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Human capital accumulation, labor supply of the elderly and government policy

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Abstract

This study examines the effect of the PAYG tax rate from short- and long-run perspectives using an overlapping-generations model with pay-as-you-go (PAYG) social security and retirement decision-making by the government. The findings are as follows: First, when the government is myopic, a tax rate exists that maximizes the utility of the present generation or some other generation in transition. In this case, the reason for introducing a PAYG pension is acknowledged. Second, when the government is concerned only with the economic growth rate in the long run, the tax rate has a negative effect on the economic growth rate, which means that PAYG social security should not be introduced. Third, the long-term economic growth rate can increase if retirement is prolonged.

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1. Introduction

This paper constructs an overlapping-generations model with pay-as-you-go (PAYG) pension and retirement decision-making by the government under human capital accumulation to compare the effects of the PAYG pension and the retirement age on the utility and economic growth rate with those obtained in a neoclassical growth.

Many developed countries have been facing the problem of the sustainability of the PAYG pension system as longevity has risen and birth rates have fallen. To sustain the current PAYG pension system, several countries have increased their official pension ages. Several empirical works show that social security benefits affect retirement decisions (Gruber & Wise 1999, and Fenge & Pestieau 2007).

Various theoretical studies have analyzed old individuals' retirement decision-making. Some studies investigated how the endogenous determination of retirement age affects economies. For example, Mizuno and Yakita (2013) prove that the restriction of the elderly labor supply by the central planner would not only be socially undesirable but also depress the fertility rate of the economy. Furthermore, Cipriani and Fioroni (2021) show that if the tax rate is sufficiently low, individuals may find it optimal to retire later and decrease fertility less with an increase in life expectancy. In contrast, Miyazaki (2014) considers the exogenous determination of retirement age by the government and indicates that if the government raises the official pension age, the labor supply of the elderly increases, whereas physical capital through savings and the social security benefit per unit of time can decrease. Similarly, Chen (2018) found that a higher retirement age reduces pension benefits with exogenous retirement age.

As for the effects on welfare, Chen and Miyazaki (2018) developed an overlapping-generations model to examine the impact of PAYG pension on welfare and demonstrated that if the social security tax rate is below a certain value, it has a positive effect on welfare. Based on this, Cipriani and Fioroni (2022) found that there exists an optimal tax rate at which government achieves the social optimum under the PAYG pension system and retirement policies. However, because these analyses were conducted in a neoclassical growth framework with physical capital accumulation, it should be verified whether these results still hold in an endogenous growth framework with human capital accumulation.

Therefore, this study investigates the effect of the PAYG tax rate on the economy from the government's myopic and hyperopic perspectives when human capital is accumulated through education investment. We show that the existence of retirement time settled by the government will lead to different tax rate effects on the utility of the present or some other generation in transition and the economic growth rate in the long run. When the government is myopic, an optimal PAYG tax rate exists that maximizes the utility of the present or some other generation. Conversely, if the government has a long-term perspective, the PAYG tax rate has a negative effect on the economic growth rate; therefore, PAYG social security should not be introduced.

The remainder of this paper is organized as follows: The model is presented in Section 2. A discussion and analysis of the effects on utility and growth are presented in Section 3. Section 4 presents the numerical example. Finally, we conclude the paper in Section 5.

2. Model

The model is based on a Diamond (1965)-type overlapping-generations model in which time is discrete and extends from one to infinity; however, accumulation is conducted through human capital rather than physical capital. We assume that individuals are identical within each generation, and that the population grows at $N_{t+1} = nN_t$ $(n > 0)$.

2.1 Individual

Individuals live through two periods, young and old, and one unit of time is endowed in each period. In period *t*, they are born as members of young generations with human capital, h_t, which is inherited from their parents and its level is the same as that of their parents, as a kind of externality. These young generations inelastically supply one unit of labor time and earn labor income which is equal to the level of human capital. On this labor income, the payroll tax is levied at a rate of $\tau \in (0,1)$ and the after-taxed income is distributed between consumption in the young period, c_t^y, and education investment, e_t. Therefore, the budget constraint of the young generation in period *t* can be written as:

$$c_t^y + e_t = (1-\tau)h_t. \tag{1}$$

The education investment made in the young period, contributes to the accumulation of their own human capital when they grow old. Based on the forms adapted in Krebs (2003), Grossmann (2008), and Lu and Yanagihara (2013), we assume that the level of human capital in the old period linearly depends linearly on the amount of education investment. Hence, human capital accumulation technology is expressed as

$$h_{t+1} = \theta e_t, \tag{2}$$

where $\theta \geq 1$ is a human capital productivity parameter.

In the old period, individuals work for $1 - l^o$ unit of time as a retirement age, which is regulated by the government, to receive labor income, $(1 - l^o)h_{t+1}$, and spend $l^o \in (0,1)$ unit of time as a retirement time. The same applies to the young generation, they must pay the payroll tax on the labor income at a rate of τ. Additionally, they receive a pension benefit, $l^o p_{t+1}$, which depends on the duration of the retirement time. The old individuals' budget constraint in period $t+1$ is

$$c_{t+1}^o = (1-\tau)(1-l^o)h_{t+1} + l^o p_{t+1}, \tag{3}$$

where c_{t+1}^o is the consumption in the old period.

Individuals' lifetime utility is given by the following log-linear function as:

$$U\left(c_t^y, c_{t+1}^o\right) = lnc_t^y + \beta lnc_{t+1}^o, \tag{4}$$

where $\beta \in (0,1)$ is the discount factor for the preference over consumption in the old period. They maximize their utility, (4), subject to budget constraints in the young and old periods, (1) and (3), respectively, and the human capital accumulation technology (2); hence, the optimal choice can be obtained as

$$c_t^y = \frac{\frac{l^o p_{t+1}}{(1-l^o)\theta} + (1-\tau)^2}{(1+\beta)(1-\tau)} h_t, \tag{5}$$

$$c_{t+1}^{o} = \frac{\beta[l^o p_{t+1} + (1-l^o)\theta(1-\tau)^2 h_t]}{1+\beta}, \tag{6}$$

$$e_t = \frac{\beta(1-\tau)^2 h_t - \frac{l^o p_{t+1}}{\theta(1-l^o)}}{(1+\beta)(1-\tau)}. \tag{7}$$

2.2 Government

The total labor supply in period *t+1* comprises by the labor supply of the young generation, $N_{t+1} = nN_t$, and that of the old generation, $(1-l^o)N_t$. Therefore, it can be represented as $N_t[(1-l^o)+n]$. In every period, the government must balance its budget for the PAYG social security. We assume that PAYG pension benefit is perfectly financed by the payroll tax. Thus, the government budget constraint can be expressed as

$$l^o p_{t+1} = \tau h_{t+1}[(1-l^o)+n]. \tag{8}$$

By substituting (2), (7) into (8), the pension benefit can be represented by a function of τ:

$$p_{t+1} = \frac{(1-l^o)(1+n-l^o)\beta\theta(1-\tau)^2\tau}{l^o[(1-l^o)(1+\beta-\beta\tau)+n\tau]} h_t. \tag{9}$$

2.3Equilibrium

In equilibrium, the levels of consumption in the young and old periods and the education investment per efficiency unit of labor can be obtained by substituting (9) into (5), (6) and (7) as follows:

$$\hat{c}_t^y = \frac{(1-\tau)(1-l^o+n\tau)}{(1-l^o)(1+\beta-\beta\tau)+n\tau}, \tag{10}$$

$$\hat{c}_{t+1}^o = \frac{(1-l^o)\beta\theta(1-\tau)^2(1-l^o+n\tau)}{(1-l^o)(1+\beta-\beta\tau)+n\tau}, \tag{11}$$

$$\hat{e}_t = \frac{(1-l^o)\beta(1-\tau)^2}{(1-l^o)(1+\beta-\beta\tau)+n\tau}, \tag{12}$$

where $\hat{c}_t^y \equiv \frac{c_t^y}{h_t}$, $\hat{c}_{t+1}^o \equiv \frac{c_{t+1}^o}{h_t}$ and $\hat{e}_t \equiv \frac{e_t}{h_t}$.

By substituting (10) and (11) into (4), the utility per efficiency unit of labor, the equilibrium level of $\hat{U}_t$, can be obtained as:

$$\hat{U}_t = ln\left[\frac{(1-\tau)(1-l^o+n\tau)}{(1-l^o)(1+\beta-\beta\tau)+n\tau}\right] + \beta ln\left[\frac{(1-l^o)\beta\theta(1-\tau)^2(1-l^o+n\tau)}{(1-l^o)(1+\beta-\beta\tau)+n\tau}\right]. \tag{13}$$

Finally, the growth rate of human capital, that is, the economic growth rate, can be obtained from (2) and (12) as follows:

$$g_t \equiv \frac{h_{t+1}}{h_t} = \frac{\theta\beta(1-l^o)(1-\tau)^2}{(1-l^o)(1+\beta-\beta\tau)+n\tau}. \tag{14}$$

It should be noted that from (10) to (12) the levels of consumption and education investment in per efficiency of labor are constant and from (14) the economic growth rate is also constant these mean that the economy is necessarily on the steady growth path.

3 Short-run and long-run analyses

In this section, based on previous findings, we conduct short- and long-run analyses under the PAYG social security system. Namely, first, we obtain the PAYG social security tax rates to maximize the utility of the initial generation and the economic growth rate. Additionally, we investigate the effect on the utility and economic growth rate when the retirement age is prolonged.

3.1 Utility

Here, we consider a situation in which the government maximizes the utility of the initial generation.

By setting $\frac{\partial \hat{U}_t}{\partial \tau} = 0$, we obtain the PAYG social security tax rates as,

$$\tau_1 = \frac{-(1-l^o+n)\sqrt{\beta(1-l^o)}\sqrt{(1-l^o)\beta^3+4n(1+\beta)(1+2\beta)}-(1-l^o)[n(2+6\beta+3\beta^2)-\beta^2(1-l^o)]}{2n(1+2\beta)(n+(-1+l^o)\beta} < 0,$$

and

$$\tau_2 = \frac{(1-l^o+n)\sqrt{(1-l^o)^2\beta^4+(1-l^o)4n\beta(1+\beta)(1+2\beta)}-(1-l^o)[n(2+6\beta+3\beta^2)-\beta^2(1-l^o)]}{2n(1+2\beta)[n-(1-l^o)\beta]}.$$

Because of $\left.\frac{\partial^2 \hat{U}}{\partial \tau^2}\right|_{\tau=\tau_2} < 0$, if we limit the argument for the situation of $\tau_2 \in (0,1)$, we can obtain the following proposition regarding the maximum of utility.

Proposition 1

There exists the PAYG social security tax rate, which maximizes the utility level per efficiency unit of labor of the generation in some transitional periods, i.e., PAYG pension is required to maximize the utility under the situation where the government sets the retirement time.

It can be considered that this proposition explains why governments have applied the PAYG pension in a real economy. That is, from the myopic perspective, it appears that governments have introduced the PAYG pension to maximize the utility of the present or some transitional generation.

In addition, from (13), we can obtain the following result,

$$\frac{\partial \hat{U}_t}{\partial l^o} = -\beta \frac{(1-l^o)[(1-l^o)(1+\beta-\beta\tau)+n\tau]+(1-l^o+n)n\tau^2}{(1-l^o)(1-l^o+n\tau)[(1-l^o)(1+\beta-\beta\tau)+n\tau]} < 0,$$

which indicates that the extension of the retirement time has a negative effect on utility. This can be easily interpreted: in our framework, when retirement age is prolonged, the income becomes larger, which brings about an increase in consumption.

3.2Growth rate

In our framework, it is also important to consider that the government maximizes the growth rate, instead of utility, if it has a long-term perspective. From (14), we can calculate,

$$\frac{\partial g}{\partial \tau} = -\frac{(1-l^o)\beta\theta(1-\tau)[n+(1-l^o)(2+\beta-\beta\tau)+n\tau]}{[(1-l^o)(1+\beta)+n\tau-(1-l^o)\beta\tau]^2} < 0. \quad (15)$$

We can easily verify that an increase in the PAYG social security tax rate has a negative effect on the economic growth rate. Therefore, we propose the following proposition:

Proposition 2
If the government maximizes the growth rate, then the PAYG social security tax rate is zero. That is, PAYG pension should not be introduced even in a situation where the government sets the retirement time in the old period.

This result contrasts with Proposition 1, in which a PAYG pension is desirable from a myopic perspective. (1) and (12) show that an increase in the PAYG social security tax rate directly decreases after-tax income, which leads to a decrease in education investment. Thus, the economic growth rate, determined by human capital accumulation through education investments, decreases. This implies that the tax rate should be set to zero.

The idea from the above proposition can be applied to the case where retirement age is prolonged: if retirement age is set later, the (after-tax) income increases. This implies that the return on the education investment becomes more beneficial. In fact, from (14), we have

$$\frac{\partial g}{\partial l^o} = -\frac{n\beta\theta(1-\tau)^2\tau}{[(1-l^o)(1+\beta-\beta\tau)+n\tau]^2} < 0.$$

We are able to verify that the economic growth rate decreases with retirement duration. Therefore, we arrive at the following proposition.

Proposition 3
If the retirement age is prolonged, then the economic growth rate increases.

This result is different from that obtained in Miyazaki (2014), in that if the government raises the official pension age (the retirement age in our analysis), the economic growth rate does not necessarily increase in the long run. The main reason for the difference in these results can be attributed to the differences in the engines of economic growth. Miyazaki (2014) considers the accumulation of physical capital within a neoclassical framework. In this circumstance, the delay in the retirement age leads to two effects on the total production: labor input becomes larger, and the per-capita capital level becomes lower. The configuration of these two effects determines whether the total production increases. In contrast, as we have mentioned, we consider the accumulation of human capital in an endogenous growth framework. In this framework, economic growth is perfectly determined by investments in education. Therefore, as the retirement time is prolonged, the economic growth rate also increases.

4 Numerical illustration

In this section, we calibrate the utility level and economic growth rate using the model presented above.

We set the values of the parameters to reflect Japan's real economy. The discount factor (β) was, set to 0.710, as used by in Bouzahzah et al. (2002). The productivity of human capital (θ) is normalized to 1, following Yanagihara and Nakabayashi (2010). The average population growth rate (n) in Japan from 2017 to 2021 is 0.996[1].

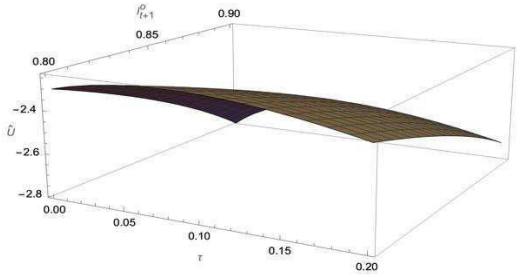

Fig.1 Utility

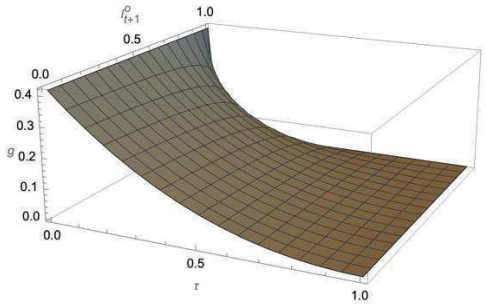

Fig.2 Economic growth rate

Under the macroeconomic circumstances given above, we can draw 3D figures of utility, as shown in Fig.1, and the economic growth rate, as shown in Fig.2. The utility level decreases as the duration of retirement increases. Furthermore, we observe that there is a PAYG social security tax rate at $\tau = 0.042$, which maximizes utility. Similarly, with a decrease in the duration of retirement and the social security tax rate, the economic growth rate decreases. These findings confirm the arguments previously posited.

5 Conclusion

This study constructs an overlapping-generations model with PAYG social security in an endogenous growth framework that contrasts with the effect of the social security tax rate on the utility level and economic growth rate when the government has different time perspectives.

The main results of this study are as follows. First, when the government is myopic, there is an optimal PAYG social security tax rate that maximizes the utility of the present generation, which means that PAYG social security is preferred. Second, when the government is only concerned with the economic growth rate in the long run, the effect of an increase in the PAYG social security tax rate is negative, which means that the PAYG pension should not be introduced. Third, contrary to a previous study on the neoclassical growth framework with physical capital accumulation, the economic growth rate increases if retirement time becomes shorter, in our endogenous growth framework with human capital accumulation.

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[1]World Bank, "World Development Indicators 2022," World Bank Data, https://databank.worldbank.org/source/world-development-indicators (accessed April 16, 2023).

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