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# Education, borrowing constraints and growth

Koji Kitaura *

*Faculty of Social Sciences, Hosei University, 4342 Aihara-cho, Machida-shi, Tokyo 194-0298, Japan*

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ABSTRACT

This paper studies the effects of educational borrowing constraints on economic growth and welfare. We consider a three-period-lived overlapping generations model in which individuals finance their educational expenditures by borrowing. We show that if the elasticity of human capital to educational expenditure is great enough, the relationship between the tightness of the constraints and the growth rate is inverted-U shaped when the constraints are binding. Moreover, when the constraints cease to be binding, the growth rate is constant. We also show that a relaxation of the constraints cannot be Pareto improving even if the growth rate rises.

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## 1. Introduction

Since the influential work by De Gregorio (1996),[1] many authors have theoretically analyzed the growth effects of borrowing constraints on human capital accumulation. Aghion et al. (2004) suggested that a relationship between borrowing constraints and growth is not monotonic and varies with economic development in their empirical analysis. Recently, de la Croix and Michel (2007) generated the inverted U-shaped relationship between borrowing constraint and the interest rate when individuals default on the debts incurred by borrowing for educational expenditures. However, the above authors did not consider both the effects of borrowing constraints and those of general-equilibrium factor price changes,[2] simultaneously in a model. In this study we construct a tractable growth model that explains this relationship in a different mechanism from the literature.

## 2. The model

We consider an overlapping generations model where individuals live for three periods without intergenerational altruism. Since we assume that parents do not have incentives to invest in human capital of their children, individuals have to borrow their educational expenditure in the capital market, and repay their debt. The population of each generation is the same and is normalized to one. Individuals born at $t-1$ are called generation $t$, and are homogenous except for their ages. The preference of any individual in generation $t$ is given by the utility function $U_t = \ln c_t + \rho \ln d_{t+1}$, where $c_t$ and $d_{t+1}$ are the individual's second- and third-period consumptions, respectively, and $\rho$ is the subjective discount rate ($0 < \rho < 1$).

In the first period of life, they choose their educational expenditure, $e_{t-1}$, and finance it by borrowing in the capital market. In the second period, they supply labor to the market and earn wages $w_t h_t$. This wage income is allocated to purchasing consumption goods $c_t$, repaying the debt $R_t e_{t-1}$, and savings $s_t$ for future consumption. In the third period, they spend all their savings and accrued interest on consumption, $d_{t+1} = R_{t+1} s_t$. Thus, the intertemporal budget constraint is:

$$w_t h_t = c_t + \frac{d_{t+1}}{R_{t+1}} + R_t e_{t-1}. \quad (1)$$

Prior to entering the workforce, human capital is accumulated through academic education. The individual's human capital $h_t$,

* Tel.: +81 42 783 3546.
*E-mail addresses:* koji.kitaura@gmail.com, kitaura@hosei.ac.jp.

1 De Gregorio (1996) showed that the borrowing constraints on human capital accumulation reduce the growth rate in a small open economy.

2 Trostel (1993) pointed out an important negative effect of taxation on human capital accumulation considering the effects of general factor price changes. Yakita (2004) showed that an increase in government subsidies to private educational debts might have a negative effect on economic growth, considering the effects of general-equilibrium factor price changes.

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which is assumed to be constant over their working period $t$, is given as:

$$h_t = \theta e_{t-1}^{\eta} h_{t-1}^{1-\eta}, \quad \theta > 0,\ 0 < \eta < 1, \tag{2}$$

where $h_{t-1}$ is the human capital stock of the parents' generation.

Individuals finance their educational expenditures by constrained borrowing. If the capital market is perfect, the young borrow the desired amount. In this paper, we assume that in imperfect capital market, the young can borrow at most only a fraction $\varphi$ of their future income[3]:

$$R_t e_{t-1} \le \varphi w_t h_t, \quad 0 < \varphi < 1. \tag{3}$$

Each household of generation $t$ maximizes its lifetime utility subject to (1)–(3). From the optimization conditions we have:

$$e_{t-1} = \begin{cases} \left(\varphi\theta \dfrac{w_t}{R_t}\right)^{\frac{1}{1-\eta}} h_{t-1} & \text{if } \eta \le \varphi \\ \left(\eta\theta \dfrac{w_t}{R_t}\right)^{\frac{1}{1-\eta}} h_{t-1} & \text{if } \eta > \varphi. \end{cases} \tag{4}$$

$$s_t = \frac{\rho}{1+\rho} I_t, \tag{5}$$

where $I_t \equiv w_t h_t - R_t e_{t-1}$. From (4), we can see that their educational expenditure increases the wage rate and the interest factor is part of the cost of education.

We assume that the economy produces a single good according to the following technology, $Y_t = AK_t^{\alpha} L_t^{1-\alpha}$, where $Y_t$, $K_t$ and $L_t$ are output, capital stock, and labor employed in period $t$, respectively. $A$ is the level of the technology. The usual solution to the firm's optimization problem sets factor costs equal to their marginal productivity:

$$R_t = \alpha A k_t^{\alpha-1}, \tag{6}$$

$$w_t = (1-\alpha) A k_t^{\alpha}, \tag{7}$$

where $k_t$ is the capital–labor ratio ($K_t/L_t$).

Since an individual works full time for one unit of time in his second period of life, his labor supply is $h_t$, and the labor demand of the economy in period $t$ is $L_t$. In a capital–market equilibrium, the next period's physical capital is equal to the savings of young adults less current borrowing for investments in education (e.g., Laitner (2000) and Yakita (2004)).[4] Thus, the equilibrium condition in the capital market is:

$$K_{t+1} = s_t - e_t. \tag{8}$$

## 3. Equilibrium

In this section we characterize the steady-state growth path. For our purpose, we must distinguish two regimes according to whether the constraints are binding or not. We define the balanced-growth rate as $1+\gamma = \frac{Y_{t+1}}{Y_t} = \frac{K_{t+1}}{K_t} = \frac{h_{t+1}}{h_t} = g_i$ ($i = \varphi, \eta$) and, making use of (2) and (4)–(8), we obtain the steady-state growth rate in the constrained regime $g_\varphi$ and in the unconstrained regime $g_\eta$, respectively:

$$g_i = \begin{cases} \Omega \left(\dfrac{\varphi^{1-\alpha}(1-\varphi)}{\alpha+\varphi(1-\alpha)}\right)^{\frac{\eta}{1-\alpha(1-\eta)}} & \text{if } \eta \le \varphi \\ \Omega \left(\dfrac{\eta^{1-\alpha}(1-\eta)}{\alpha+\eta(1-\alpha)}\right)^{\frac{\eta}{1-\alpha(1-\eta)}} & \text{if } \eta > \varphi \end{cases} \tag{9}$$

where $\Omega = \theta^{\frac{1-\alpha}{1-\alpha(1-\eta)}} \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\eta(1-\alpha)}{1-\alpha(1-\eta)}} \left(\frac{\rho}{1+\rho}\alpha(1-\alpha)A\right)^{\frac{\eta}{1-\alpha(1-\eta)}}$. The only difference between both regimes is that the parameter of the constraints $\varphi$ is replaced by the technological parameter of human capital production $\eta$.

## 4. Growth effects of borrowing constraints

In this section and the next, restricting our concern to the steady-state path, we analyze the effects of borrowing constraints on the growth rate. From (9), we have the following proposition:

**Proposition 1.** 1. *If the elasticity of human capital to educational expenditure is large enough, the relationship between the tightness of the constraints and the growth rate is inverted-U shaped when the constraints are binding.*
2. *If the elasticity of human capital to educational expenditure is small enough, the growth rate rises to an un-binding growth rate as the constraints become less restrictive.*

**Proof.** Differentiating (9) with respect to $\varphi$:

$$\frac{\partial g_\varphi}{\partial \varphi} = \frac{\Omega \varphi^{-\alpha}}{[\alpha+\varphi(1-\alpha)]^2} \times \frac{\eta}{1-\alpha(1-\eta)} \left(\frac{\varphi^{1-\alpha}(1-\varphi)}{\alpha+\varphi(1-\alpha)}\right)^{\frac{-(1-\eta)(1-\alpha)}{1-\alpha(1-\eta)}} \Gamma(\varphi)$$

where $\Gamma(\varphi) = -(1-\alpha)^2\varphi^2 + \alpha(2\alpha-3)\varphi + \alpha(1-\alpha)$. From the sign of $\Gamma(\varphi)$,

$$\begin{cases} \dfrac{\partial g_\varphi}{\partial \varphi} > 0 & \text{if } 0 < \varphi < \overline{\varphi} \\ \dfrac{\partial g_\varphi}{\partial \varphi} < 0 & \text{if } \overline{\varphi} < \varphi < 1 \end{cases} \tag{10}$$

where $\bar{\varphi} = \frac{\alpha(2\alpha-3)+\sqrt{\alpha(4-3\alpha)}}{2(1-\alpha)^2}$. □

It should be noted that the critical value $\bar{\varphi}$ depends on only the share of capital income. The relationship between the tightness of the constraints and the growth rate examined may be further clarified by a numerical example. Table 1 presents the share of capital income (Barro and Sala-i-Martin, 2003, p. 439), and these parameters generate $\bar{\varphi}$ and the maximizing growth rate when $\varphi = \bar{\varphi}$, respectively.

In addition, the elasticity of human capital to educational expenditure is from Trostel (1993), who used values of 0.1 and 0.25 for $\eta$.[5] Figs. 1a and 1b demonstrate numerical examples using US data. Proposition 1.1 indicates that there is an inverted-U shaped relationship between the tightness of the constraints and the growth rate as shown in Fig. 1a.[6]

3 de la Croix and Michel (2002) pointed out that financing of education spending can be achieved either through parental funding or through the capital market. The first setting is that parents can determine the educational level of their children, assuming that children are not allowed to borrow on the capital market. As a result, parental education funding depends on family resources. In this case, the dynamics will become more complex. The second type of borrowing constraints comes from the self-financing of education (Buiter and Kletzer, 1995; Chen, 2005). Recently, Chen (2005) gave a value of 24.95% to match the data of Jappelli and Pagano (1994), which in 1980 consumer credit was 16.1% of the net national product in the US, and that allows agents to borrow up to 16.1% of their future income.

4 Yakita (2004) pointed out that allocating more resources to education (i.e., human capital formation) may imply fewer resources available to physical-capital formation in the economy as a whole.

5 Rangazas (2000) chose $\eta = 0.20$ or 0.25 and Hendricks (1999) gave 0.30.

6 The parameters used in the baseline simulations are given as follows: $\rho = 0.3$, $\theta = 1$, $A = 1$ and Table 1.

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