_t - e_t)H_t = N_{t+1} v_t \Leftrightarrow N_{t+1} = \theta(1 - l_t - e_t)H_t, \tag{48}$$

[14] Our results in Propositions 3 and 4 are robust to a more general specification given by $\Delta N_t = \theta N_t^{\xi} H_{R,t}$, where $\xi \in (0, 1)$. Derivations are available upon request.

where the equilibrium values of $\{e_t, l_t\}$ are given in (41) and (42). Let's define the human-capital-technology ratio as $h_t \equiv H_t/N_t$, which is a state variable. Equation (48) implies that the law of motion for h_t is given by

$$h_{t+1} \equiv \frac{H_{t+1}}{N_{t+1}} = \frac{1}{\theta(1-l_t-e_t)}\frac{H_{t+1}}{H_t} = \frac{\phi e_t + 1 - \delta}{\theta(1-l_t-e_t)}, \tag{49}$$

where the second equality uses (40). In other words, the human-capital-technology ratio h_t always reaches its steady state after one period.[15] Substituting (41) and (42) into (49) yields the steady-state value of h_t given by

$$h^* = \frac{\gamma\phi}{\theta}, \tag{50}$$

which is increasing in the degree γ of parental preference for education.

Substituting (41) and (42) into (48) yields the growth rate of technology as

$$\frac{N_{t+1}}{N_t} - 1 = \frac{\theta}{\phi}\left(\frac{\phi + 1 - \delta}{1+\eta+\gamma}\right) h_t - 1, \tag{51}$$

which shows that for a given h_t, an increase in the degree γ of education preference at time t leads to a temporary decrease in the growth rate of technology. Then, at time $t+1$, h_{t+1} increases to a higher steady-state value, which in turn increases the growth rate of technology also to a higher steady-state value given by (46). The intuition can be explained as follows. The increase in education preference causes parents to devote more time to educating their children, which in turn crowds out the amount of resources available for R&D investment. This explains the initial negative effect on growth. Overtime, the higher growth rate of human capital causes technology to also increase at a higher rate. This explains the long-run positive effect on growth. We summarize this result in Proposition 4.

Proposition 4 *In the scale-invariant version of the model, an increase in the degree of parental preference for education has an initial negative effect on the growth rate of technology but a positive effect on the growth rate of human capital. The new steady-state equilibrium growth rate of technology is higher than the initial steady-state equilibrium growth rate.*

Finally, we consider the transitional dynamics of output Y_t. Substituting (19), (44) and (47) into the saving-asset equation in (21) yields

$$H_{Y,t} = N_t/\theta. \tag{52}$$

Substituting (52) into (17) yields

$$Y_t = \left(\frac{\alpha}{\mu}\right)^{\alpha/(1-\alpha)} \frac{(N_t)^2}{\theta}. \tag{53}$$

[15] Here one period is given by one generation, so this implication is not entirely unrealistic. In a more general model with $\Delta N_t = \theta N_t^{\xi} H_{R,t}$, where $\xi \in (0,1)$, we would have a more general law of motion for h_t.

Therefore, the dynamics of output Y_t is determined by the dynamics of technology N_t. Due to growth in both technology and human capital, the long-run growth rate of output Y_t is $g_Y^* = (1 + g_N^*)^2 - 1$, where g_N^* is given in (46). Therefore, the long-run growth rate of output is also increasing in the degree γ of parental preference for education. However, an increase in the degree of education preference also has an initial negative effect on the growth rate of output by temporarily slowing down the rate of technological progress (i.e., the growth rate of N_t). Therefore, the short-run implication of education preference on the transitional growth rate of the economy is the same as in our benchmark model.

5 Conclusion

In this study, we have explored how parental preference for education affects economic growth. Although a stronger preference for education leads to more human capital which is conducive to innovation, the larger investment in education crowds out resources for R&D investment. As a result, a stronger parental preference for education carries a negative effect on economic growth, in addition to the conventional positive effect. Our tractable model allows us to trace out the complete transitional effects of changes in this education preference. We find that the initial impact of an increase in the degree of education preference on growth is always negative, which justifies policymakers' concern discussed in the introduction. However, this negative short-run effect on economic growth may be offset by a positive long-run effect of accumulating more human capital, which should also be taken into account for policy consideration.

References

[1] Aghion, P., and Howitt, P., 1992. A model of growth through creative destruction. *Econometrica*, 60, 323-351.

[2] Chen, C., and Uttal, D., 1988. Cultural values, parents' beliefs, and children's achievement in the United States and China. *Human Development*, 31, 351-358.

[3] Chu, A., Cozzi, G., and Liao, C., 2013. Endogenous fertility and human capital in a Schumpeterian growth model. *Journal of Population Economics*, 2013, 26, 181-202.

[4] Eicher, T., 1996. Interaction between endogenous human capital and technological change. *Review of Economic Studies*, 63, 127-44.

[5] Futagami, K., and Yanagihara, M., 2008. Private and public education: Human capital accumulation under parental teaching. *Japanese Economic Review*, 59, 275-291.

[6] Gilbert, R., and Shapiro, C., 1990. Optimal patent length and breadth. *RAND Journal of Economics*, 21, 106-112.

[7] Glomm, G., and Ravikumar, B., 1992. Public versus private investment in human capital: Endogenous growth and income inequality. *Journal of Political Economy*, 100, 818-834.

[8] Goh, A.-T., and Olivier, J., 2002. Optimal patent protection in a two-sector economy. *International Economic Review*, 43, 1191-1214.

[9] Grossman, G., and Helpman, E., 1991. Quality ladders in the theory of growth. *Review of Economic Studies*, 58, 43-61.

[10] Hashimoto, K., and Tabata, K., 2016. Demographic change, human capital accumulation and R&D-based growth. *Canadian Journal of Economics*, forthcoming.

[11] Huang, G., and Gove, M., 2012. Confucianism and Chinese families: Values and practices in education. *International Journal of Humanities and Social Science*, 2, 10-14.

[12] Iwaisako, T., and Futagami, K., 2013. Patent protection, capital accumulation, and economic growth. *Economic Theory*, 52, 631-668.

[13] Jones, C., 1999. Growth: With or without scale effects?. *American Economic Review*, 89, 139-144.

[14] Kipnis, A., 2011. *Governing Educational Desire: Culture, Politics, and Schooling in China*. The University of Chicago Press.

[15] Prettner, K., and Strulik, H., 2016. Technology, trade, and growth: The role of education. *Macroeconomic Dynamics*, forthcoming.

[16] Romer, P., 1990. Endogenous technological progress. *Journal of Political Economy*, 98, S71-S102.

[17] Segerstrom, P., Anant, T., and Dinopoulos, E., 1990. A Schumpeterian model of the product life cycle. *American Economic Review*, 80, 1077-91.

[18] Strulik, H., 2005. The role of human capital and population growth in R&D-based models of economic growth. *Review of International Economics*, 13, 129-145.

[19] Strulik, H., 2007. Too much of a good thing? The quantitative economics of R&D-driven growth revisited. *Scandinavian Journal of Economics*, 109, 369-386.

[20] Strulik, H., Prettner, K., and Prskawetz, A., 2013. The past and future of knowledge-based growth. *Journal of Economic Growth*, 18, 411-437.

[21] Zeng, J., 1997. Physical and human capital accumulation, R&D and economic growth. *Southern Economic Journal*, 63, 1023-1038.

[22] Zeng, J., 2003. Reexamining the interactions between innovation and capital accumulation. *Journal of Macroeconomics*, 25, 541-560.