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# Welfare Analysis of Progressive Expenditure Taxation in Japan

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**Abstract**

This paper aims to establish guidelines for public pension reform in an aging Japan, using a numerical simulation approach. The paper examines the effects of demographic change and public pension policies on economic growth and welfare, using a dynamic life-cycle general equilibrium model. It deals with the benchmark case with the current Japanese pension schedule based on the 2004 reform, and the reform cases in which the whole basic pension benefit is financed by a consumption tax and in which the earnings-related pension is abolished. Moreover, it handles the case in which a progressive expenditure (or consumption) tax is introduced. The simulation results show that the level of economic welfare is higher under these reforms than under the current pension schedule.

*Keywords:* Aging population; Public pension reform; Basic pension; Progressive expenditure tax; Life-cycle general equilibrium simulation model

*JEL classification:* H30; C68

## 1 Introduction

With a population that is rapidly aging, Japan faces serious public finance problems, particularly when it comes to tax and social security issues. Structural reforms are urgently needed to accommodate the impending demographic change. In particular, the sustainability of the public pension system is an important problem in Japan, and thus a reform of the public pension program was implemented in 2004. However, this reform seems to be far from a radical reform. Hence, it was unable to dispel completely the suspicion with which the people, especially the young, view the public pension scheme. The necessity for a more drastic reform of the scheme is now becoming obvious.

This paper aims to establish guidelines for public pension and tax reforms in an aging Japan, using a numerical simulation approach. This paper examines the effects of different public pension policies on economic growth and economic welfare in an aging Japan, using a computable, general equilibrium model of overlapping generations. In the benchmark simulation, the public pension reform scheduled by Japan's 2004 pension reform is performed. Alternative simulations with another public pension reform are also implemented. The paper deals

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with the simulation case in which the whole basic pension is financed by a consumption tax or in which the earnings-related pension is abolished. Furthermore, the paper handles the case where a progressive expenditure (or consumption) tax replaces a proportional one.

To analyze the problem, this paper looks at the Japanese tax and social security systems using an extended life-cycle general equilibrium model. Many papers have studied using this kind of model; for instance, Auerbach and Kotlikoff (1983a, 1983b, 1987), Seidman (1983), Auerbach *et al*. (1989), Altig *et al*. (2001), Homma *et al*. (1987), Uemura (2001) and Ihori *et al*. (2006). Nearly all of them, however, have concentrated on analyzing the effects of an aging population on production and consumption[1], and thus on economic growth; but when dealing with tax and pension reforms it is vital to evaluate not only efficiency but also equity.

There are three themes in this paper.

First, the paper incorporates three representative households with different earnings abilities in a dynamic life-cycle general equilibrium model with an elastic labor supply. This enables us to examine equity issues in addition to efficiency issues. Thus, this paper considers intra- as well as intergenerational equity, which enables us to present some comprehensive and useful guidelines for public pension reforms. The macroeconomic and welfare effects of alternative pension policies are evaluated in a transitional process to an aging Japan.

Second, when dealing with alternative pension reforms, the paper addresses the problems that will actually arise in a transitional process of the pension and tax reforms. Concretely, in the reform case in which the earnings-related pension is abolished, a transition relief is considered for the generations that have paid contributions.

Third, we take account of a progressive expenditure (or consumption) tax as a source of revenue on public pension and tax systems.[2] Few studies have dealt with this new type of tax regime to evaluate the effects of structural tax reforms. Because there are only a few studies on a progressive expenditure tax, our study has some merit as a pioneering work. There are two types of progressive consumption taxes: expenditure tax and sales tax. The former definition, a direct tax that is levied on consumers, is used in our analysis.

This paper is organized as follows. The next section identifies the basic model employed in the simulation analysis. Section 3 explains the method of simulation analysis and the assumptions adopted. Section 4 evaluates the simulation findings and discusses policy implications. Section 5 summarizes and concludes the paper.

## 2 Theoretical Framework

The life-cycle growth model employed in this paper is grounded in the microeconomics of intertemporal choice, and the macroeconomics of savings and growth. The simulation model has three features. First, aggregate assets of the economy in each period consist of the assets of different generations that maximize their lifetime utility. This allows us to rigorously analyze changes in the supply of assets caused by demographic changes. Second, assets in the capital market, where aggregate assets appear as real capital, affect the production level. Third, it is possible to estimate realistic consumption-savings profiles for the elderly, by incorporating life-length uncertainty and unintended bequests into the model.

We calibrate the simulation of the Japanese economy by employing population data estimated by the National Institute of Population and Social Security Research in 2006. The model has 75 different overlapping generations. Three types of agents are considered: households, firms, and the government. The basic structures of households, firms, and the government are first described, and then market equilibrium conditions are explained.

### *2.1 Household Behavior*

Each household is assumed to consist of a couple of the same age. Each household appears in the economy as a decision-making unit at the age of 21 and lives to a maximum of 95. Younger people than age 21 do not affect the economy at all. Households face an age-dependent probability of death. Let $q^t_{j+1|j}$ be the conditional probability that a household born in year $t$ lives from age $j$ to $j+1$. Then the probability of a household of age 21, born in year $t$, surviving until $s$ can be expressed by

$$p^t_s = \prod_{j=21}^{s-1} q^t_{j+1|j} \ . \tag{1}$$

The probability $q^t_{j+1|j}$ is calculated from data estimated by the National Institute of Population and Social Security Research (2007).

Households are divided into three income classes: low, medium, and high. A single household type represents each income class. The household that belongs to the same cohort has the same mortality rate and the same utility function. Unequal labor endowments, however, create different income levels. The utility of each household depends on the levels of consumption and leisure. The household born in year $t$ works from age 21 to a maximum of $RE^t$, the retirement age. The labor supply is elastic but zero after retirement. Each household that maximizes the expected lifetime utility makes lifetime decisions at age 21, concerning the choice between leisure and labor supply and the allocation of wealth between consumption and savings. The utility function of a representative household of income class $i$, the form of which is assumed to be time-separable, is

$$U^{t,i} = \frac{1}{1-\frac{1}{\gamma}} \sum_{s=21}^{95} p^t_s (1+\delta)^{-(s-21)} \left\{ \left(C^{t,i}_s\right)^{\phi} \left(l^{t,i}_s\right)^{1-\phi} \right\}^{1-\frac{1}{\gamma}} , \tag{2}$$

where $C^{t,i}_s$ and $l^{t,i}_s$ represent consumption (or expenditure) and leisure, respectively, for income class $i$, of age $s$, born in year $t$, $\phi$ the share parameter for consumption, $\delta$ the adjustment coefficient for discounting the future, and $r$ the intertemporal elasticity of substitution in the consumption/leisure composite. The superscript $i\ (=l, m, h)$ stands for low, medium, and high-income classes, respectively.

The flow budget constraint equation for each household at age $s$ at time $t$ is

$$A_{s+1}^{t,i} = \{1 + r_{t+s}(1-\tau^r)\} A_s^{t,i} + [1 - \tau^w\{w_{t+s}x^i e_s(1-l_s^{t,i})\} - \tau_{t+s}^p] w_{t+s}x^i e_s(1-l_s^{t,i}) + a_s^{t,i}$$
$$+ b_s^{t,i}(\{l_u^{t,i}\}_{u=21}^{RE^t}) - \{1 + \tau_{t+s}^c(C_s^{t,i})\} C_s^{t,i}, \quad (3)$$

where $A_s^{t,i}$ represents the amount of assets held by income class $i$ born in year $t$ at the beginning of age $s$, $r_t$ the interest rate at time $t$, $w_t$ the wage rate per efficiency unit of labor at time $t$, and $e_s$ is the age profile of earnings ability. For income class $i$, of age $s$, born in year $t$, $1-l_s^{t,i}$ is the amount of labor supply, $b_s^{t,i}(\{l_u^{t,i}\}_{u=21}^{RE^t})$ is the amount of public pension benefit, and $a_s^{t,i}$ is the amount of bequest to be inherited. $\tau^w\{w_t x^i e_s(1-l_s^{t,i})\}$ is the tax rate on labor income at time $t$, $\tau_t^c(C_s^{t,i})$ that on consumption at time $t$, $\tau^r$ that on capital income, and $\tau_t^p$ is the contribution rate to the public pension scheme at time $t$. $x^i$ is the weight coefficient corresponding to the different levels of labor endowments across the three income classes.

The tax system consists of labor income, interest income, consumption, and inheritance taxes. Labor income or consumption (i.e., expenditure) is taxed progressively. The progressive tax schedule is incorporated in the same manner as in Auerbach and Kotlikoff (1987). If the tax base is $z$, we choose two parameters labeled $\alpha$ and $\beta$, and set the average tax rate ($\tau^w$ or $\tau^c$) equal to $\alpha + 0.5\beta z$ for all values of $z$. The corresponding marginal tax rate ($\overline{\tau^w}$ or $\overline{\tau^c}$) is $\alpha + \beta z$. Setting $\beta = 0$ amounts to proportional taxation. One may make the tax system more progressive, holding revenue constant, by increasing $\beta$ and decreasing $\alpha$ simultaneously.

Progressive taxation is applied to the gross wage or the level of consumption on an annual basis for households. In the case of progressive labor income taxation, the tax base, $z$, is the gross wage, $w_{t+s}x^i e_s(1-l_s^{t,i})$. If progressive expenditure (or consumption) taxation is adopted, $z$ is the level of expenditure (or consumption), $C_s^{t,i}$. The symbols, $\tau^w\{w_{t+s}x^i e_s(1-l_s^{t,i})\}$ and $\tau_{t+s}^c(C_s^{t,i})$, in equation (3) mean that $\tau^w$ and $\tau^c$ are functions of $w_{t+s}x^i e_s(1-l_s^{t,i})$ and $C_s^{t,i}$, respectively. The tax systems on interest income and inheritances are proportional.

The public pension program is assumed to be a pay-as-you-go system that is close to the current Japanese system. The program consists of the basic pension (i.e., the flat part) and a part proportional to the average annual income from labor for each household. Variables related to the program are represented by

$$b_s^{t,i}(\{l_u^{t,i}\}_{u=21}^{RE^t}) = \begin{cases} f_{t+s} + \theta_{t+s} H^{t,i}(\{l_u^{t,i}\}_{u=21}^{RE^t}) & (s \geq ST^t) \\ 0 & (s < ST^t) \end{cases}, \quad (4)$$

where

$$H^{t,i}(\{l_s^{t,i}\}_{s=21}^{RE^t}) = \frac{1}{RE^t - 20} \sum_{s=21}^{RE^t} w_{t+s}x^i e_s(1-l_s^{t,i}), \quad (5)$$

$ST^t$ is the age at which the household born in year $t$ starts to receive public pension benefit, the average annual income from labor for each income class is $H^{t,i}(\{l_s^{t,i}\}_{s=21}^{RE^t})$, the basic pension benefit per representative household is $f_t$, and the weight coefficient of the part proportional to $H^{t,i}$ is $\theta_t$. Thus, $b_s^{t,i}(\{l_u^{t,i}\}_{u=21}^{RE^t})$ reflects different earnings abilities across the three income classes. The symbol, $b_s^{t,i}(\{l_u^{t,i}\}_{u=21}^{RE^t})$, signifies that the amount of public pension benefit is a function of the age profile of leisure, $\{l_u^{t,i}\}_{u=21}^{RE^t}$.

There are accidental bequests caused by uncertainty over the length of life. The bequests, which were held as assets by deceased households, are handed to all households surviving at time $t$. The inheritance is transferred within the same income class. When $BQ_s^i$ is the sum of bequests inherited by $s$-year-old households of income class $i$ at time $t$, $a_s^{t,i}$ is defined by

$$a_s^{t,i} = \frac{(1-\tau^h)BQ_{t+s}^i}{\sum_{k=21}^{95} N_k^{t+s-k,i}}, \tag{6}$$

where

$$BQ_t^i = \sum_{s=21}^{95} (N_s^{t-s-1,i} - N_{s+1}^{t-s-1,i}) A_{s+1}^{t-s-1,i}, \tag{7}$$

$N_s^{t,i}$ is the number of income class $i$, of age $s$, born in year $t$, and $\tau^h$ is the tax rate on inheritances of bequests. The amount of inheritances received is linked to the age profile of assets chosen by each household.

When we consider the utility maximization problem over time for each income class, in addition to the flow budget constraint represented by equation (3), the following constraint is imposed:

$$\begin{cases} 0 \le l_s^{t,i} \le 1 & (21 \le s \le RE^t) \\ l_s^{t,i} = 1 & (RE^t + 1 \le s \le 95) \end{cases}. \tag{8}$$

This is a constraint that labor supply is nonnegative, and that each household invariably retires after the retirement age $RE^t$.

Let us consider the case in which each household maximizes expected lifetime utility under two constraints. Each household maximizes equation (2) subject to equations (3) and (8) (see Appendix A). From the utility maximization problem, the equation expressing evolutions of the consumption/leisure composite over time for each household is characterized by

$$V_s^{t,i} = \left(\frac{p_{s-1}^t}{p_s^t}\right)\left[\frac{1+\delta}{1+r_{t+s}(1-\tau^r)}\right] V_{s-1}^{t,i}, \tag{9}$$

where

$$V_s^{t,i} = \frac{\left\{(C_s^{t,i})^{\phi}(l_s^{t,i})^{1-\phi}\right\}^{-\frac{1}{\gamma}} \phi (C_s^{t,i})^{\phi-1}(l_s^{t,i})^{1-\phi}}{1+\alpha_{t+s}^c + \beta_{t+s}^c C_s^{t,i}}. \tag{10}$$

If the initial level, $V_{21}^{t,i}$, is specified, the level of each age, $V_s^{t,i}$, can be derived from equation (9). If $V_s^{t,i}$ is specified, the levels of consumption, $C_s^{t,i}$, and leisure, $l_s^{t,i}$, at each age are obtained. The amount of assets held by each household at each age can be obtained from equation (3). The expected lifetime utility of each household is derived from equation (2).

The welfare function of each generation, which takes account of different earnings abilities and thus provides different levels of consumption and leisure, is given by

$$W^t = U^{t,l} + U^{t,m} + U^{t,h}. \tag{11}$$

This function is derived from a summation of the expected lifetime utilities at age 21 for the three income classes. The function is of the "Benthamite type," but depends greatly on the utility of the low-income class. It is maximized if all income classes have the same level of the consumption/leisure composite.

Empirical evaluation of each simulation from Case B to E in comparison with the benchmark Case A is made by the following formulation of $RWC^t$ (relative welfare changes by percentage figures):

$$RWC^t = \frac{-100 \times (U_J^t - U_A^t)}{U_A^t}, \tag{12}$$

where $U_A^t$ signifies the lifetime utility for the generation born in year $t$ in Case A, and $U_J^t$ ($J$ = B, C, D, E) represents the lifetime utility for the generation born in year $t$ in each simulation case. The minus sign was added so that improvements in $RWC^t$ show positive numerical changes in welfare.

### *2.2 Firm Behavior*

The model has a single production sector that is assumed to behave competitively using capital and labor, subject to a constant-returns-to-scale production function. Capital is homogeneous and depreciating, while labor differs only in its efficiency. All forms of labor are perfect substitutes. Households in different income classes or of different ages, however, supply different amounts of some standard measure per unit of labor input.

The aggregate production technology is the standard Cobb-Douglas form:

$$Y_t = K_t^{\varepsilon} (B_t L_t)^{1-\varepsilon}, \tag{13}$$

where $Y_t$ is the total output (national income), $K_t$ the total capital, $L_t$ the total labor supply measured by the efficiency units, $B_t$ the labor augmenting technology, and $\varepsilon$ is a share of capital. Using the property subject to a constant-returns-to-scale production function, we can obtain the following equation:

$$Y_t = (r_t + \delta^k) K_t + w_t L_t. \tag{14}$$

where $\delta^k$ is the depreciation rate.

### *2.3 Government Behavior*

The government sector consists of a narrower government sector and a public pension sector. The narrower government sector collects taxes, and spends them on general government expenditure and a transfer to the pension sector. The budget constraint of the narrower government sector at time $t$ is given by

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

where $D_t$ is the stock of outstanding debt at the beginning of year $t$, $G_t$ is general government spending on goods and services, except for a transfer to the public pension sector, $F_t$ is the total amount of basic pension benefit, and $\mu_t$ is the ratio of the part covered by general tax revenues to $F_t$, $T_t$ is the total tax revenue from labor income, interest income, consumption, and inheritances.

The budget constraint of the public pension sector at time $t$ is given by

$$Q_{t+1} = (1+r_t)Q_t + R_t - (1-\mu_t)F_t - P_t \,. \tag{16}$$

where $Q_t$ is an accumulated public pension fund at the beginning of year $t$, $R_t$ is the total contribution to the pension program, and $P_t$ is the total benefit of the part proportional to the income from labor. $G_t$, $T_t$, $F_t$, $R_t$, and $P_t$ are defined by

$$G_t = gY_t \,, \tag{17}$$

$$T_t = LX_t + \tau^r r_t AS_t + CX_t + \tau^h BQ_t \,, \tag{18}$$

$$F_t = f_t Y_t \,, \tag{19}$$

$$R_t = \tau_t^p w_t L_t \,, \tag{20}$$

$$P_t = \theta_t \sum_{s=21}^{95} (N_s^{t-s,l} H^{t,l} + N_s^{t-s,m} H^{t,m} + N_s^{t-s,h} H^{t,h}) I_{\{s \geq ST^{t-s}\}} \,, \tag{21}$$

where $g$ is the ratio of government expenditure to national income, $f_t$ is the total basic pension to national income, $I$ is an indicator function, and

$$BQ_t = BQ_t^l + BQ_t^m + BQ_t^h \,. \tag{22}$$

$LX_t$ and $CX_t$ are tax revenues from labor income and consumption, respectively:

$$LX_t = \sum_i \sum_{s=21}^{95} N_s^{t-s,i} \left[ \alpha^w w_t x^i e_s (1 - l_s^{t-s,i}) + 0.5 \beta^w \{ w_t x^i e_s (1 - l_s^{t-s,i}) \}^2 \right]. \tag{23}$$

$$CX_t = \sum_i \sum_{s=21}^{95} N_s^{t-s,i} \left[ \alpha^c C_s^{t,i} + 0.5 \beta^c (C_s^{t,i})^2 \right] \tag{24}$$

Aggregate variables can be obtained by a simple summation of the three income classes with the same weight, because each income group accounts for the same proportion of population. Similarly, aggregate assets supplied by households, $AS_t$, and aggregate consumption, $AC_t$, are obtained by

$$AS_t = \sum_{s=21}^{95} \{ N_s^{t-s,l} A_s^{t-s,l} + N_s^{t-s,m} A_s^{t-s,m} + N_s^{t-s,h} A_s^{t-s,h} \}, \tag{25}$$

$$AC_t = \sum_{s=21}^{95} \{ N_s^{t-s,l} C_s^{t-s,l} + N_s^{t-s,m} C_s^{t-s,m} + N_s^{t-s,h} C_s^{t-s,h} \}. \tag{26}$$

### *2.4 Market Equilibrium*

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

*1 Equilibrium condition for the capital market*

Because aggregate assets supplied by households are equal to real capital, we get

$$AS_t + Q_t = K_t + D_t. \tag{27}$$

*2 Equilibrium condition for the labor market*

Measured in efficiency units, because aggregate labor demand by firms is equal to aggregate labor supply by households, we get

$$L_t = \sum_{s=21}^{95} \left[ N_s^{t-s,l} x^l e_s (1 - l_s^{t-s,l}) + N_s^{t-s,m} x^m e_s (1 - l_s^{t-s,m}) + N_s^{t-s,h} x^h e_s (1 - l_s^{t-s,h}) \right]. \tag{28}$$

*3 Equilibrium condition for the goods market*

Because aggregate production is equal to the sum of private consumption, private investment, and government expenditures, we get

$$Y_t = AC_t + \{ K_{t+1} - (1 - \delta^k) K_t \} + G_t. \tag{29}$$

An iterative program is performed to obtain the equilibrium values of the above equations.

## 3 Simulation Analysis

### *3.1 Method of Simulation*

The simulation model presented in the previous section is solved under the hypothesis of perfect foresight by households that correctly anticipate the interest, wage, tax, and contribution rates. If the tax and public pension systems are determined, the model can be solved using the Gauss-Seidel method (see Auerbach and Kotlikoff (1987) or Heer and Maußner (2005) for the computation process).

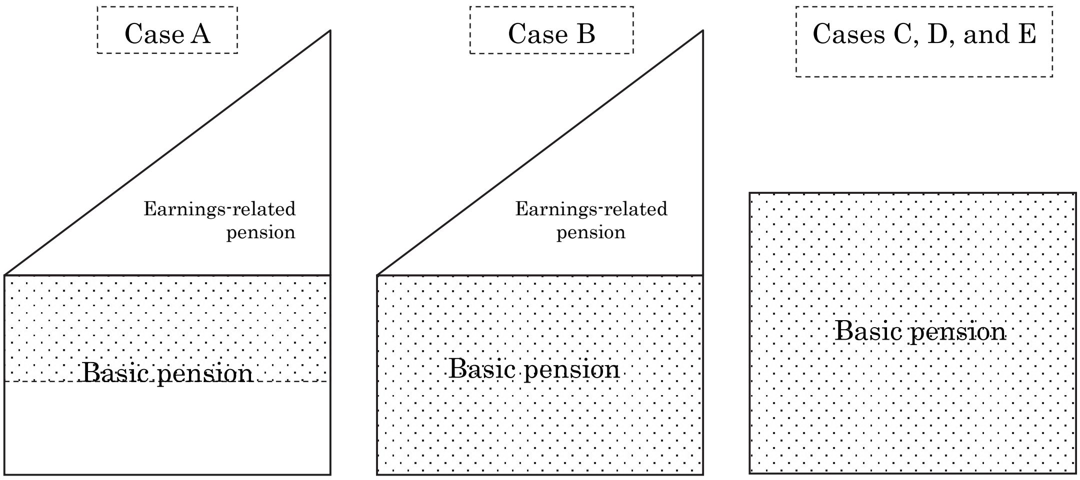
This paper deals with the Japanese transitional economy, considering the initial steady state in 2008 and the final steady state in 2200. With regard to the generations that are alive in the 2008 initial steady state and continue to survive in 2009, we should pay attention to their formation of the expectation for the future. These generations realize at the point in 2009 that their expectation from 2009 onwards has been wrong. Thus, again in 2009, they maximize their remaining lifetime utility under the hypothesis of perfect foresight.

### *3.2 Simulation Cases*

In the benchmark simulation, the public pension reform scheduled by Japan's 2004 pension reform is performed. Alternative simulations with another public pension and tax reform are also considered. We firstly deal with the reform case in which the whole basic pension is financed by a consumption tax. Then we deal with the case in which the earnings-related pension is abolished and the public pension system consists of only the basic pension financed by a consumption tax. In this respect, we can interpret that this case means the integration of public pension and tax systems. Finally, we explore a desirable source of revenue on the integrated public pension and tax systems. We handle the case in which a progressive expenditure (or consumption) tax is introduced.

With regard to the setting of the simulation cases, we make the total amount of public pension benefit in each year fixed across cases to eliminate the effects of different pension size on the simulation results. The total amount of public pension benefit in each year in Cases B, C, D and E is adjusted to be the same as in Case A: In Case B the contribution rate in each year is reduced, while in Cases C, D, and E the amount of basic pension benefit in each year is increased. We consider five simulation cases (see Figure 1 for diagrams of the public

**Figure 1 Diagrams of public pension system in each simulation case**




A shadow area shows the part financed by taxes.
Case A: Benchmark simulation, Case B: Basic pension financed by consumption tax
Case C: No earnings-related pension, Case D: Proportional expenditure tax
Case E: Progressive expenditure tax

pension system in each simulation case):

***1) Case A*** *(Benchmark simulation)*

The public pension schedule by Japan's 2004 pension reform is implemented up to 2200. The general tax revenue covers a little more than one third (i.e., 37.3%) of the basic pension in the public pension system in 2008.[3] From 2009 onwards it is raised to a half according to the pension plan. The rise in the basic pension by about one sixth is assumed to be financed by a consumption tax. The contribution rate to the public pension scheme is the actual rate of 15.35% in employee pension plans *(Kosei Nenkin)* in 2008 and increases gradually towards 2017 (see Table 1 for the contribution rate in each year). From 2017 onwards, the rate is fixed at the 18.30% level. The balance of the pension fund undergoes a transition until 2100 along the schedule by the 2004 reform.

***2) Case B*** *(Basic pension financed by a consumption tax)*

In Case A, from 2009 onwards the remaining half of the basic pension is financed by a consumption tax. Thus, from 2009 onwards the overall basic pension benefit is financed by a consumption tax.[4] The earnings-related pension remains to be financed by contributions. We consider the substitution from contributions (which mean a proportional labor income tax) to a consumption tax in a half of the basic pension.

***3) Case C*** *(No earnings-related pension)*

In Case B, the earnings-related pension is completely abolished in 2009. From 2009 onwards, the public pension system consists of only a basic pension financed by a consumption tax.[5] In other words, from 2009 onwards the whole public pension benefit is financed by a consumption tax and the contribution rates become zero. A transition relief is considered for the generations that have paid contributions.

**Table 1 Contribution rates in the benchmark simulation**

| Year | Contribution rates ($\tau_t^p$) |
|---|---|
| 2008 | 15.35% |
| 2009 | 15.704% |
| 2010 | 16.058% |
| 2011 | 16.412% |
| 2012 | 16.766% |
| 2013 | 17.12% |
| 2014 | 17.474% |
| 2015 | 17.828% |
| 2016 | 18.182% |
| 2017 — | 18.3% |

***4) Case D*** *(Proportional expenditure tax)*

In Case C, from 2009 onward a proportional expenditure (or consumption) tax finances the overall tax revenue. Labor income, capital income, and the inheritance of bequests are not taxed. All tax systems become proportional, and thus there is not the income redistribution through a tax system.

***5) Case E*** *(Progressive expenditure tax)*

In Case D, from 2009 onwards a progressive expenditure (or consumption) tax replaces a proportional one. This reform enables to perform the income redistribution through a tax system.

Case B deals with the substitution from contributions (which mean a proportional labor income tax) to a proportional consumption tax. In Case B the whole basic pension is financed by a consumption tax. In Case C the earnings-related pension is completely abolished, and the amount of the basic pension is increased. This increase strengthens income redistribution effects through a public pension scheme.

Cases D and E are extreme cases to explore guidelines for public pension and tax reforms. Case D deals with the complete shift to a proportional expenditure (or consumption) tax. Case D does not have the function of income redistribution through a tax system. Due to perform the function of income redistribution, Case E introduces a *progressive* expenditure (or consumption) tax (see Appendixes B and C for the concrete method of the introduction of a progressive expenditure tax).

In Cases C, D, and E, the earnings-related pension system is completely abolished from 2009 onwards. However, as a transition relief, the generations that have paid contributions until 2008 can receive the earnings-related pension until they die. The amount of the earnings-related pension benefit is proportional to the contributions paid. In Cases C, D, and E, the average annual income from labor for income class $i$ born in year $t$ $(t \leq 1987)$ is

$$H^{t,i}(\{l_s^{t,i}\}_{s=21}^{RE^t}) = \frac{1}{RE^t - 20} \sum_{s=21}^{\min\{2008-t, RE^t\}} w_{t+s} x^i e_s (1 - l_s^{t,i}) . \quad (5)'$$

In Cases C, D, and E, equation (5)’ replaces equation (5). With regard to the weight coefficient on the average annual income from labor for each income class, $\theta_t$, the values in Case B are applied for Cases C, D, and E.

### *3.3 Specification of Parameters*

This paper examines the implications of several public pension policies in an aging Japan. We choose parameter values that are realistic for the economy. Parameter values are assigned with reference to empirical research, such as Braun *et al*. (2005, 2009), Hayashi and Prescott (2002), and Nishiyama and Smetters (2005). The parameter values used in the benchmark simulation are given in Table 2.

**Table 2 Model calibration and data sources for exogenous variables**

| Parameter description | Parameter values | Data sources |
|---|---|---|
| Share parameter for consumption | $\phi = 0.5$ | Nishiyama and Smetters (2005): $\phi = 0.47$ |
| Adjustment coefficient for discounting the future | $\delta = -0.013$ | |
| Intertemporal substitution elasticity | $\gamma = 0.3$ | Altig *et al*. (2001): $\gamma = 0.25$ |
| Capital share in production | $\varepsilon = 0.362$ | Hayashi and Prescott (2002) |
| Depreciation rate | $\delta^k = 0.0759$ | Braun *et al*. (2005, 2009) |
| Parameters on a progressive labor income tax (Case A, B, and C) | $\alpha^w = 0.0423$, $\beta^w = 0.1747$ | |
| Parameters on a progressive expenditure tax (Case E) | $\beta^c = 0.63$ | |
| Tax rate on capital income (Case A, B, and C) | $\tau^r = 0.48$ | Hayashi and Prescott (2002) |
| Tax rate on inheritance (Case A, B, and C) | $\tau^h = 0.1$ | Ihori *et al*. (2006) |

*1 Demography*

Actual population data are used from 2008 to 2200 in a transitional process. With regard to population projections until 2200, we employ the "medium variant" data from the National Institute of Population and Social Security Research (2007). Because the data gives estimates of the future population only until 2105, the number of births and deaths and survival rates after 2105 until 2200 are assumed to be fixed at their 2105 levels. The percentage of the population of each age in the total population in the simulation equals the value based on this data. Survival probabilities $(p_s^t)$ are also calculated from the data. Our model makes no distinction by sex, and thus this study uses male–female average values.

*2 Age profile of labor efficiency*

With regard to the age profile of earnings ability, $e_s$, the data was obtained from Braun *et al*. (2005, 2009). The labor efficiency profile is constructed from Japanese data on employment, wages, and weekly hours from 1990 to 2000 (see the data appendix in Braun *et al*. (2005)).

*3 Government deficits*

The ratio of the outstanding government debt to GDP is assumed to be 107.2% in 2008 in the simulation, making reference to the Ministry of Finance (2008). We assume that the ratio of the public debt to GDP tends to decrease gradually from 2008 through 2200, as shown in Figure 2 (which presents the ratio until 2100). The movement of the decrease is connected with the decrease in the ratio of pension fund to GDP.

*4 Taxes and expenditures*

The progressive tax system on labor income in 2008 is fixed until 2200. Tax rates on capital income and inheritance are also held constant at the 2008 levels (namely, 48% and 10%, respectively) through time.[6] A consumption tax is endogenously determined to keep certain tax revenue. Because our model does not introduce such taxes as corporate and property ones, tax rates on consumption are likely to take higher values than actual ones. It should be also noted that the consumption tax in our model means an indirect tax.

The ratio of the general government expenditures to national income, $g$, is held constant at the 2008 level (i.e., 0.02239) through time. Thus the total government expenditure, $G_t$, depends on the level of national income, $Y_t$. The ratio of outstanding government debt to GDP, $D_t$, is exogenously given in our simulation. Therefore, the tax rate on consumption is endogenous in our simulation.

Next, we explain the method of assigning the parameter values that determine the tax progressivity on labor income, namely, $\alpha^w$ and $\beta^w$. Table 3 shows the data from the Ministry of Finance (2007). This table presents the effective tax rates of wageworkers on a national income tax and a residence tax for the three income classes, with regard to a couple with two children. The parameter values on labor income are chosen so that the effective

**Figure 2 Changes of the ratio of public debt to GDP**

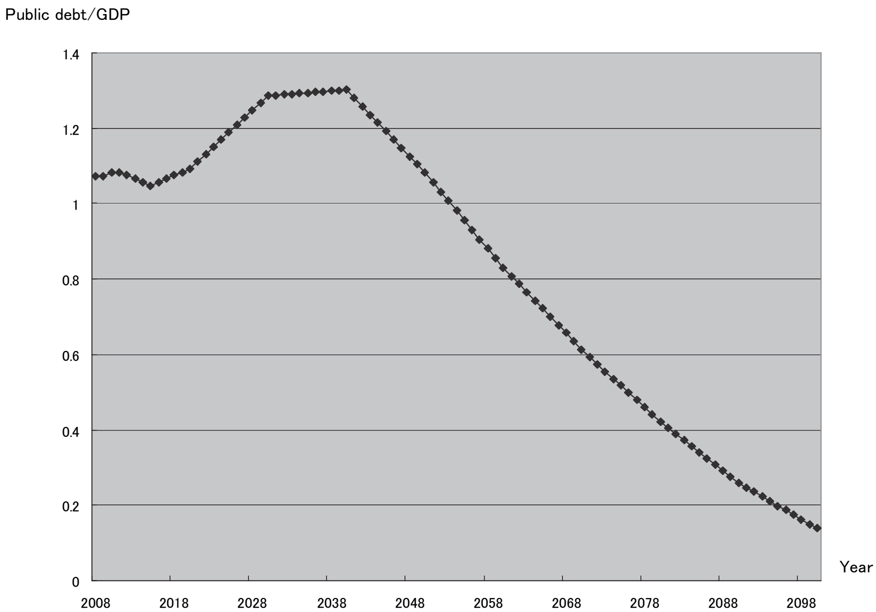



**Table 3 Effective tax rates for national income tax and residence tax of wageworkers**

| Income class | Total amount of annual income (million yen) | Weight on labor endowments | Total amount of annual taxes: national income tax and residence tax (thousand yen) | Effective tax rates (%) |
|---|---|---|---|---|
| Low | 5 | $x^l = 0.7143$ | 195 | 3.90 |
| Medium | 7 | $x = 1$ | 459 | 6.56 |
| High | 10 | $x^h = 1.4286$ | 1,130 | 11.30 |

Data given are for a couple with two children.
Source: Ministry of Finance (2008).

tax rate for each income class in 2008 in Case A is close to the estimated value, and that the average tax rate on labor income is close to the value calculated from this data (i.e., 8.11%).

Finally, we explain the method of assigning the parameter values that determine the tax progressivity on expenditure, namely, $\alpha_t^c$ and $\beta^c$, in Case E. The parameter of the part proportional to the level of consumption, $\beta^c$, is exogenously given, and thus the parameter of the constant part, $\alpha_t^c$ is endogenously determined in each year.

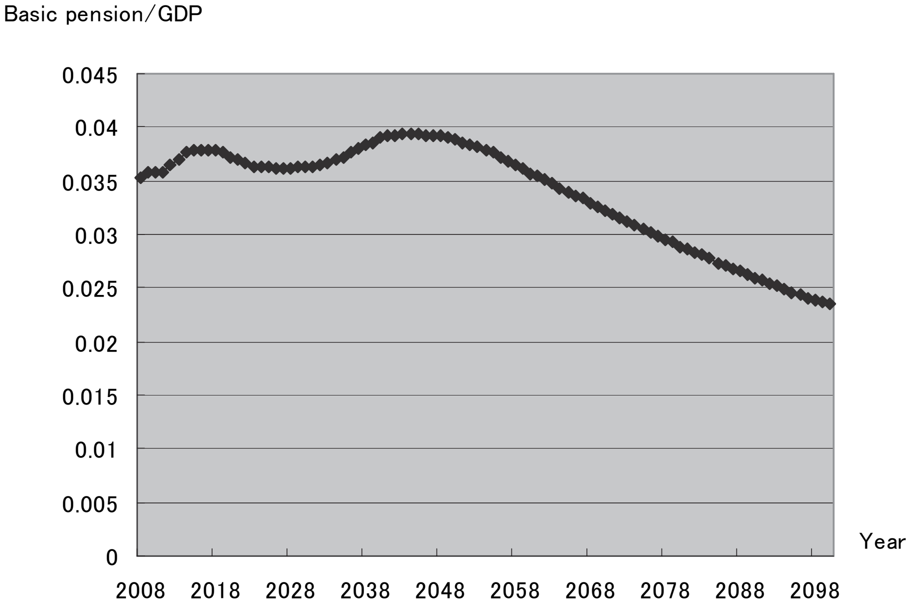
*5 Public Pension System*

The public pension program is assumed to be a pay-as-you-go system that is close to the current Japanese system. The public pension benefit consists of a basic pension (i.e., a flat part) and a part proportional to the income from labor for each income class. Under the current Japanese system, the general tax revenue covers a little more than one third of the flat part, and contributions cover both the remaining two thirds and the overall part proportional to the income from labor. The Japanese government aims to raise the ratio from 0.373 in 2008 to a half in 2009.

The ratio of the total amount of basic pension benefit $(F_t)$ to GDP $(Y_t)$, i.e., $f$, is determined so that the ratio in each simulation is the ratio presented in the Ministry of Health, Labor and Welfare (2008) (see Figure 3 for further details of the ratio). Thus, the ratio $(f_t)$ is exogenously given in each year until 2200. From 2100 onwards the ratio in 2100 is used and constant up to 2200.

In Case A, the public pension reform scheduled by Japan's 2004 reform is executed until 2105. The ratio of

**Figure 3 Changes of the ratio of basic pension to GDP**



the public pension fund to GDP in 2008 is 31.6%, namely the ratio suggested by the Ministry of Health, Labor and Welfare (2008). The public pension fund will be gradually diminishing up to 2200, as shown in Figure 4 (which presents the ratio until 2100).

The contribution rate, the public pension fund, and the basic pension benefit per household are exogenous in each year. Thus, the weight coefficient $(\theta_t)$ on the earnings-related pension is endogenous in each year. When the whole basic pension is financed by a consumption tax in Case B, the contribution rate $(\tau_t^p)$ is exogenously decreased. The contribution rates in Case B are reduced or the ratios of the total amount of basic pension benefit to GDP are increased in Cases C, D, and E, so that the total amount of public pension benefit in each year is the same as in Case A.

The age at which households start to receive public pension benefits, $ST^t$, is different across generations, because it has been modified by several public pension reforms in Japan. The starting age, $ST^t$, for each generation in the simulation is shown in Table 4. The compulsory retirement age, $RE^t$, is the starting age of

**Figure 4 Changes of the ratio of pension fund to GDP**

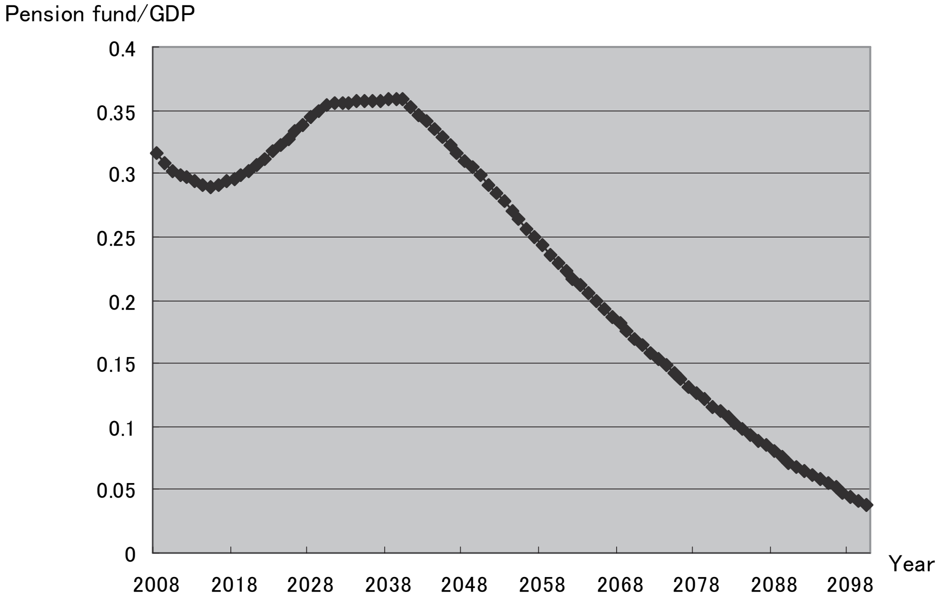



**Table 4 The starting age for receiving public pension benefits**

| The year when the generation was born | Starting age for receiving public pension benefits ($ST_t$) |
|---|---|
| — 1954 | 60 |
| 1955 — 1957 | 61 |
| 1958 — 1959 | 62 |
| 1960 — 1961 | 63 |
| 1962 — 1965 | 64 |
| 1966 — | 65 |

public pension benefits, $ST^t$, minus one.

*6 Differences in Earnings Abilities*

Next, we explain the method of assigning the weight given to labor endowments for the three income classes. In our model, the three representative households, namely, low, medium, and high-income classes, have different earnings abilities. Table 3 shows that each income class, which accounts for one third of the total population, corresponds to the representative household earning 5, 7, or 10 million yen, respectively, on an annual base. The weight on labor endowments for each income class corresponds to the ratio of its amount of earned income. The medium-income class is used as a yardstick, that is, $x^m = 1$ ; $x^l$ and $x^h$ are assigned to reflect different earnings abilities across the three income classes.

*7 Share Parameter on Consumption in Utility*

We assign the value of the share parameter on consumption in the utility function, with reference to Auerbach and Kotlikoff (1987) and Altig *et al*. (2001). We choose the value such that, on average, the medium-income class devotes approximately 40% of the available time endowment (of 16 hours per day) to labor during working years (roughly ages 21-61) in 2008 in Case A.

*8 Technological Progress*

The technological progress of private production plays a significant role because it greatly affects the economic growth. Thus, careful attention should be paid to the assumption on technological progress. The growth rate of labor augmenting technology is assumed to be zero in our simulation, reflecting Japan's experience for the last two decades, as in Ihori *et al*. (2006),

## 4 Simulation Results

Table 5 presents the simulation results on the initial steady state in 2008. In 2009, alternative public pension and tax reforms are implemented in all simulation cases. The generations that are alive in the 2008 initial steady state and continue to survive in 2009, realize in 2009 that their expectation from 2009 onwards has been wrong. Hence, again in 2009, they maximize their remaining lifetime utility under the hypothesis of perfect foresight. We evaluate their utility by their ex post lifetime utility at age 21.

### *4.1 Findings and Policy Implications*

Table 6 presents the simulation results on the benchmark case and four public pension and tax reforms, which corresponds to Case A and Cases B, C, D, and E, respectively. This table shows variables of interest for four transition years—2009, 2020, 2050, and 2100—meant to illustrate short-run, medium-run, and long-run effects. Some variables are indexed with a value of 1.000 for each year in benchmark simulation (i.e., Case A).

***Case A:*** Benchmark simulation

In Case A, the public pension reform scheduled by the 2004 reform plan is implemented.

The ratio of the part financed by taxes to the basic pension, $\mu_t$, is raised from 37.3% in 2008 to 50% in 2009. The source of revenue is a consumption tax. The contribution rates gradually increase as shown in Table 1. The public pension fund tends to gradually decrease as shown in Figure 4. In short-run, the interest rate once increases from 2.8% in 2009 to 6.7% in 2020. However, afterwards the interest rate tends to decrease, and ultimately drops to 1.7% in 2100. A possible reason for this is that we have more capital than labor, as Japan ages. In the short-run, the indirect tax rate increases from 11.6% in 2009 to 12.7% in 2020. The rate increases up to 20.6% in 2050, but it gets settled to 15.0% in the long-run.

***Case B:*** Basic pension financed by consumption tax

In Case B, from 2009 onwards the overall basic pension is financed by a consumption tax. The contribution rate in each year in Case B is reduced so that the total amount of public pension benefit in each year in Case B is the same as in Case A. Thus, we can understand that Case B deals with the substitution from contributions (which mean a proportional labor income tax) to a proportional consumption tax. The substitution promotes capital accumulation. Table 6 suggests that the level of capital stock increases in the conversion from Case A to B. In the switch from Case A to B, the capital stock increases by 3.8% in 2020 and by 4.9% in 2100. The labor supply also increases slightly by 0.9% in 2020 and by 0.3% in 2100. As a result, the national income increases by 1.9% in 2020 and by 2.0% in 2100.

Figure 5 presents the welfare changes for each generation in switching from Case A to B. The welfare for the generation born in from 1972 onwards is improved. In the long run it is improved by 0.8%. However, with regard to the generations born in from 1938 to 1971, the welfare is deteriorated. A possible reason for

**Table 5 Simulation results in the initial steady state in 2008**

| Parameter description | Parameter values |
|---|---|
| Tax rate on labor income, $\tau^w\{wx^i e_s(1-l_s^i)\}$ | 0.082[a] |
| Tax rate on consumption, $\tau_c$ | 0.167 |
| Ratio of part financed by taxes to the basic pension, $\mu$ | 0.373[b] |
| Contribution rate, $\tau_p$ | 0.1535[b] |
| Interest rate, $r$ | 0.026 |
| Wage rate, $w$ | 1.313 |
| Capital stock, $K$ | 6.798 |
| Labor supply, $L$ | 0.925 |
| National income, $Y$ | 1.903 |
| Capital-income ratio, $K/Y$ | 3.571 |
| Weight coefficient on earnings-related pension, $\theta$ | 0.1916 |

a The tax rate is progressive, and an average rate is presented.

b The variable is exogenous.

**Table 6 Simulation results on public pension reforms**

| | Case | 2009 | 2020 | 2050 | 2100 |
|---|---|---|---|---|---|
| National Income ($Y_t$)[a] | A | 1.000 | 1.000 | 1.000 | 1.000 |
| | B | 1.002 | 1.019 | 1.021 | 1.020 |
| | C | 1.052 | 1.124 | 1.114 | 1.146 |
| | D | 1.087 | 1.280 | 1.256 | 1.319 |
| | E | 1.020 | 1.190 | 1.196 | 1.246 |
| Capital Stock ($K_t$)[a] | A | 1.000 | 1.000 | 1.000 | 1.000 |
| | B | 0.996 | 1.038 | 1.050 | 1.049 |
| | C | 1.047 | 1.237 | 1.266 | 1.372 |
| | D | 1.070 | 1.630 | 1.576 | 1.788 |
| | E | 1.052 | 1.535 | 1.555 | 1.738 |
| Labor supply ($L_t$)[a] | A | 1.000 | 1.000 | 1.000 | 1.000 |
| | B | 1.005 | 1.009 | 1.006 | 1.003 |
| | C | 1.055 | 1.064 | 1.037 | 1.035 |
| | D | 1.096 | 1.115 | 1.104 | 1.109 |
| | E | 1.002 | 1.029 | 1.031 | 1.031 |
| Wage rate ($W_t$)[a] | A | 1.000 | 1.000 | 1.000 | 1.000 |
| | B | 0.997 | 1.010 | 1.016 | 1.017 |
| | C | 1.295 | 1.141 | 1.499 | 1.531 |
| | D | 0.991 | 1.147 | 1.137 | 1.189 |
| | E | 1.018 | 1.156 | 1.160 | 1.208 |
| Interest rate ($r_t$) | A | 0.028 | 0.067 | 0.015 | 0.017 |
| | B | 0.028 | 0.064 | 0.013 | 0.014 |
| | C | 0.028 | 0.054 | 0.004 | 0.002 |
| | D | 0.029 | 0.036 | 0.000 | 0.000 |
| | E | 0.024 | 0.035 | 0.000 | 0.000 |
| Indirect tax rate (Tax rate on consumption) ($\tau_t^c$) | A | 0.116 | 0.127 | 0.206 | 0.150 |
| | B | 0.135 | 0.143 | 0.239 | 0.175 |
| | C | 0.126 | 0.237 | 0.407 | 0.380 |
| | D | 0.269 | 0.380 | 0.531 | 0.491 |
| | E[b] | 0.109 | 0.383 | 0.537 | 0.500 |

[a] Indexed with a value of 1.000 for each year in Case A.

Case A: Benchmark simulation, Case B: Basic pension financed by consumption tax

Case C: No earnings-related pension, Case D: Proportional expenditure tax

Case E: Progressive expenditure tax

[b] The tax rate is progressive, and the rate presented is an average rate in each year.

this is that the tax rate on consumption is higher in Case B than in Case A: For example, the rate is 12.7% in Case A and 14.3% in Case B in 2020. A change from a labor income tax to a consumption tax creates income transfers among generations during the transition. At the onset of policy reform, the elderly who had already paid their labor income tax have to pay an additional consumption tax. Because these generations suffer from a double burden, the transition to a consumption tax is not Pareto improving. The conclusion that recommends a consumption tax will be required to provide further justification, that is, to suggest measures to avoid a double burden during the transition. One of the solutions to this problem may be to consider the transfer from the future generations that are substantially improved to the generations that suffer from a double burden, through public debts.

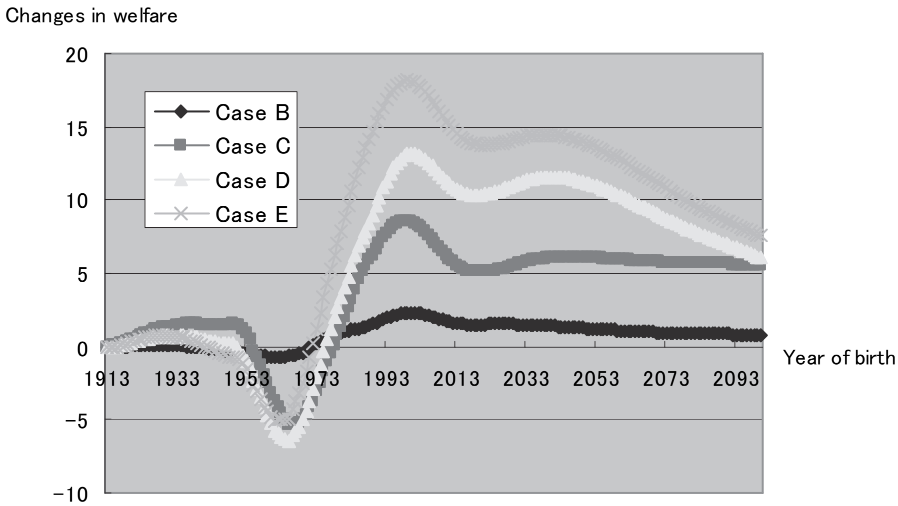
Figure 6 presents the changes in the utility for each income class in switching from Case A to B. The figure suggests that the pension reform in Case B has a similar effect on the three income classes.

***Case C:*** No earnings-related pension

In Case B the earnings-related pension is completely abolished in 2009, which produces Case C. From 2009 onwards, the public pension system consists of only the basic pension financed by a consumption tax. In other words, from 2009 onwards the whole public pension benefit is financed by a consumption tax and the contribution rates become zero. The amount of basic pension benefit in each year in Case C is increased so that the total amount of public pension benefit in each year in Case C is the same as in Case A. An increase in the basic pension in Case C strengthens the income redistribution effect through a public pension scheme.

A transition relief is considered for the generations that are alive in the 2008 initial steady state and

**Figure 5 Changes in welfare for each generation in Cases B, C, D, and E**



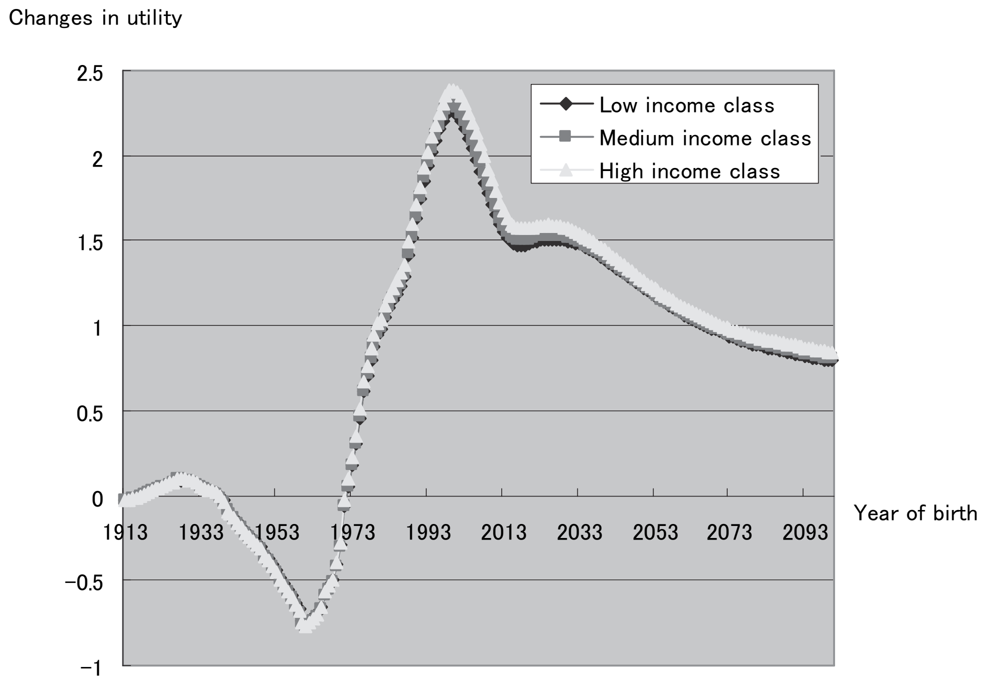

Case B: Basic pension financed by consumption tax, Case C: No earnings-related pension
Case D: Proportional expenditure tax, Case E: Progressive expenditure tax

continue to survive in 2009. The generations that have paid contributions until 2008 can receive the earnings-related pension until they die. The amount of the earnings-related pension benefit is proportional to the paid contributions. The weight coefficients given on the earnings-related pension, $\theta_t$, are the same as in Case B.

This pension reform substantially stimulates capital accumulation. Table 6 shows that the level of capital stock substantially increases in the conversion from Case A to C. In the switch from Case A to C, the capital stock increases by 23.7% in 2020 and by 37.2% in 2100. A possible reason for this is that in Case C a consumption tax completely replaces a contribution rate, and thus a whole pension benefit is financed by a consumption tax. A consumption tax enhances more capital accumulation than a contribution rate (which means a labor income tax). The labor supply also increases by 6.4% in 2020 and by 3.5% in 2100. Consequently, the national income increases by 12.4% in 2020 and by 14.6% in 2100. Therefore, the simulation results predict long-run increases in output when the public pension system consists of only the basic pension, which is financed by a consumption tax.

Figure 5 presents the welfare changes for each generation in switching from Case A to C. The welfare for the generations born in from 1978 onwards is substantially improved. In the long run it is improved by 5.6%. However, with regard to the generations born in from 1955 to 1977, the welfare is deteriorated. Especially, the welfare for the generations born in around 1965 is deteriorated by approximately 5%. It is certain that the welfare of many generations is ultimately more improved in Case C than in Case B, but the welfare for the

**Figure 6 Changes in utility for each income class in Case B**



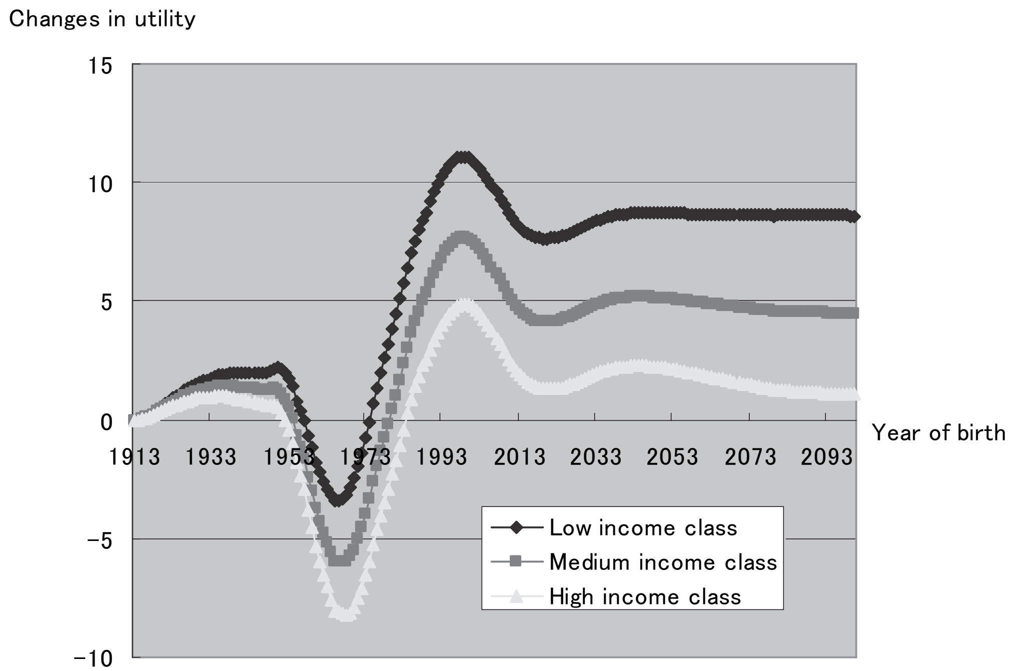

Case B: Basic pension financed by consumption tax generations born in around 1965 is more badly hurt in the transition process of the reform in Case C.

A possible reason for this is that the tax rate on consumption is much higher in Case C than in Case B: For instance, the rate is 14.3% in Case B and 23.7% in Case C in 2020. A change from a labor income tax to a consumption tax generates income transfers among generations during the transition. At the onset of policy reform, the elderly who had already paid their labor income tax have to pay an additional consumption tax. Thus, these generations suffer from a double burden.

Figure 5 shows that, in the switch from Case A to C, the welfare for the generations born in from 1915 to 1954 is also improved. One of the reasons for this would be that this paper takes account of a transition relief for the generations that have paid contributions.

Figure 7 presents the changes in the utility for each income class in switching from Case A to C. The figure suggests that the pension reform has a different effect among the three income classes. The degree of improvement of the utility is greater for the low income class, while for the high income class it is smaller. In the long run, the utility for the low income class is improved by 8.6%, but for the high income class it is ameliorated by only 1.1%. The utility for the low income class turns to be improved for the generations born in from 1975 onwards, while that for the high income class turns to be improved for those born in from 1984 onwards. A possible reason for this is that the basic pension is substantially increased in Case C, and thus it strengthens the income redistribution effect through a public pension scheme.

**Figure 7 Changes in utility for each income class in Case C**




Case C: No earnings-related pension

***Case D:*** Proportional expenditure tax

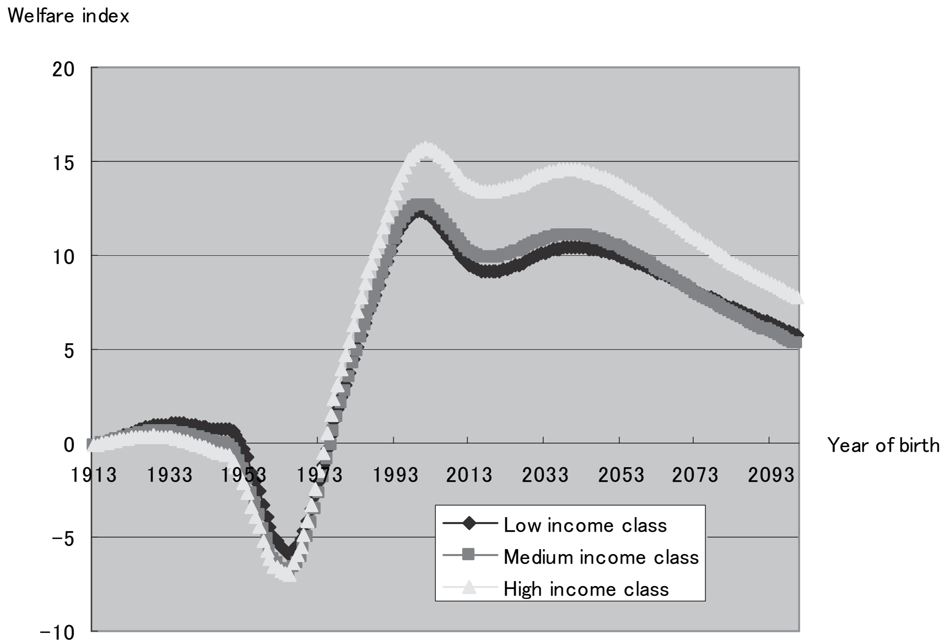
Finally, we explore a desirable source of revenue on the integrated public pension and tax systems. In Case C, from 2009 onward a proportional expenditure (or consumption) tax finances the overall tax revenue, which yields Case D. Labor income, capital income, and inheritance of bequests are not taxed. All tax systems become proportional, and thus there is not the income redistribution through a tax system.

Table 6 shows that the complete shift to a proportional expenditure (or consumption) tax substantially enhances both capital accumulation and labor supply, resulting in a high level of national income. In switching from Case A to D, the capital stock dramatically increases by 63.0% in 2020 and by 78.8% in 2100. The labor supply also increases by 11.5% in 2020 and by 10.9% in 2100. As a result, the national income substantially increases by 28.0% in 2020 and by 31.9% in 2100. Therefore, when the ratio of tax revenue from consumption to total tax revenue is high, capital accumulation is substantially promoted. The tax reform in Case D generates favorable results with regard to efficiency.

Figure 5 presents the welfare changes for each generation in switching from Case A to D. The welfare for the generations born in from 1970 onwards is higher in Case D than in Case C. However, with regard to the generations born in from 1950 to 1975, the welfare is deteriorated compared to Case A. Especially, the generations born in around 1960s are badly worse off in Case D than in Case C.

Figure 8 presents the changes in the utility for each income class in switching from Case A to D. This figure suggests that, with regard to the generations born in from 1971 onwards, the utility is improved for the high

**Figure 8 Changes in utility for each income class in Case D**




Case D: Proportional expenditure tax

income class more than for the low and medium income classes. Due to the absence of income redistribution through a tax system in Case D, the low income class is relatively worse off, while the high income class is relatively better off. Thus, the tax reform in Case D does not create favorable results with regard to equity.

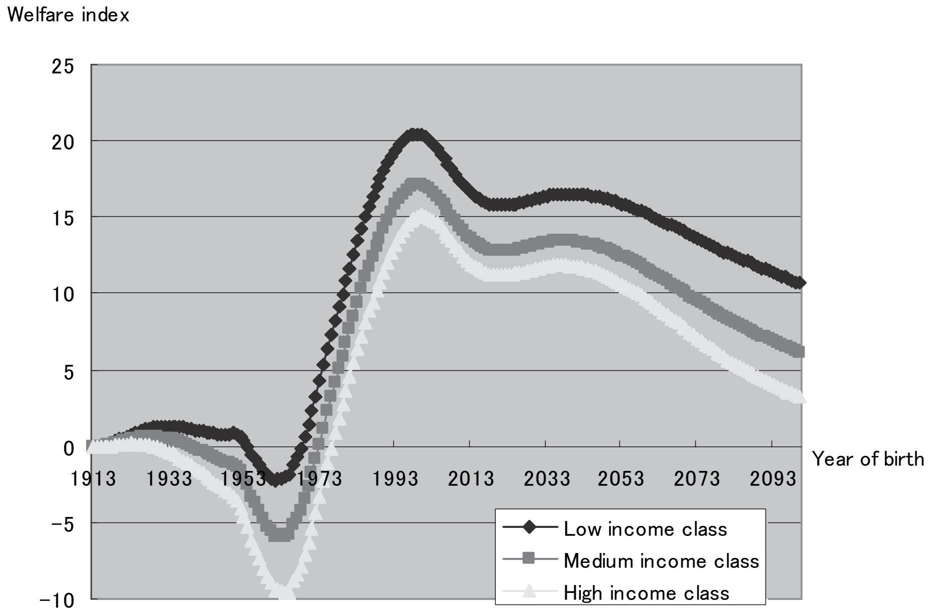
***Case E:*** Progressive expenditure tax

Because of the absence of the function of income redistribution through a tax system, Case D could not produce favorable results with regard to equity. To solve the problem, a progressive expenditure (or consumption) tax is introduced in Case D, which yields Case E. Case E examines the effects of the introduction of a progressive expenditure tax on efficiency and equity.

Table 6 shows that, with regard to efficiency, Case E is slightly inferior to Case D. The levels of the capital stock, labor supply, and national income are lower in Case E than in Case D. In switching from Case A to E, the capital stock substantially increases by 53.5% in 2020 and by 73.8% in 2100. However, the labor supply increases by only 2.9% in 2020 and by only 3.1% in 2100. As a result, the national income increases by 19.0% in 2020 and by 24.6% in 2100.

Figure 5 presents the welfare changes for each generation in switching from Case A to E. With regard to the generations born in from 1972 onwards, Case E with a progressive expenditure tax attains the highest level of welfare among all reform cases presented in this paper. In addition, in switching from Case A to E, the generations born in around 1960s are worse off in Case E less than in Case D in the transition process of the

**Figure 9 Changes in utility for each income class in Case E**




Case E: Progressive expenditure tax

reform.

Figure 9 presents the changes in the utility for each income class in switching from Case A to E. This figure shows that, with regard to all generations born in from 1913 to 2100, the utility is improved for the low income class more than for the medium income class. And, the utility is improved for the high income class less than for the medium income class with regard to all generations. This result suggests that the introduction of a progressive expenditure tax provides strong income redistribution, which enhances the welfare of the generations.

Therefore, the simulation results show that the introduction of a progressive expenditure tax not only may promote economic growth substantially but also may mitigate intragenerational inequality efficiently, resulting in a high economic welfare.

## 5 Conclusions

This paper examined guidelines for public pension and tax reforms in an aging Japan, using a dynamic life-cycle general equilibrium simulation model with different labor endowments. The paper examined the effects of demographic change and public pension and tax policies on economic growth and welfare. It evaluated the benchmark case scheduled by the 2004 reform, the case in which the whole basic pension is financed by a consumption tax, the case in which the earnings-related pension is abolished, and the case in which a progressive expenditure tax is introduced as a source of revenue on public pension and tax systems. When dealing with the pension reform case in which the earnings-related pension is abolished, this paper takes account of a transition relief for the generations that have paid contributions.

The simulation results predict long-run increases in output when the public pension system consists of only the basic pension, which is financed by a consumption tax. This is because the substitution from contributions (which mean a proportional labor income tax) to a proportional consumption tax greatly stimulates capital accumulation. Furthermore, the results show that the introduction of a progressive expenditure (or consumption) tax not only may promote economic growth substantially but also may mitigate intragenerational inequality efficiently.

It is certain that these reforms substantially enhance the welfare of many generations, but badly deteriorate the welfare for the generations born in around 1960s in the transition process of the reforms. A change from a labor income tax to a consumption tax creates income transfers among generations during the transition. At the onset of policy reform, the elderly who had already paid their labor income tax have to pay an additional consumption tax. Because these generations suffer from a double burden, the transition to a consumption tax is not Pareto improving. Although the shift to a consumption tax may ultimately improve the welfare for many (especially, future) generations, the conclusion that recommends a consumption tax will be required to provide further justification, that is, to suggest measures to avoid a double burden during the transition. One of the solutions to this problem may be to consider the transfer from the future generations that are substantially better off to the generations that suffer from a double burden, through public debts.

***Appendix A: Utility maximization problem***

The utility maximization problem over time for each income class in Section 2 is regarded as the maximization of $U^{t,i}$ in equation (2) subject to equations (3) and (8). Let the Lagrange function be

$$L^{t,i} = U^{t,i} + \sum_{s=21}^{95} \lambda_s^{t,i} \Big[ -A_{s+1}^{t,i} + \{1 + r_{t+s}(1-\tau^r)\} A_s^{t,i} + [1 - \tau^w \{w_{t+s} x^i e_s (1 - l_s^{t,i})\} - \tau_{t+s}^p] w_{t+s} x^i e_s (1 - l_s^{t,i})$$

$$+ b_s^{t,i}(\{l_u^{t,i}\}_{u=21}^{RE^t}) + a_s^{t,i} - \{1 + \tau_{t+s}^c (C_s^{t,i})\} C_s^{t,i} \Big] + \sum_{s=21}^{RE^t} \eta_s^{t,i}(1 - l_s^{t,i}), \tag{A1}$$

where $\lambda_s^{t,i}$ and $\eta_s^{t,i}$ represent the Lagrange multiplier for equations (3) and (8), respectively.

The first-order conditions on consumption $C_s^{t,i}$, leisure $l_s^{t,i}$, and assets $A_{s+1}^{t,i}$ for $s = 21, 22, ..., 95$ can be expressed by

$$p_s^t (1+\delta)^{-(s-21)} \left\{ (C_s^{t,i})^{\phi} (l_s^{t,i})^{1-\phi} \right\}^{-\frac{1}{\gamma}} \phi (C_s^{t,i})^{\phi-1} (l_s^{t,i})^{1-\phi} = \lambda_s^{t,i}(1 + \alpha_{t+s}^c + \beta_{t+s}^c C_s^{t,i}), \tag{A2}$$

$$p_s^t (1+\delta)^{-(s-21)} \left\{ (C_s^{t,i})^{\phi} (l_s^{t,i})^{1-\phi} \right\}^{-\frac{1}{\gamma}} (1-\phi)(C_s^{t,i})^{\phi} (l_s^{t,i})^{-\phi}$$

$$= \lambda_s^{t,i} \left[ (1 - \alpha^w - \tau_{t+s}^p) w_{t+s} x^i e_s - \beta^w (w_{t+s} x^i e_s)^2 (1 - l_s^{t,i}) \right] + \sum_{k=ST^t}^{95} \lambda_k^{t,i} \frac{\theta_{t+k} w_{t+s} x^i e_s}{RE^t - 20} + \eta_s^{t,i}$$

$$(s \le RE^t), \tag{A3}$$

$$\lambda_s^{t,i} = \{1 + r_{t+s}(1-\tau^r)\} \lambda_{s+1}^{t,i}, \tag{A4}$$

$$\eta_s^{t,i}(1 - l_s^{t,i}) = 0 \quad (s \le RE^t), \tag{A5}$$

$$1 - l_s^{t,i} = 0 \quad (s > RE^t), \tag{A6}$$

$$\eta_s^{t,i} \ge 0. \tag{A7}$$

The combination of equations (A2) and (A4) produces equations (9) and (10). If the initial value, $V_{21}^{t,i}$, is specified, the value of each age, $V_s^{t,i}$, can be derived from equation (9). If $V_s^i$ is specified, the values of consumption, $C_s^i$, and leisure, $l_s^i$, at each age are obtained in the method that follows.

For $S$=21, 22, ..., $RH^i$, the combination of equations (A2) and (A3) yields the following expression:

$$C_s^{t,i} = \left[ \frac{\phi\left( (1-\alpha^w - \tau_{t+s}^p) w_{t+s} x^i e_s - \beta^w (w_{t+s} x^i e_s)^2 (1 - l_s^{t,i}) + \sum_{k=ST^t}^{95} \frac{\lambda_k^{t,i}}{\lambda_s^{t,i}} \frac{\theta_{t+k} w_{t+s} x^i e_s}{RE^t - 20} + \frac{\eta_s^{t,i}}{\lambda_s^{t,i}} \right)}{(1-\phi)\{1 + \alpha_{t+s}^c + \beta_{t+s}^c C_s^{t,i}\}} \right] l_s^{t,i} \quad \text{(A8)}$$

If the value of $l_s^{t,i}$ is given under $\eta_s^{t,i} = 0$, the value of $C_s^{t,i}$ can be obtained using a numerical method, and then the value of $V_s^{t,i}$ can be derived from equation (10). The value of $l_s^{t,i}$ is chosen so that the value of $V_s^{t,i}$ obtained in the simulation is the closest to that calculated by evolution from $V_{21}^{t,i}$ through equation (9). If the value of $l_s^{t,i}$ chosen is unity or higher, the value of $C_s^{t,i}$ is obtained from equation (10) under $l_s^{t,i}=1$. If it is less than unity, the value of $C_s^{t,i}$ is derived from equation (A8).

For $s = RE^t+1,\ RE^t+2, ..., 95,$ the condition of $l_s^{t,i} = 1$ leads to the following equation:

$$V_s^{t,i} = \frac{\phi (C_s^{t,i})^{-\frac{\phi}{\gamma}+\phi-1}}{1 + \alpha_{t+s}^c + \beta_{t+s}^c C_s^{t,i}} . \quad \text{(10)'}$$

The value of $C_s^{t,i}$ is chosen to satisfy this equation.

### *Appendix B: Introduction of Progressive Expenditure Taxation*

The simulation results suggest that a progressive expenditure tax is ultimately an ideal tax regime in terms of efficiency and equity. However, a sudden move from the current Japanese tax system (that depends mainly on a progressive income tax) to a progressive expenditure tax, would generate a substantial transition cost. With regard to a short-term policy, we should rely more on a consumption tax as a transition process, and execute a gradual shift towards a progressive expenditure tax.

Nowadays, the number and variety of financial transactions that occur by Internet trading are progressing on a global scale. Hence, it is becoming more and more difficult to precisely monitor personal *income*. Levying a tax on *expenditure*, an ultimate purpose of economic activity, may solve this problem. Irrespective of a means to earn income, a tax office may be able to collect taxes efficiently and equitably by taxation on expenditure.

The amount of income of salaried workers can be precisely monitored by withholding tax at the income source. On the other hand, it is said that for self-employed persons or farm households, the ability to monitor income is substantially lower because of tax payment by self-assessment. An expenditure tax is likely to mitigate this state of unfairness between workers of different fields. Moreover, the introduction of tax progressivity to the total amount of expenditure may be desirable in terms of equity, because the range of tax base of expenditure would be wider than that of income.

Finally, the main purpose of this study is to let many academic researchers or policy makers aware of this new type of tax regime (i.e., a progressive expenditure tax) and its merits. We believe that even if a progressive expenditure tax is not actually introduced in Japan, the policy implication obtained in our analysis will still be meaningful and effective. Even in the case of implementing structural reform along the lines of the current

Japanese tax system, knowledge of this new type of tax schedule will prove to be useful.

***Appendix C: How Can Progressive Expenditure Taxation Be Implemented?***

The simulation results in this paper quantitatively suggest that a progressive expenditure tax substantially stimulates capital accumulation, and efficiently reduces within-cohort income inequality. We present the concrete measures of carrying out progressive expenditure taxation. Conceptually, it is easy to introduce progressive expenditure taxation. The feasibility of implementing progressive expenditure taxation, however, contains a serious problem in the real world: that is to measure and grasp the figures of each individual's expenditure. For its implementation, it is necessary to grasp the total amount of annual expenditure for each household. This implies that a tax authority has to grasp the whole picture of consumption activities of each individual in detail. How can we measure a tax base that is defined by expenditure? We propose that it is feasible to measure it with the method that follows.

There is a relation that states income is equal to consumption (or expenditure) plus savings. If the amounts of both income and savings are available for each individual, the balance is equal to the amount of expenditure. The income figure is efficiently obtained using the current Japanese system of withholding taxes at the income source. The savings figure can be obtained through the self-assessment system. It should be emphasized that the self-assessment of savings is the exact opposite to that of income in terms of an individual incentive. The more an individual declares savings, the lower tax rates on expenditure the individual has. This is entirely in contrast to the case of the self-assessment of income.

The savings figure can be consolidated using an electronic financial system. All financial institutions are requested to report the total amount of financial assets held by each individual with an individual tax number (or a social security number) to a tax office. Thus, the tax office is able to grasp the overall wealth of each individual. Of course, this feasibility depends solely on the development of a computer-based financial system.

To introduce a progressive expenditure tax, it is necessary that the tax office can grasp the total amount of expenditure for each individual or household. At present, computer technology is making remarkably rapid progress and over time will be able to provide a better environment for the introduction of a progressive expenditure tax in Japan. Thus, the possibility of introducing the tax regime should steadily increase.

The justification for introducing a taxpayer identification number system is presently being actively discussed in Japan. This system has already been adopted in the United States, Canada, and in Scandinavian countries. In this system, each taxpayer has an identification number (a tax number or a social security number) that enables a tax agency to monitor the total amounts of income and assets. Not only would this system help the introduction of a progressive expenditure tax, it is also necessary to efficiently and equitably provide public services for the elderly. Thus, it may not be long before a progressive expenditure tax is introduced in Japan.

## Notes

1 Altig *et al*. (2001) dealt with differences of lifetime earnings ability by incorporating 12 lifetime-income groups into a life-cycle model. Furthermore, Okamoto (2005b) introduced numerous representative households with continuous income distribution in each cohort. On the other hand, Uemura (2001) and Ihori *et al*. (2006) analyze using a life-cycle model with a single representative household.

2 See Seidman (1997) and Okamoto (2004, 2005a) for the details of a progressive expenditure (or consumption) tax. Kaldor (1955) claims that the implicit taxation of individuals with vast inherited wealth via an expenditure tax is a final goal.

3 Okamoto and Tachibanaki (2002) also included the flat basic pension in the public pension program. In that study, general tax revenue covered one third of the basic pension in the benchmark simulation, and the rate of tax transfer was raised from one third to a half (i.e., there is a rise in the basic pension by one sixth). That study examined the effects of an increase in the tax transfer on efficiency and equity.

4 With regard to simulation cases except for the benchmark, strictly speaking, the total amount of basic pension or that of public pension is not financed completely by a consumption tax. This is because there exists the part originally covered by the general tax revenue, namely, a little more than one third of basic pension currently financed by general taxes. However, we can interpret that, in those cases, this part of basic pension is financed not by the general tax revenue but by a consumption tax. Therefore, we can regard that the whole basic pension or the overall public pension is financed by a consumption tax in those cases.

5 According to Okamoto (2010), which analyzes in the steady state, if we consider a public pension program with the same scale as the current Japanese program, the highest level of social welfare is attained when a public pension system consists of only a basic pension and is financed by a consumption tax. Thus, we consider the case in which the overall public pension consists of only a basic pension and is financed by a consumption tax, namely, Case C.

6 The tax rate on capital income is assigned the same value as in Braun *et al*. (2005, 2009). The tax rate on bequests is assigned making reference to Ihori *et al*. (2006).

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