Population ageing, policy reforms and endogenous growth in Japan: a computable overlapping generations approach

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Economic and Social Research Institute
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(Abstract)

We have developed a multi-period computable endogenous growth overlapping generations model generated by the accumulation of human capital. To study whether ageing itself and policy reform that aims to cope with aging make any quantitative impact through human capital formation on the Japanese economy, we simulate two policy change scenarios and compare the results of those with endogenous growth to those with exogenous growth. Three main results are obtained: (1) the human capital investment is important to assure sustained positive economic growth; (2) policy changes, pension reform, and fiscal consolidation promote human capital accumulation and thus boost economic growth; and (3) the traditional exogenous growth OLG model underestimates the effect of policy reform, comparing the endogenous growth of the OLG model. The robustness of these results is guaranteed from the sensitivity tests.

*JEL classification :* C62; C63; C68; E27; E66; J11; J24; O41; O53;
*keywords: Overlapping generations; human capital; endogenous growth; population ageing*
1. Introduction

Japan is now, like most developed countries, experiencing the ageing of its population. Moreover, ageing in Japan 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, economic growth is mainly determined by physical capital, labor force, and technical progress. Especially, 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 technical change 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. Consequently, ageing lowers the economic growth rate through the following three channels: labor supply, capital supply, and technical progress via human capital. Meanwhile, Rebelo (1991) studied the effects of policy changes on economic growth under an endogenous growth framework. He found that policy changes have 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 examined the impacts of ageing and policy changes by using computable general equilibrium models with the overlapping generations. They found outcomes such as 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 initiated by Solow (1956) and Swan (1956), 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.

We develop a more realistic endogenous growth OLG model by allocating time to education for accumulating human capital. And we analyze numerically the impacts of ageing on the Japanese economy without a priori assumptions about the relation between population change and technical progress.
Moreover, we also conduct some alternative simulations to study the impacts of the policy changes. More closely related to our contribution is a recent paper by Bouzahzah, De la Croix and Docquier (2002). The authors study the effects of demographic change on the economy by using a computable general equilibrium model with overlapping generations of agents and an endogenous growth specification à la Uzawa-Lucas. 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 overviews the population projection and the public pension program in Japan. Section 3 depicts the model. In Section 4 we present the calibration, the scenarios, and results. Finally, Section 5 concludes, summarizes the paper, and indicates some policy implications.

2. Population Projection and Public Pension Program in Japan

First, following the National Institute of Population and Social Security Research (2003), we overview a population projection for Japan. Though the total population of Japan was 126.93 million in 2000, it is expected to gradually increase until its peak of 127.74 million in 2006, then turn to decrease, to about 100.6 million in 2050. The population decline rate is 0.5 percent (annual rate) on the average during these periods (2006/2050). As for other developed countries, their populations begin to decrease until 2030 at the latest in all countries except for the United States. This projection shows that Japan will soon enter into the process of population decline. The old-age dependency ratio increases from the current 25.5 percent to the 50.0 percent
range in 2030, then eventually up to 66.5 percent in 2050. The births per
thousand is expected to decline from 9.4 permillage in 2001 to 8.0 permil in
2013, and it continues to decline, reaching 7.0 permil in 2035 and falls up to
6.7 permil in 2050.
Next, we overview the Japanese public pension system, which was established
in 1941. That system, however, is inferior to present one regarding the range
of the targeted people. This system, namely, didn’t include self-employed
people and agricultural workers. In 1959, the National Pension Law was
enacted and was enforced on a full scale in April 1961. As a result, every
citizen age 20 and over was covered by some public pension programs that
ensured the payment of pensions for their old age.
In 1985, a fundamental reform was carried out mainly to ensure fair benefits
and burdens among different pension programs. A basic pension program was
introduced specifically to improve the employee pension programs divided
among occupations. The previous employee pensions were positioned as
providing additional benefits on top of this basic pension program.
The Japanese public pension system thus came to consist of a two-tier pension
program: the first being the “basic pension program” (national pension
program), and the second tier is the “employee pension program.” They are
mandatory, financed through contributions, and essentially pay-as-you-go systems (see Figure 1). The age of eligibility will gradually rise to 65 by 2025
(for males) and 2030 (for females).
The first tier pension program includes all the citizens age 20 and over.
The second tier pension program includes only employees. Contributions are
shared between employees and employers (in 2003 13.58 percent of the
standard monthly wages in total), and benefits are earnings based in this
second tier pension program (the average gross replacement rate about 60
percent in 2003).
The ratio of the social security benefit expenditure to GDP is about 7.6 percent
in 2001. And the basic pension program, the first tier, received 17.6905 trillion
yen, about 3.5 percent of GDP, from the central government as a subsidy in
2001. Each public pension program has a reserve to implement the smooth

1 Actually, the basic pension program contains the second tier program—the
National Pension Fund—and the employee pension program contains a third tier
pension program, the employee pension fund. Both are optionally funded systems,
and are given favorable preferential tax treatment. Recently, they are liquidated
because of the shortage of reserve. We thus ignore them in this paper.
and stable operation of it. These funds amount to 238.0092 trillion yen, or about 47.4 percent of GDP in same fiscal year.

3. The Model Structure

In this section, we present the endogenous growth OLG model, consisting of five sectors: households, human capital, firms, government, and public pensions. There is a representative individual for each generation in the households sector. Each individual at age 21 maximizes his/her intertemporal utility function with consumption. The representative firm maximizes its profits under the production function. The model is a one-country closed model, where not only the goods market but also factor markets are perfectly competitive. Details of each sector follow.

3.1. 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:

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

(1)

where \(i\) refers to the \(i\)th generation, \(j\) refers to the \(j\)th period of life, \(\rho\) is the pure rate of time preference, and \(\gamma\) 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 may be described as follows:

\[
\sum_{j=1}^{44} PDV_{i,j}(1-\tau_w-\tau_p)w_t^i h_{i,j}(1-e_{i,j}) = \sum_{j=1}^{60} PDV_{i,j}(1+\tau_c)c_{i,j} + \sum_{j=45}^{60} PDV_{i,j}p_{i,j}
\]

(2)

where \(PDV\) refers to the factor of the present discounted value, \(w_t\) is the wage.

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2 The value of key parameters is listed in the Table 1.
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 $j$, $\tau w_t$ is the labor income tax rate at time $t$, $\tau p_t$ is the public pension contribution rate at time $t$, $\tau c_t$ 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 (Equation (1)) under a budget constraint (Equation (2)). With the maximization procedure, the following Euler equations can be solved, concerning consumption per period.

$$c_{i,j} = \left\{ \frac{1 + r_t (1 - \tau w_t)}{1 + \rho} \right\} \left\{ \frac{1 + \tau c_t}{1 + \tau c_t} \right\} \frac{i}{i} c_{i,j-1} + \sum_{j=1}^{t} N_{t,j} c_{i,j}$$

where $N_{t,j}$ measures the number of the people of age $j$ at period $t$, and $C_t$ is the aggregated consumption at time $t$.

Maximizing with respect to the educational investment gives the following result:

$$e_{i,j} = \left\{ \frac{\theta l_{i,j-1} (1 - \tau w_{i,j-1} - \tau p_{i,j-1}) w_{i,j-1}}{1 + (1 - \tau w_{i,j-1}) r_{i,j-1} (1 - \tau c_{i}) w_{i,j-1}} \right\} \frac{i}{i}$$

where $l_{i,j}$ stands for the time allocated to labor activity of generation $i$ at age $j$, and $\theta$ 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.

We can obtain the following physical wealth accumulation equation:

$$a_{i,j} = a_{i,j-1} \left\{ 1 + r_t (1 - \tau r) + (1 - \tau r) w_{i,j} (1 - e_{i,j}) - (1 + \tau c_i) c_{i,j} \right\} + PA_t = \sum_{j=1}^{t} N_{t,j} a_{i,j} = K_t$$

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

Each generation optimally allocates his/her total time (normalized as unity) into educational activity ($e_{i,j}$) and labor activity ($l_{i,j}$). Therefore, effective labor supply for each period is defined as

$$L_{e,i} = \sum_{j=1}^{t} N_{t,j} h_{i,j} (1 - e_{i,j})$$
3.2. Human Capital Sector
This sector’s formula is largely attributable to Fougère and Mérette (1999) and Sadahiro and Shimasawa (2003).
First, the accumulation of human capital is:
\[ h_{i,j+1} = h_{i,j} + \frac{\Psi \Theta_{i,j} h_{i,j}}{1 + \delta_h(j)} \]
where \( \delta_h(j) \) is the exogenous human capital depreciation rate and \( \Psi \) is a scaling factor. The depreciation rate is a function of age and has been calibrated to replicate a realistic Japanese earnings profile\(^3\). This allows us to compare, as we do in Section 4, the results of the endogenous growth OLG version with that of the exogenous growth OLG version.
Equation (7) indicates that new human capital is produced by only existing human capital and education time. No other inputs are required. And the equation also expresses that the human capital stock increases most markedly where all available time is allocated to schooling investment (\( e=1 \)). Conversely, the human capital decreases by the order of depreciation where he/she invests nothing for schooling activity (\( e=0 \)).
The initial human capital level of the new generation is assumed to include a certain percentage of the previous generation’s accumulated human capital.
\[ h_{i,1} = \pi \sum_{k=1}^{I} \sum_{g=1}^{L} h_{k,g} \]
The parameter \( \pi \) 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.
Aggregate human capital is defined as:
\[ H_t = \sum_{j=1}^{J} h_{i,j} N_{i,j} \]

3.3. 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

\( \mu = 88.3 + 7.08j - 0.146j^2 \) (\( \mu \): wage profile, \( j \): age)
physical capital \((K^0)\) and effective labor \((L^0)\) to maximize profits with the given factor prices of wage and rent, which are determined in the perfect competitive markets.

\[
Y_t = AK_t^a L_{e,t}^{1-a}, \quad K_t = K_i^D, \quad L_{e,t} = L^D.
\]

\[
K_t = I_t + (1 - \delta)K_{e,t} \quad (11)
\]

\[
r_t = \alpha AK_t^a L_{e,t}^{1-a} - \delta, \quad w_t = (1 - \alpha) AK_t^a L_{e,t}^{1-a} \quad (12)
\]

where \(Y\) is output, \(\alpha\) stands for capital income share, \(A\) is a scale parameter, \(K\) is the physical capital stock, and \(L_e\) is the effective labor.

3.4. 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

\[
T_t = \tau_i w_t L_{e,t} + \tau_c C_t + \tau_r r_t K_t, \quad G_t = gY_t \quad (13)
\]

\[
D_{t+1} = G_t + SUBP_t + (1 + r_t)D_t - T_t \quad (14)
\]

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.

As the government decides the tax rate according to the following intertemporal budget constraints, the budget does not have to balance for each period. Here, the wage tax rate is endogenously determined according to the difference of government revenues and government expenditure.

\[
D_t + \sum_{i=0}^{\infty} (G_{t+i} + SUBP_{t+i}) / \prod_{j=0}^{i} R_{i+j} = \sum_{i=0}^{\infty} T_{t+i} / \prod_{j=0}^{i} R_{i+j} \quad (15)
\]

where \(R \equiv I/I + r_t\)

3.5. Public Pension Sector

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

\[
B_t = \sum_{j=1}^{\infty} N_{i,j} \tau_i w_{i,j} h_{i,j} l_{i,j} \quad (16)
\]

where \(B\) stands for the aggregated pension contribution.
As we saw in Section 2, pension benefit consists of basic pension (first tier) and employee pension (second tier) in Japan. Thus we represent the pension benefit as

\[ p_{i,j} = p_{b_{i,j}} + p_{e_{i,j}} \]

where \( p_{b} \) is the benefit of the basic pension, \( p_{e} \) is the benefit of the employee pension, \( \beta \) denotes replacement rate, \( \text{ret} \) stands for retirement age, and \( P \) is the aggregated pension benefit.

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

\[ F_{t+1} = (1+(1-\tau)\rho_{i})F_{t} + \text{SUBP}_{t} + B_{t} - P_{t} \]  

where \( F_{t} \) represents a reserve of the public pension at time \( t \).

The subsidy to the basic pension program from the government can be shown as follows.

\[ \text{SUBP}_{t} = \xi \sum_{j=\text{ret}+1}^{60} N_{i,j}p_{b_{i,j}} \]

where \( \xi \) is a government subsidy rate on basic pension at time \( t \).

The pension contribution rate is endogenously determined to keep this budget constraint (19).

3.6. 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.

\[ K_{t} + D_{t} = PA_{t} + F_{t} \]

The second condition is the equilibrium in the goods market.

\[ Y_{t} = C_{t} + G_{t} + \text{SUBP}_{t} + I_{t} \]

In the model simulation, private investment \( (I) \) is determined by using this equilibrium condition.

4. Simulation Results
4.1. Calibrating the Model

The benchmark 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 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 percent 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.

Usually the calibration of dynamic computable general equilibrium models assumes a steady state for the simulation starting year. However, since many countries including Japan have been experiencing terrible demographic changes up to now, it is very difficult to approximate the economy in 2001 in a steady state. So we begin simulations from non-steady-state initial conditions, which are based on 2001. Therefore, we assume that the economy in 2001 was not in a steady state, but was on the transition pass to a steady state in the long run.

By starting with actual Japanese fiscal, economic, and demographic realities, the model generates a much more realistic time-path of the variables, including population age structure, elderly dependency ratio, and capital deepening. The calibration results are provided in Table 2.

4.2. Simulation Analysis

We present estimates of the macroeconomic effects of ageing, based on the endogenous growth overlapping generations model described in the previous section. First, we describe the baseline simulation results on the main economic variables, which appear to be appropriate to capture the impacts of ageing. Second, we present the results of two policy change scenarios on them. We also compare the long-run effects with the exogenous growth OLG model. Finally, we provide two sensitivity tests by modifying the value of the elasticity of human capital production $\gamma$.

Since the model is simulated to year 2400 (500 periods), we consider a long enough period for a steady-state to be achieved. We report our analysis mostly on the period 2003-2050, which corresponds to the demographic
projection of the NIPSSR. 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.

Each person enters the model at the age of 21, and he/she lives for 60 periods (at age 80) in the model, which correspond to Japanese average life span. As a result, one period in the model is equivalent to one year of the real world approximately. Moreover, we use 20-24 year-old population data estimated by NIPSSR until 2050. After that, the growth rate between generations is assumed to be 0 percent. In the long run, as the population reaches a steady state, we can also surmise that the economy will reach a steady state.

4.3. Simulation Results

The simulation results describing the macroeconomic impacts of ageing are summarized in Figures 2 to 5. We present the results for economic growth rate, effective wage income tax rate, pension contribution rate, national savings rate, interest rate, and human capital.

**Baseline Scenario**

First, we see the change in the population structure in the model. Figure 2 shows the difference between the old age dependency ratio calibrated in the model and the one from the original NIPSSR projection. As can be seen from the figure, we succeeded in approximating the projected demographic shock.

Second, we see the baseline simulation results. Figure 3 gives the results. During the demographic transition, the effective wage income tax rate hardly changes or slightly decreases to maintain an intertemporal government budget constraint. The pension contribution rate, in turn, increases sharply, by 7.6 percent points from its 2003 level in 2050, to finance increased benefits.

Population ageing puts downward pressure on national savings under the life cycle hypothesis. As mentioned above, the life-cycle theory of consumptions/savings behavior is a key assumption of the model. According to our results, the national savings rate falls by 9.6 percent points between 2003 and 2050. According to the result, it is the same that the savings rate is
decreased by ageing, whether we use the exogenous growth OLG model or the endogenous growth OLG model. Ageing also leads to a reduction in the growth rate of the labor force and capital stock (due to the reduction of savings rate). However, since the labor force is more negatively affected by the demographic shock than is the capital stock, the capital deepening progresses; this puts downward pressure on the real return to physical capital by 0.8 basis points between 2003 and 2050, and upward pressure on real wage rates. Since the rise of present value of future net real wages makes the time allocated to education increase, the human capital stock increases. It also raises effective labor. Thus because a reduction in the growth rates of the labor force and capital stock is offset by the rise of the effective labor productivity, the aggregated economic growth rate maintains positive growth.

As shown in Figure 3(6), the demographic shock leads to an increase in human capital. And it is about 2.8 times between 2003 and 2050.

4.4. Policy Change Scenarios
To study the impacts of the policy change against ageing and to compare its predictions with the exogenous growth OLG model, we simulate two policy change scenarios and the exogenous growth version. We assume that policy changes will be executed in 2004. Of course, we chose this year quite arbitrarily. Figures 4 to 5 represent the effect on the main economic variables mentioned above in terms of deviations from the baseline results.

*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 4 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 percent 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**
Third, as a second policy change scenario, we suppose that government expenditure is cut by about 6 percent compared to GDP, which corresponds to government bonds to GDP year 2001 level, at 2004. We present the results in Figure 5.
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.

4.5. Sensitivity Tests
Finally, we provide two alternative scenarios for the sensitivity tests—Senst 1 and Senst 2—to study the robustness of the endogenous growth model. First we reduce the elasticity of human capital production with respect to the fraction of time allocated to education $\gamma$, on which there is no consensus, from original value 0.7 to 0.5 (Senst 1). Second, we increase it from 0.7 to 0.9 (Senst 2).
As shown in Table 3, the long-run effect of ageing on economic growth is reduced by 1.6 percent in Senst 1. In turn, it is increased by 1.3 percent in Senst 2. From this table, we can see that the change of this parameter produces similar steady states. The economic growth rate, savings rate, effective wage income tax rate, pension contribution rate, and interest rate are roughly similar to each scenario. In short, the difference between the
baseline and two sensitivity scenarios is too small. Hence, we conclude that our model developed in this paper is robust on the parameters of the production function of human capital at a certain level; moreover, the simulation results obtained in the previous section are unaffected by the value of parameters.

5. Conclusion

Ageing is expected to progress sharply through the 21st century in Japan. In this paper, to study whether ageing itself and policy reforms to cope with ageing make any impact through human capital formation on the Japanese economy quantitatively, we develop a multi-period computable endogenous growth overlapping generations model where growth is generated by the accumulation of human capital.

We have thus computed responses to the following three scenarios: a baseline scenario, in which economic/fiscal/public pension situations in 2001 are maintained into the future (scenario 1); a change from the pay-as-you-go pension scheme to a fully funded pension scheme (scenario 2); and government expenditure cut by 6 percent compared to GDP (scenario 3) in using this endogenous growth OLG model. Furthermore, to analyze the significant roles the policy changes have on the economy, we compare the results of the endogenous growth version with those of the exogenous growth version.

We conclude that the main results of these scenarios are:

1. Human capital investment is important to assure sustained economic growth. The endogenously determined growth rate of human capital offsets the negative labor growth rate, which in turn keeps a positive aggregated economic growth rate as well as a positive per capita growth rate.

2. Two policy changes—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 but modest effects, too, on the long-run economic growth rate.

3. The traditional exogenous growth OLG model underestimates the effect of
policy reform comparing the endogenous growth OLG model. From these results, we believe that it is important to manage policies that put emphasis on and give priority to the role of human capital investment through education and the work training to cope with the ageing population, to avoid the negative impacts potentially inherent in ageing, and to maintain positive sustained growth.

References


Table 1 Values of key parameters and exogenous variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital income share</td>
<td>( \alpha )</td>
<td>0.25</td>
</tr>
<tr>
<td>Intertemporal elast. of subst.</td>
<td>( 1/\gamma )</td>
<td>2.2409</td>
</tr>
<tr>
<td>Pure rate of Time preference</td>
<td>( \rho )</td>
<td>0.02</td>
</tr>
<tr>
<td>Education parameter</td>
<td>( \theta )</td>
<td>0.7</td>
</tr>
<tr>
<td>Replacement ratio</td>
<td>( \beta )</td>
<td>0.594</td>
</tr>
<tr>
<td>Subsidy ratio*</td>
<td>( \xi )</td>
<td>0.33/0.50</td>
</tr>
<tr>
<td>Physical capital depreciation</td>
<td>( \delta )</td>
<td>0.05</td>
</tr>
<tr>
<td>Gov. Exp. to GDP ratio</td>
<td>( g )</td>
<td>23.4</td>
</tr>
<tr>
<td>Consumption tax rate</td>
<td>( \tau_c )</td>
<td>0.05</td>
</tr>
<tr>
<td>Interest rate</td>
<td>( \tau_r )</td>
<td>0.20</td>
</tr>
</tbody>
</table>

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

Table 2 Calibration results (The fiscal year 2001)

<table>
<thead>
<tr>
<th></th>
<th>Official</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>National saving rate (percent)</td>
<td>25.9</td>
<td>26.2</td>
</tr>
<tr>
<td>Pension contribution rate (percent)</td>
<td>13.58</td>
<td>13.40</td>
</tr>
<tr>
<td>Bond to GDP ratio (percent)</td>
<td>6.3</td>
<td>6.5</td>
</tr>
<tr>
<td>Interest payment on public debt (percent)</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>National debt to GDP ratio (percent)</td>
<td>96.4</td>
<td>97.1</td>
</tr>
<tr>
<td>Effective wage income tax rate (percent)</td>
<td>-</td>
<td>16.9</td>
</tr>
<tr>
<td>Interest rate (percent)</td>
<td>-</td>
<td>2.10</td>
</tr>
</tbody>
</table>

Table 3 Sensitivity tests (deviation from the baseline)

<table>
<thead>
<tr>
<th></th>
<th>Senst 1</th>
<th>Senst 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP growth rate (percent)</td>
<td>-1.6</td>
<td>1.3</td>
</tr>
<tr>
<td>National saving rate (percent)</td>
<td>-0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Wage income tax rate (percent)</td>
<td>0.1</td>
<td>-0.6</td>
</tr>
<tr>
<td>Pension contribution rate (percent)</td>
<td>0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>Interest rate (basis points)</td>
<td>0.02</td>
<td>-0.02</td>
</tr>
</tbody>
</table>
Figure 1  Pension programs in Japan

- **Basic pension program (National pension program)**
- **Employees pension program**

- Self-employed (21,540 thousands persons),
- Nonworking spouse (11,530 thousands),
- Etc (total: 33,070 thousands persons)

Sources: NIPSSR (2003) and author’s calculation

Figure 2  Old age dependency ratio

Sources: NIPSSR (2003) and author’s calculation
Figure 3  Baseline simulation (Scenario1)

(1) GDP growth rate

(2) Saving rate

(3) Wage income tax rate

(4) Pension contribution rate

(5) Interest rate

(6) Human capital per capita
Figure 4  Pension reform (Scenario 2)

(1) GDP growth rate
(4) Pension contribution rate

(2) Saving rate
(5) Interest rate

(3) Wage income tax rate
(6) Human capital per capita
Figure 5  Fiscal reconstruction (Scenario3)

(1) GDP growth rate
(2) Saving rate
(3) Wage income tax rate
(4) Pension contribution rate
(5) Interest rate
(6) Human capital per capita