Asian Economic and Financial Review, 2013, 3(4):490-511

Asian Economic and Financial Review

journal homepage: http://aessweb.com/journal-detail.php?id=5002

CHILD BENEFITS AND WELFARE FOR CURRENT AND FUTURE GENERATIONS: SIMULATION ANALYSES IN AN OVERLAPPING-GENERATIONS MODEL WITH ENDOGENOUS FERTILITY

Kazumasa Oguro

Associate Professor, Institute of Economic Research Hitotsubashi University, Japan

Manabu Shimasawa

Senior Researcher, National Institute for Research Advancement, Japan

Junichiro Takahata

Assistant Professor, Dokkyo University, Japan

ABSTRACT

We constructed an overlapping-generations model with endogenous fertility to analyze the effects of child benefits and pensions on the welfare of current and future generations. The following results were obtained. First, in the case without pension and accelerated fiscal reforms, the best policy to improve the welfare of future generations is to finance the provision of child benefits by capital taxation, followed by issuing government debt, consumption taxation (VAT), and wage taxation, in that order. Second, debt reduction coupled with increasing child benefits is preferable to debt reduction alone to reduce public debt for future generations. In particular, coupling increased child benefits and fiscal reform simultaneously stands out as the most desirable option. Third, from the viewpoint of pension reform, maintaining pension benefits by increasing VAT is better than cutting benefits coupled with increasing child benefits for future generations.

Keywords: Overlapping-generations model, Child benefit, Endogenous fertility, Theorem of zero capital tax

INTRODUCTION

This paper aims to analyze the effect of child benefits and pensions on the welfare of current and future generations, by constructing an overlapping-generations (OLG) model with endogenous fertility[1].

The decline in fertility rate is a major concern for the Japanese economy. The reason for this is that an economy with a low birth rate and an aging population has created serious problems in terms of the sustainability of fiscal and social security systems, including public pension. In order to maintain sustainability, we have several policy choices. The first is to promote fiscal reform, e.g., increase consumption tax. The second is to carry out social security reform, e.g., decrease public pension benefits. The third is to revise the population trends, e.g., increase fertility rate by expanding child benefits. The Japanese government has attempted to work with the first and the second policies. However, due to conflicting interests between younger and older generations, obtaining an agreement on the reform by both generations is often too difficult for the government to achieve. Therefore, the government is trying to promote child benefits expansion as the third policy. Consequently, we should consider how to finance child benefits expansion. In general, the financial resource selection to provide child benefits determines the type of welfare effects on current and future generations. At this point, key research results on the OLG models with exogenous versus endogenous fertility should be compared.

For the standard OLG model represented by Diamond (1965) and others, it is well established that consumption taxation (VAT) is the most effective method to raise financial resources for the welfare of future generations, followed by wage taxation and capital taxation, the second and third methods of choice, respectively, given the future path of government expenditure. This can be explained as follows. The first benchmark is the theorem of zero taxation of capital income, derived from (Atkinson and Stiglitz, 1972) the orem of optimal tax. The theorem is best understood by considering the OLG model with two generations, working and retired, living concurrently. At the first period (working period), each generation earns wage income by providing labor force, consumes a part of that income, and saves the remainder. At the second period (retired period), the retired generation consumes the principal and the interest derived from that saving. In this setting, Atkinson and Stiglitz (1976) have proved that the case in which the consumption tax of the first period is different from that of the second period is not optimal. In addition, since these respective differing consumption taxes have the taxation property for the interest on the savings consumed in the retired period, this theorem suggests that zero taxation of capital income is optimal; it holds in

[1] In our paper, child benefits cover the total cost of child rearing and child care, but we do not distinguish between benefits in cash (e.g., child benefit) and benefits in kind (e.g., subsidies for using nursery and forreceiving high education). Therefore, the analyses in this paper do not establish that benefits in cash are more effective than benefits in kind.

the OLG model with multi-concurrent generations and exogenous fertility[2]. Similarly, Chamley (1986) and Judd (1985) also indicate that zero taxation of capital income in the OLG model with exogenous fertility and taking over inheritance among generations is most effective in the long term. Moreover, on the steady state, the equation (1 – wage tax rate) × (1 + consumption tax rate) = 1 holds and consumption taxation becomes equivalent to wage taxation with no borrowing constraint and no change in government policies. Because of this, a switch in government policies from wage-based to consumption-based taxation, if implemented at a tax rate equivalent to that described previously, may have no influence on the generation immediately after the policy change, but the effect during the transition period may differ. Taxation on the retired generation's consumption in the early stage of the transition period presents less distortion as it works like a lump-sum tax. In other words, considering intertemporal government budget constraints with the zero-sum feature of intergenerational income transfer, this policy would result in a transfer of income from the retired generation to the working and future generations. An increase in the public debt tends to instigate the crowding-out effect, which may lead to a restrained accumulation of capital and a decrease in future economic growth. In the same manner, according to Hatta and Oguchi (1999), among others, the pay-as-you-go public pension also carries an "implicit debt" of approximately 150% of GDP and may inhibit future growth. Although public pensions transfer income from the working and future generations to the retired generation, implementation of the above-mentioned policies would have the opposite effect, transferring the income from the retired generation to the working and future generations, resulting in an increase in capital accumulation and enhanced future growth. From this we can infer that, in the standard OLG model with exogenous fertility and given the future path of government expenditure, consumption taxation (VAT) would most often be the optimal source of funding for expenditure, followed by wage taxation and capital income taxation, in that order. However, as the assumptions in the OLG model with exogenous fertility are realistically modified, the conclusions drawn—such as the theorem of zero taxation of capital income—begin to differ. For example, Cremer and Gahvari (1995) indicated that if the wage income in the second (retired) period is uncertain, it is desirable that the taxation imposed on the second-period consumption is higher than that of the first (working) period. This means that capital income taxation is desirable.

Similarly, Conesa *et al.* (2007) suggest that, when life expectancy and wage income are uncertain, a capital income tax is desirable. Saez (2002) adds that zero capital taxation is not always optimal, as the desirable savings rate differs with varying levels of individual skill. Moreover, Weinzierl (2007) shows that, when wage income varies with age and there are heterogeneous demographics, a 15% tax would increase social welfare more than the zero-taxation scenario. In addition, Hubbard

[2]The reader should remember that Atkinson and Stiglitz's (1976) partial equilibrium analysis greatly influences the optimal tax rule,while considering the OLG model with exogenous fertility based on the evaluation criteria of the growth process known as the "golden rule."

and Judd (1986) found that, when the capital market is incomplete and there are borrowing constraints, the implementation of capital taxation can be justified. As described above, modifications by Atkinson and Stiglitz (1976) suggest that there are various justifications for the implementation of capital taxation. However, these are based on the OLG model with exogenous fertility; research on the justification of capital taxation, assuming the OLG model with endogenous fertility, remains insufficient. Our results show that the child-rearing cost is the key parameter in the OLG model with endogenous fertility. For example, zero capital taxation may no longer be considered optimal if the child-rearing cost is an increasing function of lifetime income. This can be explained as follows. First, zero capital taxation is desirable in the standard OLG model with exogenous fertility; however, in comparison to nonzero capital taxation, both lifetime income and child-rearing costs increase for future generations. If the positive effect of increased lifetime wages is overshadowed by a larger negative effect of increased child-rearing costs, the relative value of lifetime wages for child-rearing costs decreases due to the lifetime budget constraints of each generation. In such a case, although the implementation of capital income taxation is in fact justified, research based on the OLG model with endogenous fertility is not being pursued.

On the basis of the findings of Oguro *et al.* (2009), we construct an OLG model with multi-concurrent generations and endogenous fertility, assuming consumption, wage, capital, and other taxations as potential funding sources for increased child benefits, to analyze the effect on the welfare of each generation. We then analyze the effect on the welfare of each generation from the perspective of future social security reforms in two hypothetical cases: reducing pension benefits and using consumption tax to partially fund pension benefits. According to our simulation results, the welfare for the future generation in the case with child benefits expansion funded by capital income tax is greater than in the case with child benefits expansion funded by consumption tax. This indicates that zero taxation of capital income in the OLG model with endogenous fertility is not the most effective in the long term. Our research is organized as follows. In Section 2, we explain the OLG model with multi-concurrent generations and endogenous fertility used in this paper. In Section 3, we describe the data, as well as the calibration and simulation scenarios used in our research. In Section 4, we evaluate the simulation results. Finally, in Section 5, we summarize our results and suggest topics for future discussion.

The Model Structure

In this section, we describe the demographic and economic structure of our model. The model used here is a computable general-equilibrium OLG model with perfect foresight agents, multiple periods, and endogenous fertility. In our model, there is a representative individual for each generation in the household sector. Each individual at age 20 maximizes his/her intertemporal utility function with consumption and the number of children. The representative competitive firm has a standard Cobb–Douglas production technology and maximizes its profits. In our model, not only the goods market but also factor markets are perfectly competitive. The model has five main building blocks: (1) household behavior, (2) firm behavior, (3) the public pension, (4) the government, and (5) market equilibrium. Details of each block follow.

Household Behavior

There is a representative individual for each generation in the household sector. We assume that preference forms are the same for all agents in all generations. Moreover, each individual lives for a fixed number of periods. In each period of the model, the oldest generation dies and a new one enters. Further, the representative individuals maximize their intertemporal utility function with consumption and the number of children subject to their lifetime income. They are also assumed to be rational and with perfect foresight. Each generation enters the labor market at age 21, bears and brings up their children at ages 21 to M + 20, retires at age $Q-1$, is granted a pension at Q, and dies at age Z. In addition, each supplies labor inelastically, and the utility functions of the *t*-th generation born in year *t* are specified as:

$$U_t = \alpha \frac{n_t^{1-\sigma_1}}{1-\sigma_1} + (1-\alpha)\sum_{j=1}^{Z-20}\left(\frac{1}{1+\rho}\right)^j \frac{c_{t,j}^{1-\sigma_2}}{1-\sigma_2} \tag{1}$$

where α refers to the weight between number of children and consumption, σ_1 the preference parameter of number of children, *j* the *j*-th period of life, ρ the pure rate of time preference, and σ_2 the reverse of the elasticity of intertemporal substitution of consumption. The arguments of the utility function are the number of children (n_t) and the consumption per period ($c_{t,j}$).

In addition, we assume that the number of children ($n_{t,j}$) whom the *t*-th generation bears at the *j*-th period of life is the following:

$$n_{t,j} = p_j n_t \ (where \ \ p_j > 0 \quad (if \ \ 1 \le j \le M-20) \quad and \ \ p_j = 0 \quad (if \ \ j > M-20)), \tag{2}$$

where p_j refers to the possibility that each generation bears the children at the *j*-th period of life and this parameter is assumed to be exogenous.

Moreover, the technological progress λ is assumed to be exogenous and labor embodied. We model age-specific labor productivity by assuming a hump-shaped age-earnings profile, that is, a quadratic form of its age *j*, so its age-wage profile e_j takes the following form:

$$e_j = \varsigma_0 + \varsigma_1 j + \varsigma_2 j^2, \ \ \zeta_0, \zeta_1 \ge 0 \text{ and } \zeta_2 \le 0 \tag{3}$$

The intertemporal budget equation of each generation is described as follows:

$$\sum_{j=1}^{M-20}(1+tc_{t+j+20})\sum_{g=1}^{20}\frac{\phi_g(1-\theta_{t+j-1+g+20})n_{t,j}}{\prod_{k=1}^{j-1+g}RN_{t+k+20}} + \sum_{j=1}^{Z-20}\frac{(1+tc_{t+j+20})c_{t,j}}{\prod_{k=1}^{j}RN_{t+k+20}} = NW_t$$

$$\equiv \sum_{j=1}^{Q-21} \frac{(1-tw_{t+j+20}-\tau w_{t+j+20})w_{t+j+20}(1+\lambda)^{t+j+20}e_j}{\prod_{k=1}^{j} RN_{t+k+20}} + \sum_{j=Q-20}^{Z-20} \frac{(1-\tau p_{t+j+20})q_{t+j+20}}{\prod_{k=1}^{j} RN_{t+k+20}}, (4)$$

where $1/\prod RN$ refers to the factor of the present discounted value derived from the gross interest rate after tax $RN_t \equiv 1+(1-tr_t)r_t$, the rate of return r_t, and the capital tax tr_t in year *t*, and ϕ_g is the child-rearing cost at the *g*-th period of life; θ_t is the government subsidy in year *t*; tc_t is the consumption tax rate in year *t*; tw_t is the labor income tax rate in year *t*; τw_t is the public pension premium rate in year *t*; NW_t is the net lifetime income of generation *t*; w_t is the wage rate in year *t*; τp_t is the tax for pension benefit in year *t*; and q_t stands for the pension benefit in year *t*.[3] In addition, the child-rearing cost is assumed to be proportional to net lifetime income; that is, $\phi_g = \Phi_g NW_t/(1+\bar{t}c_t)$, where Φ_g is the constant parameter and $\bar{t}c_t$ the average rate of consumption tax imposed on the *t*-th generation.

Each generation maximizes its utility function (1) under the budget constraint (4).

When $\sigma \equiv \sigma_1 = \sigma_2$, the maximization procedure differentiating the household utility function (2) with respect to n_t and $c_{t,j}$, subject to the individual's lifetime budget constraint (4), yields the following equations concerning consumption per period and number of children.

$$c_{t,j} = \left\{ (1-\alpha)\left(\frac{1}{1+\rho}\right)^j \Bigg/ \mu \frac{(1+tc_{t+j+20})}{\prod_{k=1}^{j} RN_{t+k+20}} \right\}^{1/\sigma}, \quad n_t = \left\{ \alpha \Bigg/ \mu \sum_{j=1}^{M-20}(1+tc_{t+j+20}) \sum_{g=1}^{20} \frac{\phi_g(1-\theta_{t+j-1+g+20})p_j}{\prod_{k=1}^{j-1+g} RN_{t+k+20}} \right\}^{1/\sigma}, (5)$$

and

$$\mu^{1/\sigma} = \left[\frac{\alpha^{1/\sigma}}{\left\{ \sum_{j=1}^{M-20}(1+tc_{t+j+20}) \sum_{g=1}^{20} \frac{\phi_g(1-\theta_{t+j-1+g+20})p_j}{\prod_{k=1}^{j-1+g} RN_{t+k+20}} \right\}^{1/\sigma-1}} + \sum_{j=1}^{Z-20} \frac{(1-\alpha)^{1/\sigma}\left(\frac{1}{1+\rho}\right)^{j/\sigma}}{\left\{ \frac{(1+tc_{t+j+20})}{\prod_{k=1}^{j} RN_{t+k+20}} \right\}^{1/\sigma-1}} \right] \Bigg/ NW_t$$

If the parameter μ is stable, these equations dictate the following two relationships: (1) as in any life-cycle model, the trade-off between current and future consumption is determined by the ratio of the interest rate and the time preference rate, and by the degree of risk aversion, and (2) the number

[3] In Japan, there are some indirect taxes (e.g., alcohol and tobacco tax) other than consumption tax. We calculatethe indirect tax rate from the total amount of indirect tax revenue in the national account. The rate is about 12%. 5% is the consumption tax rate and 7% the other indirect tax rate. Therefore, the effect of the other indirect tax rate is also considered in our simulation. However, in the simulation, we focus on the effect of increased consumption tax. Hence, we let tc_t represent the consumption tax only in our paper.

of children declines when the child-rearing cost increases or the government subsidy decreases. Moreover, from these equations, the following forms can be shown:

$$C_t = \sum_{j=1}^{Z-20} N_t c_{t-j-20,j}\ ,\ N_t = \sum_{j=1}^{M-20} N_t n_{t-j-20,j} \tag{6}$$

where C_t is the aggregated consumption in year *t* and N_t indicates the ordinal number of the generation born in year *t*. In addition, we can also derive the following physical wealth accumulation equation:

$$a_{t,j} = a_{t,j-1}(1-tr_{t+(j-1)+20})R_{t+(j-1)+20} + (1-tw_{t+j+20} - \tau w_{t+j-20})w_{t,j} - (1+tc_{t+j+20})c_{t,j}$$
$$-(1+tc_{t+j+20})\sum_{g=1}^{j}\phi_g(1-\theta_{t+j+20})n_{t,j-g+1}\text{, and } PA_t = \sum_{j=1}^{Z-20} N_t a_{t-j-20,j} \tag{7}$$

where $a_{t,j}$ is the physical wealth asset of generation *t* at the *j*-th period of life and PA_t is the aggregated private asset in year *t*.

Firm Behavior

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 and effective labor in order to maximize its profit with the given factor prices of wage and rent, which are determined in the perfect competitive markets.

$$Y_t = AK_t^{\varepsilon} L_{e,t}^{1-\varepsilon}\ ,\ L_{e,t} \equiv \sum_{j=1}^{Q-20}(1+\lambda)^t e_j N_{t-j-20} \tag{8}$$

$$K_t = I_t + (1-\delta)K_{t-1} \tag{9}$$

where Y_t is the output, ε stands for capital income share, *A* is a scale parameter, K_t is the physical capital stock, and $L_{e,t}$ is the effective labor.

We can derive two factor prices, the rate of return r_t and the wage rate per unit of effective labor w_t, by the first-order conditions for the firm's maximum profit:

$$R_t \equiv 1 + r_t = \varepsilon A K_t^{\varepsilon-1} L_{e,t}^{1-\varepsilon} + (1-\delta)\ ,\ w_t = (1-\varepsilon)AK_t^{\varepsilon} L_{e,t}^{-\varepsilon} \tag{10}$$

where δ is the depreciation of physical capital.

The Public Pension

The pension sector grants a pension to the retiring generations while a pension premium is collected from the working generations.

$$P_t = \tau w_t \times w_t L_{e,t} \tag{11}$$

where P_t stands for the aggregated pension premium.

The aggregated pension benefits in year *t* is given by the product of the retirement-age population, the replacement rate, and the average earnings of each generation during the working period $\overline{W}_t$.

$$B_t = \sum_{j=Q-19}^{Z-20} q_{t+j+20} N_{t+j+20} = \sum_{j=Q-19}^{Z-20} \gamma \times \overline{W}_{t+j+20} N_{t+j+20} \tag{12}$$

where γ denotes the replacement rateand B_t the aggregated pension benefit.

We explicitly model the public pension system as a pay-as-you-go scheme. The budget constraint of the pension sector can be shown as follows:

$$P_t = (1 - sp) B_t \tag{13}$$

where sp denotes the public subsidy to the pension scheme, financed by government expenditure G_t.

Moreover, we assume that the public pension sector maintains a fixed replacement rate exogenously. As a result, in our model, the pension premium rate is endogenously determined in order to keep the budget constraint (13).

The Government

The government sector imposes four types of taxes: the wage tax, the consumption tax, the capital tax, and the pension benefit tax.

$$T_t = tw_t \times w_t L_{e,t} + tc_t \times C_t + tc_t \times CH_t + tr_t \times R_t \times PA_t + tp_t \times B_t \tag{14}$$

We keep all tax rates constant. The role of the government is to endogenously determine the rate of the public debt issue as a residual of government expenditure and revenue.

$$D_t = G_t - T_t + (1 + r_t) D_{t-1} \tag{15}$$

where G_t stands for government expenditure in year *t*, T_t denotes tax revenue in year *t*, and D_t denotes public debt in year *t*.

Market Equilibrium

Finally, in our closed-economy model, we require a financial market equilibrium, in which the aggregate value of assets equals the market value of capital stocks plus the value of outstanding government bonds:

$$PA_t = K_t + D_t \tag{16}$$

Data, Calibration, and Scenarios

In this section, we describe the outline of the data and the parameters of our model, and explain the scenarios of our simulation.

Data and Calibration

First, we present the values of the main parameters and exogenous variables of the model in Table 1. The parameter values for the households' and firms' behaviors are derived from Auerbach and Kotlikoff (1987) and various early OLG simulation studies in Japan.[4] These parameters, such as the technological and preference parameters except the weight parameter α, are assumed to be

[4]See Sadahiro and Shimasawa (2001, 2003), Uemura (2002), and Ihori et al. (2006).

constant. The exogenous variables, such as the macroeconomic, fiscal, and public pension variables, are derived mainly from OECD (2007) and Whitehouse (2007).In addition, the child-bearing possibility parameter is derived from the "age-specific fertility rate" data provided by the National Institute of Population and Social Security Research (2007), and the parameter values of the child-rearing cost and the government subsidy are derived from the special research report on the social cost of rearing children, provided by the Director-General for Policies on a Cohesive Society, Cabinet Office, Japan (2005).

Second, by controlling the weight parameters during the years 1900–2007, we calibrate our demographic projection to fit the data's trend in "Population by Age (generation born in 1900–2007)," provided by the Statistics Bureau, Ministry of Internal Affairs and Communications (MIAC), with the collaboration of other ministries and agencies in Japan[5]. Fig. 1 reports the actual and computed values of demographic projections. Note the close correspondence between the actual and calculated values. In addition, since the model is simulated over 500 periods from 2007, the base year of our simulation, we ensure a sufficiently long period for a steady state to be achieved. In the simulation, we also keep the outstanding government debt to GDP at the same level after 2035, by controlling consumption tax. Table 2 reports the actual values of some key variables in 2007 and the computed values in the model. Further, it is observed that the actual values closely correspond to the calculated values.

Scenarios

Next, we present the simulation scenarios. The scenarios are classified into nine categories (See Table 3). Japan's government recently announced that the rate of consumption tax will increase to 10% by the mid-2010s. In addition, International Monetary Fund (2011) has suggested that the Japanese government should begin a gradual increase in consumption tax from 5% to 15% over several years, in order to maintain fiscal sustainability. Therefore, Scenario 1 assumes the baseline case with no expansion of child benefits, no reduction of public pension, and consumption tax reform (an increase in consumption tax to 10% from 2015 to 2024 and to 15% from 2025 to 2034).Scenarios 2 to 5 assume 100% increase in child benefit after 2015. Then, the additional financial resource in Scenario 2 is covered by the increase in consumption tax, in Scenario 3 by the increase in wage tax, in Scenario 4 by the increase in capital tax, and in Scenario 5 by the increase in government bond revenue. On the other hand, Scenarios 6 and 7 are those of the public pension reform. Scenario 6 assumes 50% reduction of the aggregated pension premium by increasing the consumption tax after 2015. Scenario 7 assumes 10% reduction of the public pension benefit and

[5] On the calibration with the demographic projection, we also control the weight parameter α in equation (1) during the years 1900–2007. Concretely, we adapt the following operation. Let N^*_t denote the population of the generation born in year t, provided by MIAC, and N_t, the population of the generation born in year t in equation (6). The parameter α_t in the utility of the generation born in year t increases (decreases), if $N_{t+\Delta}<N^*_{t+\Delta}$($N_{t+\Delta}>N^*_{t+\Delta}$, e.g., $\Delta=25$). In addition, the parameter α_t is fixed after year 2007.

100% increase in child benefit after 2015.Finally, Scenarios 8 and 9 are those of the accelerated fiscal reform. Scenario 8 assumes no expansion of child benefits but an increase in consumption tax to 15% (consumption tax reform) from 2015. Scenario 9 is the policy mix of Scenario 2 (permanent expansion) and Scenario 8.

SIMULATION RESULTS

In this section, we will describe the simulation results reported in Table 4 and Figs. 2 to 6.

Demographic Projection and Macroeconomic Variables

First, we describe the demographic projection. Fig. 2 shows the population projection of future generations born in the period 2000–2050. The projection in Scenario 1 closely corresponds to the official estimation provided by theNational Institute of Population and Social Security Research (2008). In contrast to Scenario 1, Scenarios 2 to 5 (100% permanent child benefits increases) and 9 (accelerated fiscal reform and 100% permanent child benefits increase) depict a population increase in the generation born after 2015. On the other hand, Scenarios 6 (50% reduction of the aggregated pension premium by increasing consumption tax), 7 (10% reduction of the public pension benefit and 100% permanent child benefits increase), and 8 (accelerated fiscal reform) show a population decrease in the generation born after 2015. In Scenario 5 (child benefits expansion financed by government debt), the population of the generation born in 2030 is the highest, increasing by 216,000.The population under Scenario 3 (child benefits financed by increasing wage tax) shows an increase of 177,000; followed by the population under Scenario 2 (consumption-tax-funded child benefits) with an increase of 173,000; the population under Scenario 4 (capital-tax-funded child benefits) with an increase of 169,000; and, finally, the population under Scenario 9 (accelerated fiscal reform and 100% permanent child benefits increase) with an increase of 105,000. Scenario 6 (half of the pension premium covered by consumption tax) demonstrates a decrease of 19,000; Scenario 7 (10% reduction of the public pension benefit and 100% permanent child benefits increase), a decrease of 47,000; and Scenario 8 (only accelerated fiscal reform), a decrease of 30,000.

Fig. 4 shows the total fertility rate (TFR) from 1995 to 2030. The projections in Scenario 1 closely correspond to the official estimation provided by the National Institute of Population and Social Security Research (2007). Fig. 2 shows a TFR projection for all scenarios. For example, Scenario 5 shows the highest TFR with 1.55, followed by Scenario 3 with 1.48, in 2030.Fig. 3 shows a projection of the retired population ratio from 2010 to 2050. The projection in Scenario 1 closely corresponds to the official estimation provided by the National Institute of Population and Social Security Research (2007). In comparison to Scenario 1, the 2030 retired population ratio in Scenarios 2 to 5, with permanent child benefit increases, decreases between 0.33% of a point and 0.42% of a point. Similarly, the ratio in Scenario 9 decreases by 0.22% of a point, not a highly significant difference. Further, the 2050 retired population ratio in Scenarios 2 to 5, with permanent child benefit increases, decreases between 2.5% of a point and 2.0% of a point, compared to the other scenarios. Regardless of the long-term improvements, in the short term, it seems unlikely that the retired population rate will decrease to any significant degree in response to child-rearing benefits. Next, we simply explain the projection from a macroeconomic perspective. As our model employs a life-cycle hypothesis, the savings rate is highly influenced by the aging population. Looking at the transition of macroeconomic variables shown in Table 4, all scenarios show a decrease in the savings rate between 2010 and 2050, compared to the 2007 rate of 4.72%. However, in comparison to Scenario 1, Scenarios 2 (child benefits expansion financed by consumption tax, and permanent child benefits increases), 4 (funded by capital income tax), 5 (funded by government debt), and 6 (50% reduction of the aggregated pension premium by increasing consumption tax) show a rise in the savings rate in 2030. Further, Scenarios 2 to 9 show a rise in the savings rate in 2050, as compared to Scenario 1.Finally, the factor price shows a stable transition in all scenarios, fluctuating between the interest rates of 2.43% (wage rate) and 3.99% (93.38% to 101.37%). In general, increased child benefits lead to more births, creating a greater workforce. However, an expanded workforce will lower the capital-labor ratio, possibly increasing the interest rate while simultaneously restraining the wage rate. Table 4 shows Scenarios 2 to 5 (permanent child benefits increases) reflecting a lower capital-labor ratio for 2030 than that of Scenario 1, along with lower GDP and GDP per employee. On the other hand, pension and fiscal reforms, as implemented in Scenarios 6 through 9, result in a higher capital-labor ratio, GDP, and GDP per employee.

Fiscal Variables

A pension system reform reducing benefits by 10% or accelerated fiscal reform to increase consumption taxation to 15% from 2015 will stabilize the future fiscal balance and the value of outstanding government bonds to GDP. Given the above, the projections in Table 4 and Fig. 5 together yield that in comparison to Scenario 1, debt per employee in 2030 improves in Scenario 7 (pension benefits cut by 10% and child benefits expansion) and in Scenarios 8 and 9 (accelerated fiscal reform). In turn, as Table 4 indicates, the outstanding government debt to GDP in 2030 shows more improvement in Scenarios 7 to 9 than in Scenario 1. In particular, the public debt-to-GDP ratio after 2035 is projected at roughly 311% in Scenario 1, 281% in Scenario 7, 261% in Scenario 8, and 272% in Scenario 9.On the other hand, Scenarios 2 (child benefits expansion financed by increase in consumption tax), 3 (increase in wage tax), 4 (increase in capital income tax), and 5 (child benefits expansion financed by government debt) are worse in terms of debt per employee in comparison to Scenario 1; Scenarios 2 to 4 show increased interest due to the lower capital-labor ratio and Scenario 5 shows increased public debt due to the lower capital-labor ratio and the issue of government bonds to fund child benefits. Therefore, the public debt-to-GDP ratio after 2035 is projected at roughly 327% in Scenarios 2, 320% in Scenario 3, 335% in Scenario 4, and 372% in Scenario 5.The tax changes in Table 4 also show that the funding required for increased child benefits ranges from 2.12% to 3.44% in Scenario 2 (consumption tax funding), 2.40% to 3.12% in Scenario 3 (wage tax funding), and 5.36% to 7.65% in Scenario 4 (capital income tax funding).

Welfare

Finally, we describe the welfare estimation for each generation (welfare with equivalent variation). Fig. 6 shows the welfare in Scenarios 1 to 9 with welfare of the generation born in 1930 standardized as 1. As the birthrate dwindles and the aging population grows, the pay-as-you-go pension premium increases. In addition, an increased government-issued debt to GDP inhibits investment of private assets in production and lowers future economic growth. As a result, the welfare of the working and future generations decreases in comparison to that of the generation born in 1930.However, all scenarios (except Scenarios 1 and 6) have a downward convex shape, with the lowest welfare occurring in 2020 for Scenarios 2 to 4, in 2015 for Scenario 5, in 2065 for Scenario 7, in 2060 for Scenario 8, and in 2025 for Scenario 9. This basically suggests that the negative effect of the declining birthrate and the aging population is mitigated by expanding the child benefits that increases the birthrate, or public pension and accelerated fiscal reforms that decrease the pension premium and public debt to GDP. We can also see that in comparison to Scenario 1, the welfare of the generations born after 1975, 1990, or 1995 improves in Scenarios 6 to 9, while the welfare of the generations born after 2020 or 2025 improves in Scenarios 2 to 5. The reason for this is as follows. Generally, child benefits expansion reduces the relative price of the number of children to consumption for each generation and increases the number of dependents (i.e., children). Then, in Scenarios 2 to 5, the total cost of child-rearing rises for the working generation in the early stage of child benefits expansion. Therefore, the welfare of the generation becomes lower than that in Scenarios 1, 6, and 8. Scenarios 7 and 9 also have the negative effect of child benefits expansion. However, these scenarios include the effect of public pension and accelerated fiscal reforms. For this reason, the welfare of the generation born in the period 1995 to 2020 is higher in Scenarios 7 and 9, as compared to in Scenarios 2 to 5. This indicates that the positive effect of public pension and accelerated fiscal reforms is much larger than the negative effect of child-rearing cost on the welfare of the generation. In addition, among Scenarios 2 to 5, the welfare of the generations born in the period 1955 to 1980 is lowest in Scenario 2 (child benefits expansion financed by consumption tax). An additional tax on the retired generation's consumption in the early stage after the child benefits expansion of Scenario 2 presents less distortion as it works as a lump-sum tax. This indicates that child benefits expansion funded by consumption tax results in an intergenerational income transfer from the retired to the younger generation.

On the other hand, the welfare for the generation born in 2075 is the highest in Scenario 9 (accelerated fiscal reform and child benefits expansion). The next highest figure is for Scenario 4 (child benefits expansion financed by capital income tax), followed by Scenario 5 (financed by government debt), Scenario 2 (financed by consumption tax), and Scenario 3 (financed by wage tax), in that order. All these scenarios have child benefits expansion. The sixth highest figure is that for Scenario 6 (maintains half of the pension premium through VAT), followed by Scenario 7 (pension benefits cut by 10% and child benefits expansion), Scenario 8 (accelerated fiscal reform), and, finally, Scenario 1, ranking ninth (baseline). All these scenarios (except Scenario 7) do not have child benefits expansion. Generally, public pension and accelerated fiscal reforms have the pressure of rising capital-labor ratio in the long period. In our model, while increased capital-labor ratio improves lifetime wage, it also increases child-rearing cost. Then, if the positive effect of improved lifetime wage is overshadowed by the negative effect of increased child-rearing cost, the welfare of future generations does not improve. The above order of the welfare for the generation born in 2075 indicates this mechanism, except for in Scenario 9. On the other hand, child benefits expansion leads to more births, creating a greater workforce, and has the pressure of reducing capital-labor ratio in the long run. This mitigates the negative effect of increased child-rearing cost. In addition, in our model, each generation obtains the welfare gain from more births. Therefore, the welfare for the generation born in 2075 is higher in Scenarios 2 to 5 and 9, as compared to in other scenarios[6].Placing the highest importance on the welfare of future generations, Scenario 9 (accelerated fiscal reform and child benefits expansion) stands out as the most desirable option.

Conclusion and Future Issues

In this paper, we presented an OLG model with multi-concurrent generations and endogenous fertility to analyze the effects of increased child benefits and reduced pension benefits on the welfare of the working and future generations. The following results were obtained through the analysis. First, we considered increased child benefits without pension and accelerated fiscal reforms. Among Scenarios 2 to 5, the welfare of future generations improved most through child benefits funded by capital income tax. This indicates that the best policy is to cover child benefits via capital income taxation, followed by government bonds, VAT, and wage taxation, in that order. We also looked at the existing method of accelerated fiscal reform. In this case, rather than fiscal reform alone, coupling increased child benefits and fiscal reform simultaneously improves the welfare of future generations more. In particular, according to our simulation, it stands out as the most desirable option. Public pension reform was also examined. We found that using consumption tax to partially fund the pension premium, rather than cutting pension benefits coupled with increasing child benefits, yields a higher welfare for future generations.

Finally, we would like to address some relevant topics for future research.

[6]In Scenario 7, the effect of public pension reform on capital-labor ratio is greater than the effect of child benefits expansion on the same. Therefore, the welfare for the generation born in 2075 is lower in this scenario, as compared to in Scenarios 2 to 5 and 9.

The first key step is to analyze the optimum taxation for the OLG model with endogenous fertility. In this paper, we mainly examine funding for increased child benefits based on consumption, wage, and capital income taxes, and how those taxes would affect the welfare of the working and future generations. However, rather than focusing only on child benefit financing, we should explore optimal tax structures when existing governmental expenditures other than child rearing and pension benefits (such as education and medical care) are added as parameters. This will be a major point for future discussions. The second key issue is how to handle heterogeneity within generations. To simplify the analysis, we disregarded such considerations in this study. However, if the heterogeneity factor is added to the simulation, we must expect changes in the macroeconomic effects of child benefits, including the future transition of population demographics. Then, we must be able to analyze the effect of child benefits expansion, public pension, and fiscal reforms on the intragenerational equity for the representative households with different earnings abilities. This will also be a major point for future discussions. The third issue is to develop the model further to include endogenous labor supply. For simplified analysis, we assumed inelastic labor supply and disregarded the time selection of each generation between childbirth or child rearing and labor supply. However, in the real world, this time selection is crucial and should be incorporated into future studies. The fourth issue is to analyze the effect of public health insurance. In aging Japan, public health insurance is as important as public pension. Thus, an incorporation of the medical cost would be expected to make our analysis more comprehensive. This will also be a major point for future discussions. Finally, the fifth issue is to analyze the robustness of the simulation results. The results may depend on specifications of the model and parameters. If we change the model and incorporate the above issues (e.g., heterogeneity within generations, endogenous labor supply, and public health insurance) in the model, there exists the possibility that our results change. In addition, we calibrate the parameters of our model to the macro data of Japan. However, if we calibrate it to that of other countries, the results may change. These two issues are left for future discussions. We also need to analyze the impact of the following on governmental policies: (1) lower pension premiums and higher pension benefits for households with more children to endogenize the externality of pay-as-you-go public pensions and (2) an attitude of regarding children as investments, not as consumption. Finally, enhancing the framework of analysis, for example, expanding it from a closed- to an open-economy model and incorporating uncertainties, will certainly stimulate further research.

REFERENCES

Atkinson, A.B. and J.E. Stiglitz, 1972. The structure of indirect taxation and economic efficiency. Journal of Public Economics, 1: 97-119.

Atkinson, A.B. and J.E. Stiglitz, 1976. The design of tax structure: Direct versus indirect taxation. Journal of Public Economics 6(1-2): 55-75.

Auerbach, A.J. and L.J. Kotlikoff, 1987. Dynamic fiscal policy. Cambridge: Cambridge University Press.

Chamley, C., 1986. Optimal taxation of capital income in general equilibrium with infinite lives. Econometrica, 54(3): 607-622.

Conesa, J.C., S. Kitao and D. Krueger, 2007. Taxing capital? Not a bad idea after all! Nber.

Cremer, H. and F. Gahvari, 1995. Uncertainty, optimal taxation and the direct versus indirect tax controversy. Economic Journal, 105: 1165-1179.

Diamond, P.A., 1965. National debt in a neoclassical growth model. American Economic Review, 55(5): 1126-1150.

Hatta, T. and Y. Oguchi, 1999. The theory of public pension reform: Transform to funding system. Nikkei Publishing, Inc. [in Japanese].

Hubbard, R.G. and K.L. Judd, 1986. Liquidity constraints, fiscal policy, and consumption. Brookings Papers on Economic Activity, 1: 1-59.

International Monetary Fund, 2011. Raising the consumption tax in japan: Why, when, how? Available from IMF Staff Discussion Note No. 2011/13.

Judd, K.L., 1985. Redistributive taxation in a simple perfect foresight model. Journal of Public Economics, 28(1): 59-83.

National Institute of Population and Social Security Research, 2007. Population statistics of japan [in Japanese].

National Institute of Population and Social Security Research, 2008. Available from Population Projections for Japan: 2006-2055.

Oguro, K., J. Takahata and M. Shimasawa, 2009. Child benefit and fiscal burden: Olg model with endogenous fertility. IPSS Discussion Paper Series 2009-E01.

Saez, E., 2002. The desirability of commodity taxation under non-linear income taxation and heterogeneous tastes. Journal of Public Economics, 83(2): 217-230.

Weinzierl, M., 2007. The surprising power of age-dependent taxes. Available from http://www.econ.yale.edu/seminars/jr-fac/jf08/Weinzierl_JMP.pdff.

Whitehouse, E., 2007. Pensions panorama: Retirement-income systems in 53 countries. The World Bank.

Table-1. Parameter values of the model

PARAMETER			VALUE
Utility function			
Time preference rate	ρ		0.01
Intertemporal elasticity of substitution	$1/\sigma$		2.0
Weight parameter between number of children and consumption	α		0.84*
Production function			
Technology progress	λ		0.002
Capital share in production	ε		0.3
Physical capital depreciation	δ		0.05
Tax policy parameters			
Wage tax	tw		20.0%
Capital tax	tr		20.0%
Consumption tax	tc		5.0%
Pension benefit tax	tp		10.0%
Pension policy parameters			
National subsidy to pension	sp		25.0%
Replacement ratio	γ		50.0%
Other parameters			
Child-rearing cost to net lifetime income	Φ_g g=	0 to 5	0.78%
		6 to 10	0.46%
		11 to 15	0.55%
		16 to 20	0.58%
Childbearing possibility	p_j j=	1 to 5	3.0%
		6 to 10	7.4%
		11 to 15	7.0%
		16 to 20	2.6%
Government subsidy to child-rearing cost	θ		0.1
Age-wage profile	ς_0		88.3
	ς_1		7.08
	ς_2		-0.146
Age limit for childbearing	M		40
Age of retirement	Q		65
Average life expectancy	Z		85

* This parameter is fixed after year 2007.

Table-2. Year 2007 of the baseline scenario

	OFFICIAL	MODEL
National Income (% of GDP)		
Private consumption	74.1%	81.8%
Government purchases of goods and services	21.0%	24.3%
Saving rate	3.1%	4.7%
Government Indicators		
Pension premium to wage	14.9%	14.9%
Gross public debt *(% of GDP)*	170.6%	172.4%
Primary balance *(% of GDP)*	-2.4%	-4.3%
Tax revenues *(% of GDP)*	18.4%	19.8%
Other Indicators		
Capital output ratio	2.9	4.4
Interest rate	1.7%	2.6%

Source: OECD Economic Outlook No. 84, 2008, and "Annual Report on National Accounts," the Japanese SNA statistics (Cabinet Office).

Table-3. Scenarios

	Child benefits	Additional financial resources	Consumption tax*	Public pension reform
Scenario 1	No increase	–	5% from 1997 to 2014 10% from 2015 to 2024 15% from 2015 to 2034	–
Scenario 2	100% increase after 2015	By the increase in consumption tax	Scenario 1 and the effect of 100% increase after 2015	–
Scenario 3	100% increase after 2015	By the increase in wage tax	Same as Scenario 1	–
Scenario 4	100% increase after 2015	By the increase in capital tax	Same as Scenario 1	–
Scenario 5	100% increase after 2015	By the increase in government bond revenue	Same as Scenario 1	–
Scenario 6	No increase	–	Scenario 1 and the effect of public pension reform	50% reduction of the aggregated pension premium by increasing consumption tax after 2015
Scenario 7	100% increase after 2015	–	Same as Scenario 1	10% reduction of the public pension benefit after 2015
Scenario 8	No increase	–	5% from 1997 to 2014 15% from 2015 to 2034	–
Scenario 9	100% increase after 2015	By the increase in consumption tax	Same as Scenario 8	–

* In each simulation scenario, we keep the outstanding government debt to GDP after 2035 at the same level, by controlling consumption tax.

Table 4. Simulation results

	Year	Macroeconomic projections (%)											
		GDP	GDP per employee	Savings rate	Capital-labor ratio	Interest rate	Wage rate	Debt-GDP ratio	Debt per employee	Consumption tax	Wage tax	Capital tax	Pension premium to wage
Scenario1	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.34%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	189.01%	107.89%	5.00%	20.00%	20.00%	15.83%
	2015	93.42%	102.33%	5.38%	99.13%	2.71%	99.74%	221.88%	121.90%	10.00%	20.00%	20.00%	17.37%
	2020	89.86%	104.36%	-1.10%	100.52%	2.64%	100.16%	243.90%	131.30%	10.00%	20.00%	20.00%	24.07%
	2030	81.18%	102.87%	-4.68%	94.20%	2.99%	98.22%	287.24%	150.95%	15.00%	20.00%	20.00%	26.77%
	2040	69.11%	105.86%	-8.03%	97.77%	2.79%	99.32%	311.24%	159.99%	17.48%	20.00%	20.00%	31.19%
	2050	58.51%	108.80%	-13.86%	98.48%	2.75%	99.54%	311.24%	152.48%	18.84%	20.00%	20.00%	38.80%
Scenario 2	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.58%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	189.32%	107.92%	5.00%	20.00%	20.00%	15.83%
	2015	92.80%	101.66%	6.63%	96.99%	2.83%	99.09%	224.48%	122.35%	12.43%	20.00%	20.00%	17.37%
	2020	89.19%	103.57%	-1.12%	98.02%	2.77%	99.40%	249.71%	133.10%	12.25%	20.00%	20.00%	26.17%
	2030	80.82%	102.42%	-4.36%	92.82%	3.08%	97.79%	298.88%	154.48%	17.12%	20.00%	20.00%	27.25%
	2040	68.92%	105.32%	-7.23%	96.32%	2.87%	98.88%	327.80%	162.80%	20.91%	20.00%	20.00%	31.59%
	2050	59.34%	107.24%	-11.75%	95.64%	2.91%	98.67%	327.80%	154.28%	21.92%	20.00%	20.00%	37.77%
Scenario 3	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.56%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	189.33%	107.94%	5.00%	20.00%	20.00%	15.83%
	2015	93.72%	102.67%	4.70%	100.22%	2.65%	100.07%	221.59%	121.98%	10.00%	22.40%	20.00%	17.37%
	2020	89.64%	104.11%	-2.21%	99.70%	2.68%	99.91%	245.56%	131.57%	10.00%	22.72%	20.00%	25.99%
	2030	80.83%	102.43%	-4.70%	92.85%	3.07%	97.80%	293.13%	151.52%	15.00%	22.72%	20.00%	27.10%
	2040	68.78%	105.11%	-7.38%	95.68%	2.91%	98.69%	320.83%	158.93%	18.57%	22.89%	20.00%	31.44%
	2050	59.20%	106.97%	-11.58%	94.84%	2.95%	98.43%	320.83%	150.37%	19.92%	23.12%	20.00%	37.73%

Table-4. Simulation results (continued)

	Year	Macroeconomic projection (%)											
		GDP	GDP per employee	Savings rate	Capital-labor ratio	Interest rate	Wage rate	Debt-GDP ratio	Debt per employee	Consumption tax	Wage tax	Capital tax	Pension premium to wage
Scenario 4	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.45%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	189.18%	107.92%	5.00%	20.00%	20.00%	15.83%
	2015	92.98%	101.86%	4.50%	97.61%	2.80%	99.28%	223.52%	122.14%	10.00%	20.00%	27.65%	17.37%
	2020	88.68%	102.99%	-2.08%	96.18%	2.88%	98.84%	250.17%	132.69%	10.00%	20.00%	27.22%	26.27%
	2030	79.83%	101.16%	-4.26%	89.06%	3.31%	96.59%	303.72%	155.23%	15.00%	20.00%	25.67%	27.38%
	2040	68.00%	103.94%	-6.96%	92.16%	3.12%	97.58%	335.84%	164.81%	19.61%	20.00%	25.56%	31.60%
	2050	58.60%	106.04%	-11.66%	92.03%	3.12%	97.54%	335.84%	156.33%	20.64%	20.00%	25.36%	37.82%
Scenario 5	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.59%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	189.37%	107.95%	5.00%	20.00%	20.00%	15.83%
	2015	93.65%	102.58%	6.01%	99.95%	2.67%	99.98%	223.30%	122.79%	10.00%	20.00%	20.00%	17.37%
	2020	89.47%	103.91%	-0.85%	99.07%	2.72%	99.72%	255.64%	136.66%	10.00%	20.00%	20.00%	26.04%
	2030	80.08%	101.48%	-3.86%	90.00%	3.25%	96.89%	327.51%	167.30%	15.00%	20.00%	20.00%	27.39%
	2040	68.22%	104.21%	-6.26%	93.03%	3.06%	97.85%	372.60%	181.83%	23.37%	20.00%	20.00%	32.02%
	2050	59.20%	106.33%	-12.03%	93.33%	3.04%	97.95%	372.60%	172.68%	23.76%	20.00%	20.00%	38.46%
Scenario 6	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.83%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	189.39%	107.80%	5.00%	20.00%	20.00%	15.83%
	2015	87.46%	95.81%	17.67%	79.58%	3.99%	93.38%	242.53%	124.39%	33.83%	20.00%	20.00%	8.69%
	2020	86.24%	100.15%	7.05%	87.64%	3.41%	96.12%	270.78%	139.48%	30.55%	20.00%	20.00%	9.67%
	2030	81.66%	103.48%	-3.84%	96.06%	2.88%	98.80%	295.95%	156.12%	31.47%	20.00%	20.00%	12.28%
	2040	69.84%	106.96%	-8.16%	101.22%	2.60%	100.36%	310.99%	162.11%	31.44%	20.00%	20.00%	14.89%
	2050	59.50%	110.88%	-11.64%	104.64%	2.43%	101.37%	310.99%	156.70%	34.03%	20.00%	20.00%	17.50%

Table-4. Simulation results (continued)

		Macroeconomic projection (%)											
	Year	GDP	GDP per employee	Savings rate	Capital-labor ratio	Interest rate	Wage rate	Debt-GDP ratio	Debt per employee	Consumption tax	Wage tax	Capital tax	Pension premium to wage
Scenario 7	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.35%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	188.98%	107.87%	5.00%	20.00%	20.00%	15.83%
	2015	93.87%	102.83%	3.15%	100.74%	2.63%	100.22%	220.01%	121.45%	10.00%	20.00%	20.00%	17.37%
	2020	90.34%	104.92%	4.82%	102.33%	2.54%	100.69%	237.15%	128.37%	10.00%	20.00%	20.00%	9.67%
	2030	82.12%	104.06%	-4.78%	97.87%	2.78%	99.36%	266.90%	142.29%	15.00%	20.00%	20.00%	23.92%
	2040	70.08%	107.42%	-8.33%	102.59%	2.53%	100.77%	281.31%	147.87%	14.52%	20.00%	20.00%	27.29%
	2050	58.84%	110.28%	-12.83%	102.47%	2.54%	100.73%	281.31%	140.59%	15.74%	20.00%	20.00%	33.04%
Scenario 8	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.28%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	188.87%	107.85%	5.00%	20.00%	20.00%	15.83%
	2015	91.84%	100.60%	6.84%	93.66%	3.03%	98.06%	223.85%	120.95%	15.00%	20.00%	20.00%	17.37%
	2020	89.40%	103.82%	-1.62%	98.79%	2.73%	99.64%	230.76%	123.64%	15.00%	20.00%	20.00%	26.16%
	2030	82.34%	104.34%	-5.93%	98.74%	2.73%	99.62%	245.70%	131.24%	15.00%	20.00%	20.00%	26.76%
	2040	69.75%	106.87%	-8.19%	100.88%	2.62%	100.26%	261.09%	136.17%	15.50%	20.00%	20.00%	30.73%
	2050	58.58%	109.46%	-12.39%	100.15%	2.66%	100.04%	261.09%	129.06%	17.01%	20.00%	20.00%	37.09%
Scenario 9	2007	100.00%	100.00%	4.72%	100.00%	2.67%	100.00%	172.42%	100.00%	5.00%	20.00%	20.00%	14.90%
	2010	98.37%	100.93%	3.64%	100.55%	2.64%	100.16%	189.09%	107.89%	5.00%	20.00%	20.00%	15.83%
	2015	91.85%	100.62%	7.08%	93.70%	3.02%	98.07%	224.53%	121.22%	15.00%	20.00%	20.00%	17.37%
	2020	89.36%	103.78%	-1.37%	98.66%	2.74%	99.60%	233.39%	124.79%	15.00%	20.00%	20.00%	26.17%
	2030	82.12%	104.07%	-5.79%	97.90%	2.78%	99.36%	253.73%	133.91%	15.00%	20.00%	20.00%	26.84%
	2040	69.64%	106.51%	-7.77%	99.94%	2.67%	99.98%	272.53%	138.50%	16.51%	20.00%	20.00%	30.85%
	2050	59.42%	108.54%	-11.38%	98.83%	2.73%	99.65%	272.53%	131.09%	17.96%	20.00%	20.00%	36.75%

Fig-1. Demographic projection of each generation

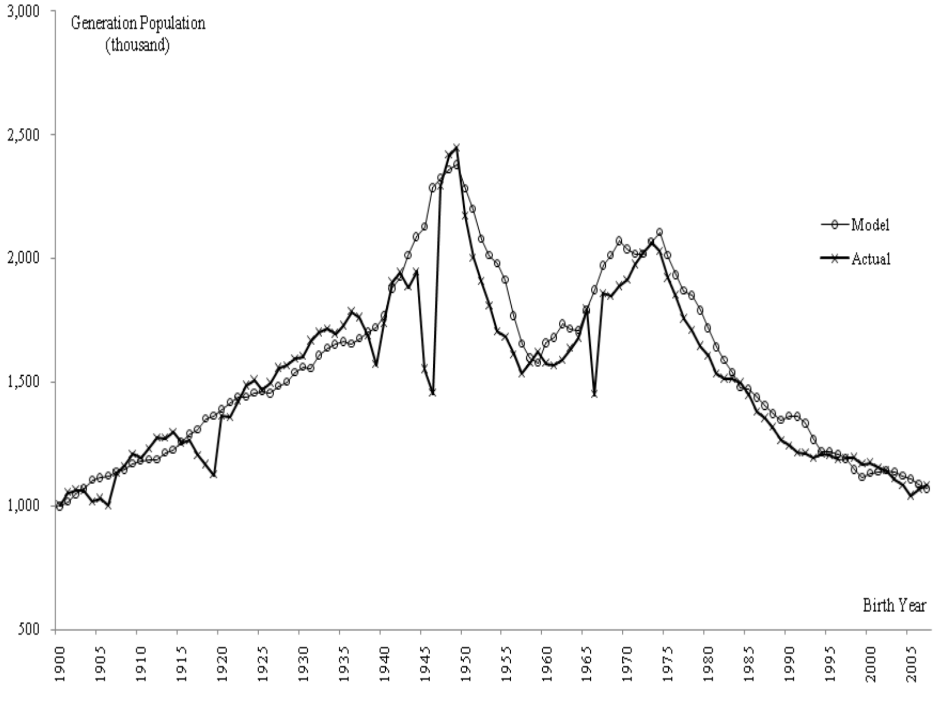


Fig-2. Simulation results: demographic projection of future generations

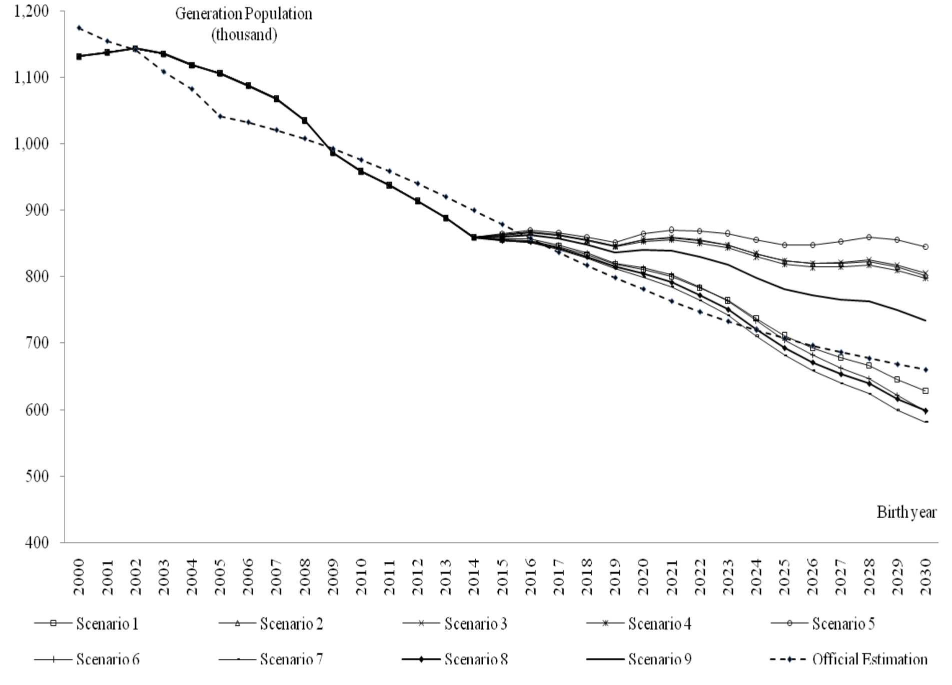


Fig-3. Simulation results: retired population ratio

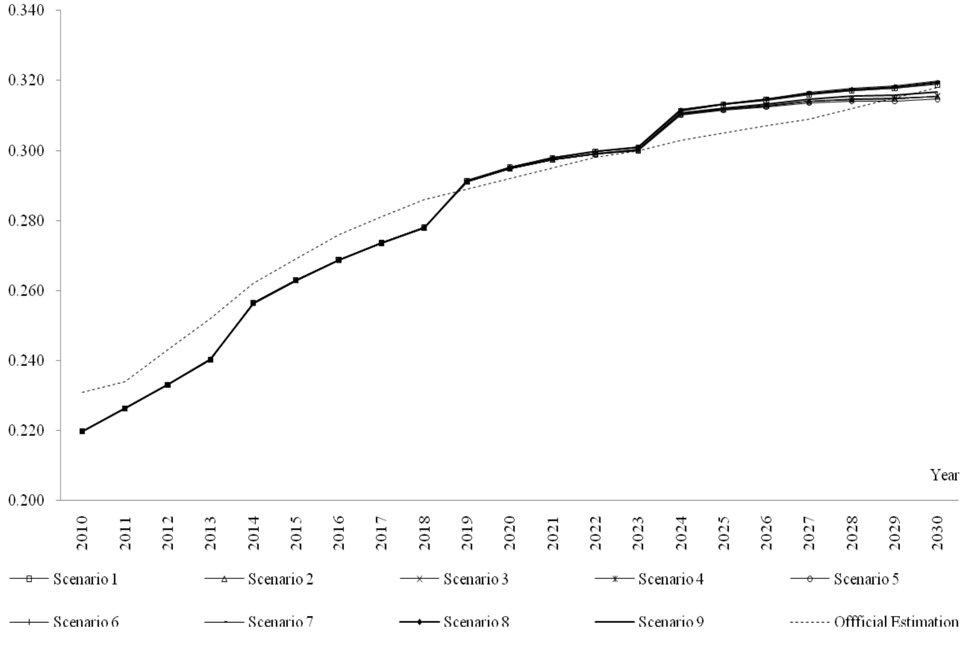


Fig. 4. Simulation results: total fertility rate

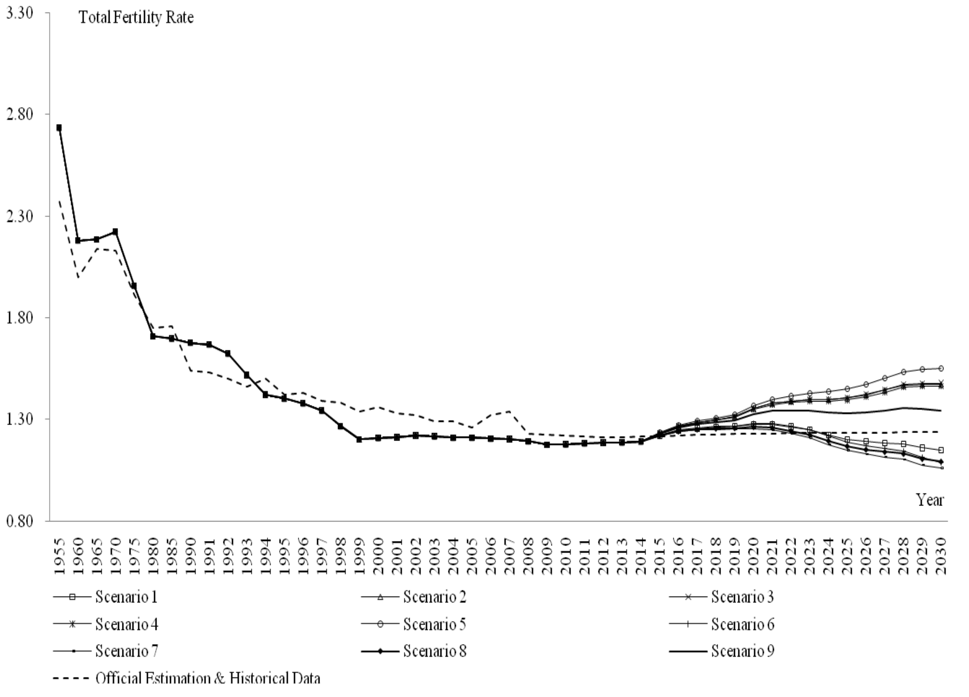


Fig. 5. Simulation results: debt per employee

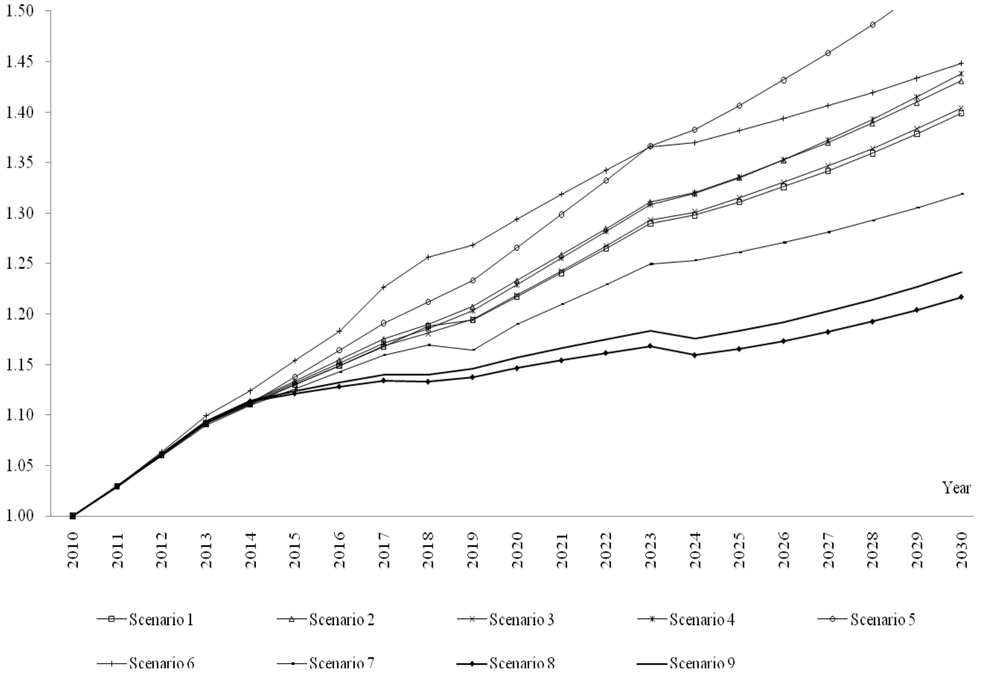
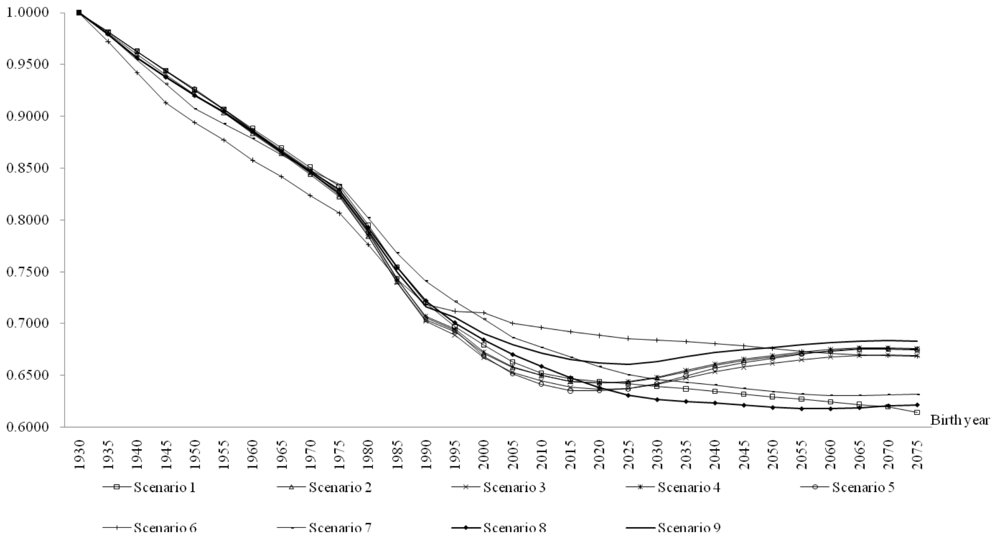


Fig. 6. Simulation results: welfare with equivalent variation



Additional Information Simulation results: welfare with equivalent variation

Birth year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9
1930	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1935	0.9814	0.9803	0.9813	0.9814	0.9813	0.9722	0.9789	0.9792	0.9792
1940	0.9627	0.9600	0.9625	0.9624	0.9627	0.9423	0.9544	0.9567	0.9567
1945	0.9441	0.9399	0.9439	0.9436	0.9442	0.9130	0.9313	0.9376	0.9376
1950	0.9255	0.9212	0.9253	0.9251	0.9262	0.8940	0.9074	0.9198	0.9200
1955	0.9068	0.9033	0.9071	0.9062	0.9066	0.8771	0.8928	0.9045	0.9042
1960	0.8882	0.8832	0.8868	0.8859	0.8865	0.8577	0.8786	0.8854	0.8847
1965	0.8696	0.8639	0.8665	0.8661	0.8677	0.8418	0.8631	0.8661	0.8652
1970	0.8509	0.8438	0.8456	0.8462	0.8484	0.8235	0.8482	0.8472	0.8457
1975	0.8323	0.8222	0.8235	0.8250	0.8272	0.8063	0.8343	0.8292	0.8259
1980	0.7950	0.7840	0.7842	0.7868	0.7886	0.7760	0.8020	0.7925	0.7897
1985	0.7545	0.7402	0.7396	0.7433	0.7435	0.7433	0.7682	0.7539	0.7492
1990	0.7198	0.7038	0.7022	0.7071	0.7054	0.7184	0.7411	0.7219	0.7164
1995	0.6969	0.6925	0.6889	0.6947	0.6933	0.7121	0.7212	0.7009	0.7061
2000	0.6794	0.6715	0.6672	0.6727	0.6683	0.7107	0.7043	0.6843	0.6904
2005	0.6629	0.6575	0.6529	0.6581	0.6515	0.7004	0.6864	0.6701	0.6795
2010	0.6524	0.6499	0.6449	0.6500	0.6417	0.6961	0.6771	0.6588	0.6717
2015	0.6469	0.6441	0.6387	0.6441	0.6350	0.6921	0.6675	0.6477	0.6652
2020	0.6442	0.6426	0.6367	0.6430	0.6353	0.6885	0.6584	0.6382	0.6617
2025	0.6420	0.6433	0.6371	0.6438	0.6370	0.6857	0.6507	0.6307	0.6607
2030	0.6395	0.6475	0.6412	0.6482	0.6421	0.6839	0.6459	0.6266	0.6633

Additional information Simulation results: welfare with equivalent variation (continued)

Birth year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9
2035	0.6370	0.6539	0.6475	0.6547	0.6495	0.6826	0.6432	0.6249	0.6679
2040	0.6345	0.6599	0.6535	0.6609	0.6566	0.6808	0.6408	0.6234	0.6722
2045	0.6320	0.6643	0.6580	0.6654	0.6622	0.6783	0.6376	0.6212	0.6751
2050	0.6295	0.6678	0.6616	0.6690	0.6667	0.6757	0.6344	0.6190	0.6772
2055	0.6270	0.6710	0.6650	0.6723	0.6707	0.6734	0.6320	0.6178	0.6794
2060	0.6245	0.6735	0.6678	0.6749	0.6738	0.6714	0.6307	0.6178	0.6814
2065	0.6220	0.6749	0.6694	0.6764	0.6756	0.6700	0.6306	0.6188	0.6828
2070	0.6195	0.6752	0.6699	0.6768	0.6760	0.6691	0.6314	0.6207	0.6834
2075	0.6145	0.6743	0.6691	0.6758	0.6752	0.6683	0.6317	0.6216	0.6828