Government Subsidy for Student Loans, Human Capital Accumulation and Economic Development

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Abstract

Devising effective economic policies that promote investment in human capital is essential for economic development. Government subsidy for student loans is often discussed as one of the various policy instruments that support human capital accumulation. The purpose of this study is to investigate the relationship between a government's subsidy rate for student loans and economic growth from a theoretical perspective. This study also considers how changes in life expectancy and the labor force population affect economic growth. To address these issues, we construct an overlapping-generations model with uncertain lifetime. Our model suggests that increasing the government's subsidy rate for student loans promotes economic growth. Moreover, there is a positive relationship between improved life expectancy among individuals with sufficient investment in human capital and economic growth. Furthermore, a decline in the labor force population decreases economic growth, even when negative peer effects are predominant in human capital formation.

Keywords Economic development, Human capital, Life expectancy, Peer effects, Student loans

JEL Classification H52, I22, I25, J11, O40

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1 Introduction

Economists widely recognize that human capital plays a crucial role in economic development. Specifically, since the seminal work of Lucas (1988), various models have been presented in the field of endogenous growth theory that accumulating human capital leads to sustained economic growth (e.g., see Caballé and Santos, 1993; De Gregorio, 1996; Blankenau and Simpson, 2004; Lu and Yanagihara, 2013; Noda, 2022). Additionally, many empirical studies have confirmed the evidence that human capital is a source of economic growth (e.g., Barro, 2001, Krueger and Lindahl, 2001; Sala-i-Martin et al., 2004; de la Fuente and Doménech, 2006; Cohen and Soto, 2007). Therefore, it is essential to consider effective economic policies that promote human capital accumulation in both developed and developing countries.

Government subsidies for student (or educational) loans are frequently discussed policy tools that support human capital accumulation. In the justification of a government's subsidy policy for student loans, it is argued that through government subsidies, more people have access to educational opportunities. Thereby, government subsidies promote economic growth through intergenerational externalities associated with human capital accumulation. However, as Yakita (2004) noted, it is not necessarily clear whether such subsidy policies are effective in promoting economic growth. Despite its significance, there has been limited theoretical research on the relationship between student loan subsidies and economic growth. Therefore, this study aims to clarify the impact of changes in the government subsidy rate for student loans on economic growth from a theoretical perspective based on an overlapping-generations (OLG) model.

Although, as mentioned above, there have been few theoretical studies in this field, several exceptional studies can be cited. Such studies include those conducted by Yakita (2004), Shindo (2010), and Eckwert and Zilcha (2014). Using a three-period OLG model with human capital accumulation, Yakita (2004) examined how changes in government subsidy rates for student loans impact economic growth, finding that such policies can have both positive and negative effects under certain conditions. In particular, Yakita (2004) noted that even with significant human capital externalities, increasing the subsidy rate may negatively impact long-term economic growth due to general equilibrium effects on prices of factors of production, potentially leaving future generations worse off.

Shindo (2010) examined the effects of education subsidies on regional economic growth and the disparities between two Chinese regions, Jiangsu and Liaoning, by simulating their economies using a six-period OLG model in which individuals decide their length of education. In addition, Shindo (2010) estimated the long-term growth rates (i.e., the steady-growth paths of the regional economies based on current education subsidies) and explored their effect on human capital accumulation in terms of economic growth while considering an increase in education subsidies. Shindo (2010) found that both regions achieve higher economic growth, as greater government subsidies in education induce individuals to invest in human capital.

Eckwert and Zilcha (2014) constructed a two-period equilibrium framework to analyze the effects of two subsidy regimes for higher education on human capital formation and income distribution. Under their model setting, individuals finance their investments in higher education through income-contingent education loans and subsidies from government. The subsidy is financed through taxes of various types. Moreover, Eckwert and Zilcha (2014) compared an egalitarian subsidy scheme, which reduces by a uniform amount the tuition fee charged to students, with a student loan subsidy that is proportional to the student's debt service obligation. Eckwert and Zilcha (2014) concluded that both types of subsidy reduce economy-wide underinvestment in higher education and lead to a more equal income distribution. Furthermore, according to social welfare criteria, the student loan subsidy regime is preferable if the subsidy level is predetermined, whereas the tuition subsidy regime is optimal if the subsidy level is a variable chosen by the government.

Among the studies mentioned, our work is most closely related to that of Yakita (2004), though key differences exist between the two. Specifically, Yakita (2004) assumed that the population size of each generation is unity, which precluded analysis of population changes on economic growth. Given the relevance of population decline in developed countries, our model examines the impact of changes in labor force population on long-term economic growth. Additionally, Yakita (2004) assumed that all individuals live for three periods. This means that people's life expectancy at birth is fixed at a constant value. However, as shown by Ashraf and Weil (2024, Ch.4), life expectancy in many developed countries has increased consistently from the 19th century to the present. On this historical basis, we examine the effect of an increase in longevity (improvement in life expectancy) on the long-term economic growth. Furthermore, on the basis of research on peer effects in the field of educational economics conducted by Aizer (2008), Chaudhuri and Sethi (2008), Lyle (2009), and Paulsen (2022), we believe that it is essential to consider the role of peer effects in the process of human capital formation. The peer effect is an interaction effect brought about by peer learning through friendly competition in, for example, the classroom. Specifically, if many students at the same school are enthusiastic about their studies, it is thought that peer effects increase synergistically and the academic performance of the individuals improves. This is an example of a particularly positive peer effect. Conversely, a negative peer effect may occur in environments with many unmotivated students. Although peer effects are an important element in the analysis of human capital accumulation as mentioned above, Yakita (2004) did not consider peer effects. In contrast, for the reasons above, we introduce an indicator of peer effects into the formulation of human capital accumulation. As understood from the above explanation, Yakita's (2004) model can also be interpreted as a simplified special case of our model.

The main results of our study are as follows. First, an increase in the government ' s subsidy rate for student loans promotes long-term economic growth. Second, improved life expectancy positively affects long-term economic growth. Third, a decline in the labor force population reduces the long-term growth rate, even when negative peer effects are dominant. Thus, the labor force population is a critical factor for sustained economic growth.

The remainder of the article is organized as follows. In Section 2, we explain the model setting and derive the economic growth rate per worker in a steady-state equilibrium. In Section 3, we examine comparative statics regarding the government subsidy rate for student loans, the increase in longevity of people, and the labor force population. Finally, Section 4 presents concluding remarks.

2 The Model

2.1 Households

We begin by describing the basic setup of our OLG model with uncertain lifetime regarding the behavior of households (individuals). In the closed economy, N individuals are born in each period. For simplicity, we assume that N is a constant. The cohort of individuals born at the beginning of period t is called generation t. All individuals are unisex and live for three periods at most. The first period is termed the childhood period, the second is termed the young adult period, and the third is termed the older adult period. Individuals of generation $t \geq 0$ can be presumed to live from their childhood period to their young adult period. However, their survival into the older adult period is uncertain. More specifically, people of generation $t \geq 0$ live in their older adult period with a probability of $\lambda \in (0, 1)$, but die at the beginning of the older adult period with a probability of $1 - \lambda$. This probability is common knowledge within the same generation and across different generations. In our model, λ is treated as a parameter. Therefore, the total population in each period is $(2 + \lambda)N$. In addition, when the aged ratio of a country is expressed as α, the relation $\alpha = \lambda/(2 + \lambda)$ holds. Figure 1 depicts the population of each generation from generation $t - 1$ to generation $t + 1$ and overlap between generations.

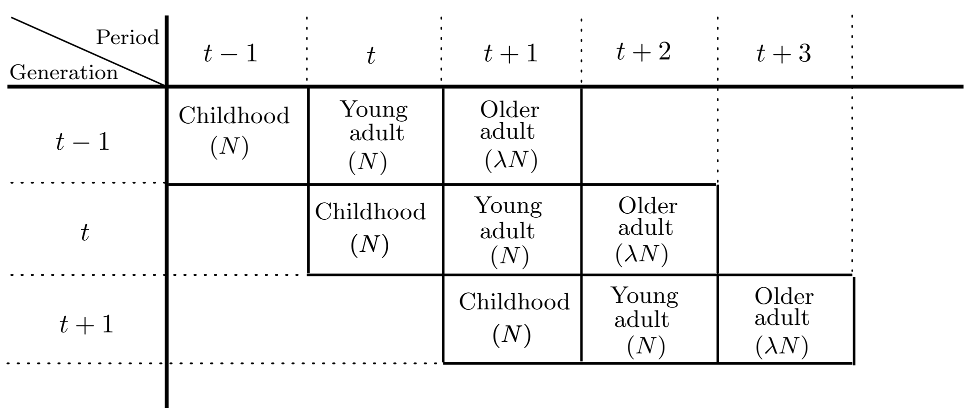

Figure 1: Population of each generation and overlap between generations

Let us consider individuals of generation $t - 1$. During their childhood, they invest in improving their skills by borrowing funds for their education. We represent their educational investment in childhood by e_{t-1}, which is a student loan, and their human capital in young adult period by h_t, and the individual's human capital thus accumulates according to

$$h_t = A\bar{h}_{t-1}^{\eta}(\mu e_{t-1})^{1-\eta}, \tag{1}$$

where $\bar{h}_{t-1}$ is the average human capital of generation $t-2$, which is the parent generation of individuals of the generation $t-1$, the parameter $\eta \in (0,1)$ is the elasticity of an individual's human capital in generation $t-1$ with respect to the average human capital in the parent generation of generation $t-1$, and the parameter $A > 0$ is the total factor productivity related to human capital accumulation. The term $\mu > 0$ is a parameter related to the level of effectiveness of human capital formation. Therefore, μ is interpreted as a type of the peer effects in the accumulation of human capital. As discussed in Section 1, peer effects in human capital accumulation have received increasing attention in the field of educational economics. In our model, peer effects refer to educational influences in childhood period, where individuals are affected directly and indirectly by peers in their generation during human capital formation. Following Noda (2022), we formulate peer effects as $\mu = N^{\omega}$. Here, ω is a parameter that satisfies $-1 < \omega < 1$. That is, we assume that there are positive and negative peer effects. In our model, $0 < \omega < 1$ indicates a state in which a positive peer effect is dominant, whereas $-1 < \omega < 0$ indicates a state in which a negative peer effect is dominant. Consequently, Eq. (1) can be rewritten as

$$h_t = A\bar{h}_{t-1}^{\eta}e_{t-1}^{1-\eta}N^{\nu}. \tag{2}$$

In Eq. (2), we define ν as $\nu \equiv \omega(1-\eta)$ to shorten the symbol notation. Note that the term N^{ν}, which reflects the peer effect, is regarded as a given for individuals. Moreover, all individuals engage in work only in the young adult period and inelastically provide one unit of human capital.

Here, we assume the presence of risk-neutral insurance companies and a perfectly competitive private annuity market based on the work of Yaari (1965). In this case, if the interest rate in period t is expressed as r_t, the rate of return on pensions received by individuals in generation $t-1$ who continue to live in their older adult period is $(1+r_{t+1})/\lambda$. The budget constraint of an individual of generation $t-1$ in the young adult period is given by

$$w_t h_t - T_t = c_t^1 + s_t + (1-\varepsilon)(1+r_t)e_{t-1}, \tag{3}$$

where w_t is the wage rate, T_t is the lump-sum tax, c_t^1 is the consumption in the young adult period of an individual in generation $t-1$, s_t is the savings in the young adult period of an individual of generation $t-1$, and ε is the subsidy rate provided by the government to the individual's debt payment of a student loan. The budget constraint of an individual in generation $t-1$ in their the older adult period is given by

$$\frac{(1+r_{t+1})s_t}{\lambda} = c_{t+1}^2, \tag{4}$$

where c_t^2 is the consumption in the older adult period of an individual in generation $t-1$. Considering Eqs. (3) and (4), the lifetime budget constraint of an individual in generation $t-1$ is given by

$$w_t h_t - T_t = c_t^1 + \frac{\lambda c_{t+1}^2}{(1+r_{t+1})} + (1-\varepsilon)(1+r_t)e_{t-1}. \tag{5}$$

The lifetime utility function of an individual born in period $t-1$ is formulated as

$$U_{t-1} = \log c_t^1 + \lambda\rho \log c_{t+1}^2, \tag{6}$$

where $\rho \in (0,1)$ is the subjective discount factor. Households maximize utility as shown in Eq. (6) under the budget constraint in Eq. (5). Following Yakita (2004), we consider the household's optimization problem in two steps. The first step involves maximizing the net return on educational expenditure. Specifically, the individual determines the education investment expenditure e_{t-1} that maximizes $w_t A\bar{h}_{t-1}^{\eta} e_{t-1}^{1-\eta} - T - (1-\varepsilon)(1+r_t)e_{t-1}$ under the condition of Eq. (2). First, Eqs. (2) and (3) lead to

$$w_t A\bar{h}_{t-1}^{\eta} e_{t-1}^{1-\eta} N^{\nu} - T - (1-\varepsilon)(1+r_t)e_{t-1} = c_t^1 + s_t. \tag{7}$$

By calculating e_{t-1} that maximizes the left-hand side of Eq. (7), we obtain

$$e_{t-1} = \left[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{w_t}{1+r_t}\Big)\right]^{\frac{1}{\eta}} \bar{h}_{t-1}. \tag{8}$$

Here, we express the maximized net earnings as I_t. Moreover, it follows from Eqs. (2) and (8) that

$$w_t h_t - (1-\varepsilon)(1+r_t)e_{t-1} = \frac{(1-\varepsilon)\eta}{1-\eta}(1+r_t)\left[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{w_t}{1+r_t}\Big)\right]^{\frac{1}{\eta}} \bar{h}_{t-1}. \tag{9}$$

Therefore, by subtracting the lump-sum tax T_t from the right-hand side of Eq. (9), I_t is written as

$$I_t = (1+r_t)\frac{(1-\varepsilon)\eta}{1-\eta}\Big[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{w_t}{1+r_t}\Big)\Big]^{\frac{1}{\eta}}\bar{h}_{t-1} - T_t. \tag{10}$$

The second step is the individual's lifetime utility maximization problem. Considering Eq, (10), the budget constraint in Eq. (3) is rewritten as

$$\begin{aligned} c_t^1 + s_t &= w_t h_t - T_t - (1-\varepsilon)(1+r_t)e_{t-1} \\ &= I_t. \end{aligned} \tag{11}$$

Thus, Eq. (11) implies that

$$c_t^1 = I_t - s_t. \tag{12}$$

The substitution of Eqs. (4) and (12) into Eq. (6) leads to

$$U_{t-1} = \log(I_t - s_t) + \lambda\rho\log\Big[\frac{(1+r_{t+1})s_t}{\lambda}\Big]. \tag{13}$$

Therefore, households maximize the lifetime utility given in Eq. (13). Solving this problem yields

$$s_t = \Big(\frac{\lambda\rho}{1+\lambda\rho}\Big)I_t. \tag{14}$$

2.2 Firms

Next, we analyze the behavior of firms. In this economy, a single homogeneous good, which is regard as the numéraire, is produced and its price is normalized to unity. For simplicity, we assume that physical capital fully depreciates after one period. When firms produce homogeneous goods, they pay a wage rate, w_t, for human capital input and pay a rental price, $1+r_t$, for physical capital input.

Firms have access to the same production technology. Specifically, the aggregate production function is given by

$$Y_t = K^{\beta}H_t^{1-\beta}, \tag{15}$$

where Y_t is the flow of aggregate output, which is interpreted as the gross domestic product (GDP), K_t is the aggregate physical capital input, and H_t is the aggregate human capital input. The Cobb–Douglas production function in Eq. (15) can then be written in intensive form as

$$y_t = k^{\beta} h_t^{1-\beta}, \tag{16}$$

where $y_t \equiv Y_t/N$ is the output per worker, $k_t \equiv K_t/N$ is the physical capital per worker, and $h_t \equiv H_t/N$ is the human capital per worker.

A perfectly competitive firm, which takes $1 + r_t$ and w_t as given, maximizes profit by setting

$$1 + r_t = \beta\left(\frac{k_t}{h_t}\right)^{\beta-1}. \tag{17}$$

Therefore, the firm chooses the ratio of physical capital to human capital that equates the marginal product of physical capital to the rental price. Moreover, in the subjective equilibrium of firms, the profit for a perfectly competitive firm is zero. This requires that the wage rate equals the marginal product of human capital. We thus obtain

$$w_t = (1-\beta)\left(\frac{k_t}{h_t}\right)^{\beta}. \tag{18}$$

2.3 Government

The government uses revenue from lump-sum tax collected from households to finance the education debts of individuals. Specifically, it provides subsidies at the rate of ε to repay individuals' educational debts. Additionally, we assume that the government maintains a balanced budget. In this case, the government's budget constraint is given by

$$T_t N = \varepsilon(1 + r_t)e_{t-1}N. \tag{19}$$

In Eq. (19), the left-hand side represents revenue and the right-hand side represents expenditure.

2.4 Steady-state Equilibrium

In any period, physical capital is financed by the difference between young people's savings in the previous period and their childhood borrowings. Therefore, in equilibrium in the physical capital market, it holds that

$$k_{t+1} = s_t - e_t. \tag{20}$$

According to Eqs. (4) and (8), Eq. (20) can be rewritten as

$$k_{t+1} = \left\{ \frac{\lambda\rho w_t}{1+\lambda\rho}\Big[1-\Big(1-\frac{1-\eta}{1-\varepsilon}\Big)\Big] - \Big[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{w_{t+1}}{1+r_{t+1}}\Big)\Big]^{\frac{1}{\eta}} \right\} h_t. \tag{21}$$

Here, we denote a physical capital–human capital ratio at the beginning of period t by x_t. It follows from Eqs. (2), (14), (17), and (18) that

$$\frac{h_{t+1}}{h_t} = AN^{\nu}\Big[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{1-\beta}{\beta}\Big)x_{t+1}\Big], \tag{22}$$

where $x_{t+1} = k_{t+1}/h_{t+1}$. Considering Eq. (18) and dividing both sides of Eq. (21) by h_{t+1}, we get

$$x_{t+1} = \left\{ \frac{\lambda\rho}{1+\lambda\rho}(1-\beta)x_t^{\beta}\Big[1-\Big(1-\frac{1-\eta}{1-\varepsilon}\Big)\Big] - \Big[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{1-\beta}{\beta}x_{t+1}\Big)\Big]^{\frac{1}{\eta}} \right\} \frac{h_t}{h_{t+1}}. \tag{23}$$

Moreover, the substitution of Eqs. (22) and (23) into Eq. (21) leads to

$$\begin{aligned} x_{t+1} \;=\; & \left\{ \Big(\frac{\lambda\rho}{1+\lambda\rho}\Big)(1-\beta)x_t^{\beta}\Big[1-\Big(1-\frac{1-\eta}{1-\varepsilon}\Big) - \Big[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{1-\beta}{\beta}\Big)x_{t+1}\Big]^{\frac{1}{\eta}} \right\} \\ & \times AN^{\nu}\Big[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{1-\beta}{\beta}\Big)x_{t+1}\Big]. \end{aligned} \tag{24}$$

Furthermore, by dividing both sides of Eq. (24) by x_{t+1} and after some manipulation, we obtain

$$\begin{aligned} x_{t+1} &= f(x_t) \\ &= \theta^{\eta} x_t^{\beta\eta}, \end{aligned} \tag{25}$$

where

$$\theta \equiv \frac{(1-\beta)\Big(\frac{\lambda\rho}{1+\lambda\rho}\Big)\Big[AN^{\nu}\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{1-\beta}{\beta}\Big)\Big]^{\frac{(\eta-1)}{\eta}}\Big[1-\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big]}{AN^{\nu}\Big[1+\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{1-\beta}{\beta}\Big)\Big]}. \tag{26}$$

Note that for $\theta > 0$ to hold, the condition $\eta > \varepsilon$ must be satisfied. In addition, because the relation $0 < \beta\eta < 1$ holds, the behavior of x_t in Eq. (25) is as shown in Figure 2.

Figure 2 confirms that $\lim_{t\to\infty} x_t = \widehat{x}$ holds. In other words, x_t converges toward a steady-state value, $\widehat{x}$, over time. It follows from Eq. (25) that

$$\widehat{x} = \theta^{(\frac{\eta}{1-\beta\eta})}. \tag{27}$$

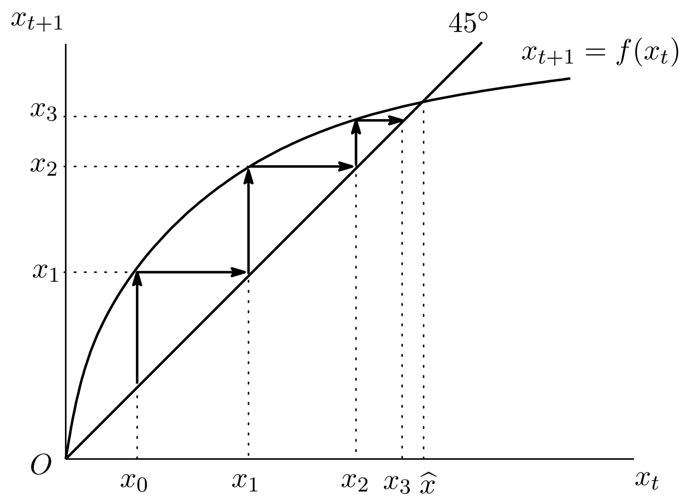

Figure 2: Behavior of the ratio of physical capital to human capital

Therefore, in the steady-state equilibrium of our model, it is confirmed by Eq. (16) that in terms of the gross growth rates of y_t, k_t, and h_t, it holds that

$$\frac{y_{t+1}}{y_t} = \frac{k_{t+1}}{k_t} = \frac{h_{t+1}}{h_t} \equiv \gamma.$$

Specifically, considering the relationship of Eqs. (22), (26), and (27), γ is obtained as

$$\gamma = A^{\frac{1}{\eta}} N^{\frac{\nu}{\eta}} \theta^{(\frac{1-\eta}{1-\beta\eta})} \Big[\Big(\frac{1-\eta}{1-\varepsilon}\Big)\Big(\frac{1-\beta}{\beta}\Big)\Big]. \tag{28}$$

Hence, from Eq. (28), $\gamma - 1$ can be interpreted as the long-term growth rate of GDP per worker. In the following discussion, we simply refer to the gross growth rate as the growth rate.

3 Comparative Statics

According to our model setting and the analytical results in Section 2, we focus on the steady-state equilibrium and examine comparative statics in this section. First, we analyze the relationship between the government's subsidy rate, ε, for student loans (or education debt payments) and the long-term economic growth rate, γ in Eq. (28). We find that the relation $\partial\gamma/\partial\varepsilon > 0$ holds. That is, unlike the result for Yakita's (2004) model, an increase in the subsidy rate for student loans definitely increases the long-term economic growth rate. This outcome is reasonable, as a higher subsidy rate boosts individuals ' disposable income, which in turn supports greater consumption and economic growth. Notably, our comparative statics result aligns with Shindo's (2010) model.

Next, we consider the relationship between improved life expectancy and the long-term economic growth rate. As mentioned in Section 2, improved life expectancy is captured by a higher survival probability survival probability, λ, in the older adult period. Recall that the rate of the elderly population in our model is $\alpha = \lambda/(2 + \lambda)$. The relation $\partial\alpha/\partial\lambda > 0$ then holds. Therefore, an increase in λ means an increase in the rate of the elderly population in our model. When we calculate the qualitative effect that longer lifespans (or an increase in the rate of the elderly population) has on the economic growth rate, it is easy to confirm that the relation $\partial\gamma/\partial\lambda > 0$ holds. In other words, under our model settings, population aging positively affects the long-term economic growth rate.

Intuitively, population aging (an increase in the probability of survival in the older age period) means that the consumption demand for goods increases in each period. That is, it is interpreted that economic growth is promoted through such a demand creation effect of consumption. Additionally, the implications of our model regarding aging and economic growth are consistent with simulation results obtained by Fougère and Mérette (1999). This supports a positive relationship between improved life expectancy when individuals invest sufficiently in human capital and the long-term economic growth rate. Furthermore, He and Li's (2020) empirical analysis indicates that the positive impact of life expectancy on economic growth is stronger in highly aged groups, as longer life expectancy enhances human capital returns, encouraging more investment in education and thus boosting economic growth.

Finally, we focus on the relationship between the labor force population, N, and long-term economic growth rate, γ. Although the calculated result for $\partial\gamma/\partial N$ is complex, we find that if $\omega < 0$, then the relation $\partial\gamma/\partial N > 0$ holds. This result, while counterintuitive, can be understood as follows: a decline in the labor force population reduces the long-term economic growth rate, even when negative peer effects dominate. Thus, the labor force population is a critical determinant of long-term economic growth.

4 Concluding Remarks

We examined the relationship between a government subsidy rate for student loans and the long-term growth rate of GDP per worker within the context of an OLG model with uncertain lifetime. We also considered effects of changes in life expectancy and the labor force population on the long-term growth rate of GDP per worker.

This study's main contribution lies in deriving meaningful findings that expand the existing knowledge in this field, based on a more generalized framework that extends Yakita's (2004) OLG model. Specifically, by incorporating peer effects, the labor force population, and increased life expectancy identifies new determinants of long-term GDP growth per worker, which were not addressed in previous research. Expanding the analysis to include these factors is therefore a significant contribution to the field.

The key findings of this study are as follows. First, regarding the government's subsidy rate for student loans and GDP growth per worker, Yakita's (2004) model found both positive and negative effects under specific conditions. In contrast, our generalized model shows that increasing the subsidy rate for education loans consistently promotes long-term growth rate of GDP per worker, indicating that Yakita's conclusion does not necessarily hold. This positive effect is also consistent with the implication of Shindo's (2010) model. Second, our model shows that increased life expectancy positively affects long-term growth rate of GDP per worker, particularly among individuals with substantial human capital investment, a result supported by Fougère and Mérette (1999) and He and Li (2020). Finally, a decline in the labor force population negatively impacts long-term growth rate of GDP per worker, even when negative peer effects are prevalent in human capital formation. With developed countries like Japan, Italy, and Germany facing population decline, our model underscores the urgency of addressing this demographic issue to economic development.

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