ECONOMICS BULLETIN

Population ageing, policy reforms and economic growth in Japan : a computable OLG model with endogenous growth mechanism

Manabu Shimasawa
Akita University

Abstract

We have developed a computable endogenous growth OLG model generated by the accumulation of human capital. To study whether policy reform against aging make any quantitative impacts through human capital formation on the Japanese economy and whether it has long-run effect, we simulate two policy change scenarios and compare the results of those with endogenous growth to those with exogenous growth. The results are very encouraging: (i) policy changes promote human capital accumulation and thus accelerate economic growth. (ii) they have positive effects in the long run. Moreover, the traditional exogenous growth OLG model underestimates the effect of policy reform.

I would like to thank the seminar participants at Economic and Social Research Institute, Cabinet Office, Government of Japan. The views expressed in this paper do not necessarily represent those of the ESRI. All errors are mine
Citation: Shimasawa, Manabu, (2007) "Population ageing, policy reforms and economic growth in Japan : a computable OLG model with endogenous growth mechanism." *Economics Bulletin,* Vol. 3, No. 49 pp. 1-11
Submitted: May 29, 2007. **Accepted:** October 9, 2007.
URL: http://economicsbulletin.vanderbilt.edu/2007/volume3/EB-07C60004A.pdf

1. Introduction

Japan is now, like most developed countries, experiencing the ageing of its population. Moreover, it is expected to progress further at a serious pace. As a result, Japan seems to be the eminent ageing society in the world at the beginning of this century.

As is well known, technical progress is the most critical factor for sustained economic growth from the viewpoint of standard growth theory. Moreover, Romer (1986, 1990) and Lucas (1988) pointed out that it has a positive relation to human capital, which also has a positive relation to population levels. And if so, ageing reduces the working age population, and thus technical change declines. Meanwhile, Rebelo (1991) studied the effects of policy changes on economic growth under an endogenous growth framework. He found that policy changes have long-run and cumulative effects on economic growth in the case of endogenous growth, unlike that of exogenous growth.

A number of papers written after the seminal study by Auerbach and Kotlikoff (1987) have found that ageing caused a sharp reduction in the national savings rate and economic welfare in the long run. These studies, however, were based on the exogenous growth model, and disregarded interrelations that might exist between population change and technical progress, and between policy reform and economic growth. In this respect, those studies seemed to be incomplete. The few exceptions are the papers of Fougère and Mérette (1999), Bouzahzah, De la Croix and Docquier (2002), and Sadahiro and Shimasawa (2003), which endogenize the rate of labor productivity growth. However, Fougère and Mérette (1999), and Sadahiro and Shimasawa (2003) didn’t analyze the effect of policy changes. In this paper, we contribute to the ongoing debate on the importance of the policy reforms in the phase of ageing population in two ways. First, we rigorously quantify the impacts of the policy changes to cope with ageing population. Second, we compare the results of endogenous growth OLG model with those of exogenous growth OLG model in terms of studying the log-run effect of policy change. For this purpose, we develop a more realistic endogenous growth OLG model by allocating time to education for accumulating human capital. More closely related to our contribution is a recent paper by Bouzahzah, De la Croix and Docquier (2002). While similar to our approach, there are important differences, and three are worth noting: (i) as agents live for 60 periods in our model, one period in the model is approximately equivalent to one year of the real world. Thus we are succeed in modeling realistic population dynamics capable of capturing complicated patterns of “baby boom and bust” along the transition path; (ii) we don’t assume that the starting point of the simulation is in a steady state--thus the economic variables, e.g. individuals' asset profiles, capital-labor ratio, behave more realistically; and (iii) we take a more careful calibration of the model to actual fiscal/public pension conditions and institutions. Thus we can compare the simulation results with the actual economy appropriately.

The rest of the paper is organized as follows. Section 2 depicts the model. In Section 3 we present the calibration, and simulation results. Finally, Section 4 concludes, summarizes the paper, and indicates some policy implications.

2. The Model Structure

2.1. Household Sector

The overlapping generations model used in this paper is based on the life cycle theory of consumptions/savings behavior. We consider an economy in which every person lives for a fixed number of periods. Each generation enters the labor market at age 21 (1st period), retires at age 64 (44th period), is granted a pension at age 65 (45th period), and dies at age 80 (60th period). These are rational, forward-looking agents. His/her utility function may be specified thus:

$$U_i = \sum_{j=1}^{60} \left(\frac{1}{1+\rho} \right)^{j-1} \frac{\left[c_{i,j} \right]^{1-\gamma}}{1-\gamma} \tag{1}$$

where i refers to the i th generation, j refers to the j th period of life, ρ is the pure rate of time preference, and γ is the reverse of the elasticity of intertemporal substitution. The arguments of the utility function are the consumption per period ($c_{i,j}$).

His/her intertemporal budget equation is described as follows:

$$\sum_{j=1}^{44} PDV_{i,j}(1\text{-}\tau w_t\text{-}\tau p_t) w_t h_{i,j}(1\text{-}e_{i,j}) \;=\; \sum_{j=1}^{60} PDV_{i,j}(1+\tau c_t) c_{i,j} + \sum_{j=45}^{60} PDV_{i,j} p_{i,j} \tag{2}$$

where PDV refers to the factor of the present discounted value, w_t is the wage rate at time t, $h_{i,j}$ is the human capital stock of generation i at age j, $e_{i,j}$ measures the time invested in education of generation i at age j, τw_t is the labor income tax rate at time t, τp_t is the public pension contribution rate at time t, τc_t is the consumption tax rate at time t, and $p_{i,j}$ stands for pension benefit of generation i at age j. Each generation maximizes his/her utility function under a budget constraint. Maximizing with respect to the educational investment gives the following result:

$$e_{i,j} = \left\langle \frac{\theta l_{i,j+1} \left(1\text{-}\tau w_{t+1}\text{-}\tau p_{t+1} \right) w_{t+1}}{\left\{ 1+\left(1\text{-}\tau r_{t+1} \right) r_{t+1} \right\} \left\{ \left(1\text{-}\tau w_t\text{-}\tau p_t \right) w_t \right\}} \right\rangle^{\frac{1}{1-\theta}} \tag{3}$$

where $l_{i,j}$ stands for the time allocated to labor activity of generation i at age j, and θ measures the elasticity of human capital production with respect to the fraction of time allocated to education, $\theta \in (0\ ,\ 1)$ This equation shows that the educational investment increases with the discounted level of future net wages, but decreases with the current net wage, which means an opportunity cost. Further, we obtain the following physical wealth accumulation equation:

$$a_{i,j} = a_{i,j-1}\left\{1 + r_t\left(1\text{-}\tau r_t\right)\right\} + (1\text{-}\tau w_t)w_t h_{i,j}(1\text{-}e_{i,j})\text{-}(1+\tau c_t)c_{i,j} \quad , \quad PA_t = \sum_{j=1}^{60} N_{t,j}a_{i,j} \tag{4}$$

where $N_{t,j}$ measures the number of the people of age j at period t, $a_{i,j}$ is physical wealth asset of generation i at age j, r_t is the interest rate at time t, τr_t is the tax rate on interest income at time t, and PA_t is the aggregated private asset at period t.

2.2. Human Capital Sector

This sector's formula is be largely attributable to Fougère and Mérette (1999) and Sadahiro and Shimasawa (2003). First, the accumulation of human capital is:

$$h_{i\ ,\ j+1} = \frac{h_{i\ ,\ j}}{1+\delta_h(j)} + \Psi e^{\theta}_{i\ ,\ j} h_{i\ ,\ j} \tag{5}$$

where $\delta_h(j)$ is the exogenous human capital depreciation rate and Ψ is a scaling factor. The depreciation rate is a function of age and has been calibrated to replicate a realistic Japanese earnings profile[1]. This allows us to compare, as we do in Section 3, the results of the endogenous growth OLG version with those of the exogenous growth OLG version.

The initial human capital level of the new generation is assumed to include a certain percentage of the previous generation's accumulated human capital.

$$h_{i\ ,\ 1} = \pi \sum_{k=1}^{i-1}\sum_{g=1}^{i-1} h_{k\ ,\ g} \tag{6}$$

The parameter π is calibrated to replicate the same effective labor productivity level at 2001 in Japan. This equation models the basic educational institution and plays role in transmitting to the newcomer at time t an initial human capital stock that is equivalent to the fraction of the human capital accumulated by its previous generations as a kind of social bequest.

2.3. Firm Sector

The input/output structure is represented by the Cobb-Douglas production function with constant return to scale. The firm decides the demand for physical capital (K) and

[1] The earnings profile is similar to the one in Sadahiro and Shimasawa (2001):
$\mu = 88.3 + 7.08j - 0.146j^2$ (μ : *wage profile*, j : *age*)

effective labor (L_e) to maximize profits with the given factor prices of wage and rent, which are determined in the perfect competitive markets.

$$Y_t = AK_t^{\alpha} L_{e,t}^{1-\alpha} \tag{7}$$

$$r_t = \alpha A K_t^{\alpha-1} L_{e,t}^{1-\alpha} - \delta \quad , \quad w_t = \left(1-\alpha\right) A K_t^{\alpha} L_{e,t}^{-\alpha} \tag{8}$$

where Y is output, α stands for capital income share, and A is a scale variable.

2.4. Government Sector

The government sector issues bonds and collects three types of taxes as its revenue; wage tax, consumption tax and capital tax. And government expenditure is restricted to subsidy to pension sector, public goods expenditure, and interest payments on the public debt. The government budget constraint in each period may be written as

$$T_t = \tau w_t w_t L_{e,t} + \tau c_t C_t + \tau r_t r_t K_t \quad , \quad G_t = gY_t \tag{9}$$

$$D_{t+1} = G_t + SUBP_t + (1 + r_t) D_t - T_t \tag{10}$$

where G_t stands government expenditure at time t, T_t denotes tax revenue at time t, D_t denotes public debt at time t, $SUBP_t$ is the subsidy to pension sector at time t, and g is a fraction of GDP.

2.5. Public Pension Sector

The pension sector grants a pension to the retirement generations while the pension contribution is collected from the working generations.

$$B_t = \sum_{j=1}^{ret} N_{i,j} \tau p_t w_t h_{i,j} l_{i,j} \tag{11}$$

where B stands for the aggregated pension contribution.

Pension benefit consists of basic pension and employee pension in Japan. Thus we represent the pension benefit as

$$p_{i,j} = pb_{i,j} + \beta \frac{1}{ret} \sum_{j=1}^{ret} w_t h_{i,j} l_{i,j} \quad , \quad P_t = \sum_{j=ret+1}^{60} N_{i,j} p_{i,j} \tag{12}$$

where pb is the benefit of the basic pension, β denotes replacement rate, ret stands for retirement age, and P is the aggregated pension benefit.

Here, the budget constraint of the pension sector can be shown as follows

$$F_{t+1} = (1 + (1 - \tau r_t) r_t) F_t + SUBP_t + B_t - P_t \quad , \quad SUBP_t \equiv \xi_t \sum_{j=ret+1}^{60} N_{i,j} pb_{i,j} \tag{13}$$

where F_t represents a reserve of the public pension at time t, and ξ is a government subsidy rate on basic pension at time t.

2.6. Equilibrium Condition

To close the model structure, the following two market-equilibrium conditions must be hold. The first condition is the equilibrium in the financial market.

$$K_t + D_t = PA_t + F_t \tag{14}$$

The second condition is the equilibrium in the goods market.

$$Y_t = C_t + G_t + SUBP_t + \left(K_t \text{-} (1\text{-}\delta)K_{t\text{-}1}\right) \tag{15}$$

3. Simulation Results

3.1. Calibrating the Model

The values of the main parameters of the model are presented in Table 1. The sources of the parameter values are: Kato (2002) for household preferences, and Sadahiro and Shimasawa (2001) for production; Cabinet Office (2003) for macroeconomic variables; the National Institute of Population and Social Security Research (NIPSSR) for Japanese demographic data; and Fougère and Mérette (1999) for the human capital sector. We obtain the average annual growth rate of the individual human capital 0.53 % by calibrating this model under these parameter settings. This value is compatible with the actual growth rates of human capital stock measured by the average years of school and the college wage premium in Japan. For simplicity, government expenditures to GDP ratio are assumed to remain constant at year 2001 levels. In the model, any pressure on the government budget constraint is endogenously compensated by a change in the wage income tax rate, and also by any shocks on current benefits that are endogenously financed by an increase in the contribution rate. The calibration results are provided in Table 2.

3.2. Simulation Results

To study the impacts of the policy change against ageing and to compare its long-run effect with the exogenous growth OLG model, we simulate two policy change scenarios and the exogenous growth version. Figures 1 to 2 represent the effect on the main economic variables, economic growth rate, effective wage income tax rate, pension contribution rate, national savings rate, interest rate, and human capital, in terms of deviations from the baseline results[2].

[2] We can conclude that our model is robust on the parameters of the production function of human capital at a certain level. See Shimasawa (2003).

Pension Reform

The first policy change is pension reform. We suppose that the pay-as-you-go public pension system will be entirely abolished in 2004. So agents in the model rely solely on private savings to support their lives post-retirement. Figure 1 shows the results. The first effect of pension reform is to increase the present value of future net income. This net increase of it, in turn, has effects on the following two directions: increased savings rate, and creation new incentives to invest in human capital formation. Thus increases in physical capital stock caused by the rise in savings and in human capital stock make economic growth rate accelerate and rise by 16.2 % in the long run compared with in the baseline scenario. As far as the interest rate is concerned, the long-run effect is negative as physical capital stock increases.

Comparing now the exogenous growth version, we conclude that the effect in endogenous growth is more cumulative and larger than that in exogenous growth.

Fiscal Reconstruction

As a second policy change scenario, we suppose that government expenditure is cut by about 6 % compared to GDP, which corresponds to government bonds to GDP year 2001 level, at 2004. We present the results in Figure 2. In this simulation, as well as in the previous simulation results, the endogenous/exogenous growth scenarios deliver the same direction of conclusions. The effective wage income tax rate and pension contribution rate are reduced and the savings rate increases, which leads to a decrease in interest rates thanks to capital deepening. A consequence of these two effects, through the same channel as the previous simulation results, makes the time allocated to education increase. Thus the aggregated economic growth rate is stimulated because of the accumulation of physical capital attributed to the rise of savings and of human capital. The long-run growth rate effect of the policy change, however, does not continue in the exogenous OLG model in this simulation. Moreover, we also conclude that the effect of the policy change is larger in the endogenous growth version than in the exogenous growth version, even in this case.

4. Conclusion

In this paper, our purpose was to study the impacts of policy changes to cope with ageing under an endogenous growth framework, and to compare configurations with endogenous growth and exogenous growth specifications quantitatively. The results are very encouraging: our two policy change scenarios give reasonable results. Namely, policy changes, e.g. pension reform, and fiscal consolidation, promote human capital accumulation and thus accelerate economic growth. Consequently, policy reforms which do affect incentives to allocate more time to acquire human capital, lead to growth effects. We find that both policy changes have positive effects on the long-run economic growth rate. Moreover, the traditional exogenous growth OLG model underestimates the effect of policy reform comparing the endogenous growth OLG model. In fact, policy change has cumulative and long-run effects on economy.

From these results, we obtain the policy implication that not only Japan but also other countries, experiencing ageing now, or being expected to progress in future, should manage policy reforms which do affect the incentive to acquire human capital to cope with the ageing population, to avoid the negative impacts potentially inherent in ageing, and to maintain positive sustained growth.

References

Auerbach, A.J. and L.J. Kotlikoff. (1987) Dynamic Fiscal Policy. Cambridge University Press: Cambridge.

Bouzahzah, M., De la Croix, D., and Frédéric Docquier. (2002) Policy Reforms and Endogenous Growth in Computable OLG Economies. Journal of Economic Dynamics and Control. 26, 2093–2113.

Fougère, M. and M. Mérette. (1999) Population Ageing and Economic Growth in Seven OECD Countries. Economic Modelling. 16, 411-427.

Kato, R.R. (2002) Government Deficit, Public Investment, and Public Capital in the Transition to an Ageing Japan. Journal of the Japanese and International Economies. 16, 462-491.

Lucas, R. E. Jr. (1988) On the Mechanics of Economic Development. Journal of Monetary Economics. 22, 3-42.

National Institute of Population and Social Security Research. (2003) Population Projections for Japan, HWS Association, Tokyo.

Rebelo, S. (1991) Long-Run Policy Analysis and Long-Run Growth. Journal of Political Economy. 99, 500-521.

Romer, P. (1986) Increasing Returns and Long-Run Growth. Journal of Political Economy. 94, 1002-1037.

Romer, P. (1990) Endogenous Technological Change. Journal of Political Economy. 98, 71-102.

Sadahiro, A. and M. Shimasawa. (2001) Fiscal Sustainability and the Primary Surplus: A Simulation Analysis with OLG Model. JCER Economic Journal. 43, 117-132.

Sadahiro, A. and M. Shimasawa. (2003) "The Computable Overlapping Generations Model with an Endogenous Growth Mechanism," Economic Modelling. 20, 1-24.

Table 1 Values of key parameters and exogenous variables

Capital income share	α	0.25
Intertemporal elast. of subst.	$1/\gamma$	2.2409
Pure rate of Time preference	ρ	0.02
Education parameter	θ	0.7
Replacement ratio	β	0.594
Subsidy ratio*	ξ	0.33/0.50
Physical capital depreciation	δ	0.05
Gov. Exp. to GDP ratio	g	23.4
Consumption tax rate	τc	0.05
Interest tax rate	τr	0.20

* The pension system is reformed in 2004. And the subsidy ratio is changed to 50 % after the year 2004.

Table 2 Calibration results (The fiscal year 2001)

	Official	Model
National saving rate (%)	25.9	26.2
Pension contribution rate (%)	13.58	13.40
Bond to GDP ratio (%)	6.3	6.5
Interest payment on public debt (%)	3.1	3.2
National debt to GDP ratio (%)	96.4	97.1
Effective wage income tax rate (%)	—	16.9
Interest rate (%)	—	2.10

Figure 1 Pension reform

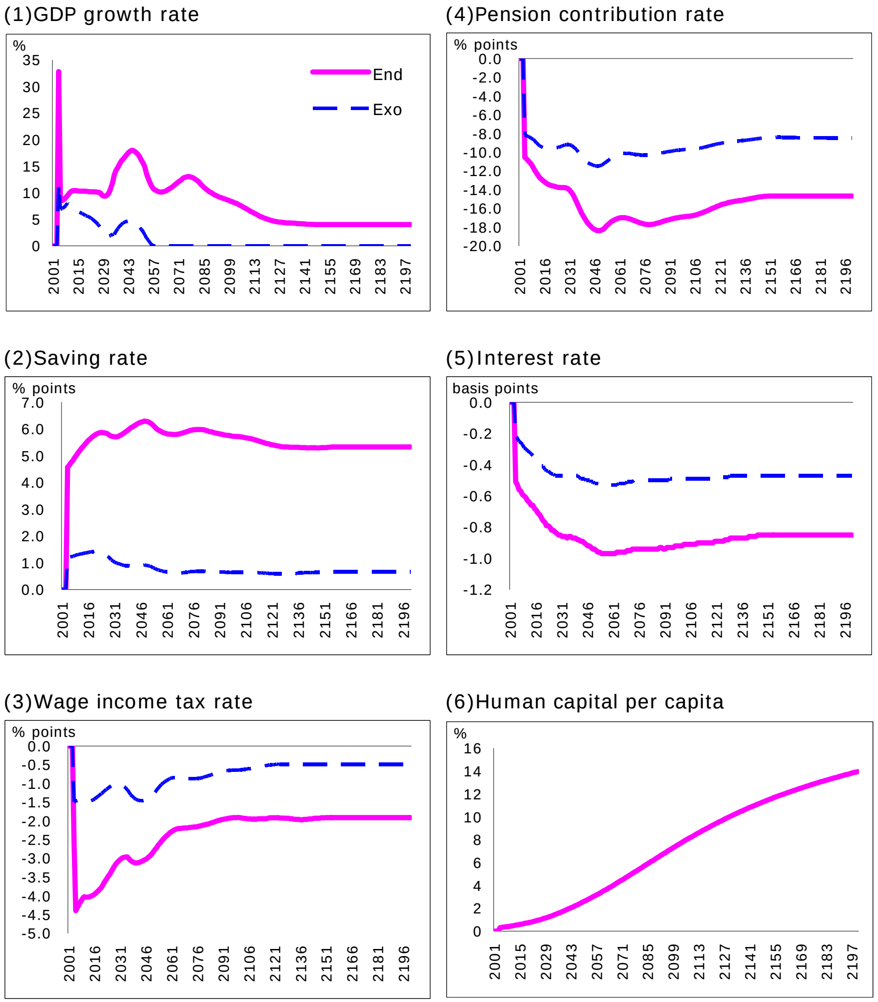

Figure 2 Fiscal reconstruction