Simulating Public Pension Reforms in an Aging Japan: Welfare Analysis with LSRA Transfers*1

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Abstract
This paper explores the effect of different public pension schemes on economic welfare, and intergenerational and intragenerational equity. Besides the benchmark case based on the 2004 public pension reform, the paper considers two alternative cases: first, the financing of the basic pension benefit by a consumption tax, and second, the elimination of the earnings-related pension benefit. To distinguish potential efficiency gains or losses from possibly offsetting changes in the welfare of different generations, the paper introduces the Lump Sum Redistribution Authority (LSRA). The simulation results suggest that although consumption tax financing of only a basic pension increases economic output by inducing capital formation, even with LSRA transfers it may not bring about a Pareto improvement.

Keywords: Aging population; Pension reform; Consumption tax; Pareto improvement; Simulation analysis
JEL classification: H30; C68

I. Introduction

With the most aged population in the world, Japan faces serious public finance problems, particularly in the areas of tax and social security. Structural reforms are urgently needed to accommodate the impending demographic change. The public pension program was reformed in 2004, and scheduled pension reforms are ongoing. However, reforms to date have been insufficient. Many Japanese, particularly the young, worry about the sustainability of the public pension system. The need for drastic reform of the scheme is becoming obvious.

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particular, a pension reform plan in which the basic pension benefit would be entirely financed by a consumption tax is currently receiving much attention.

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 different public pension policies on economic welfare and intergenerational and intragenerational equity, using a computable, general equilibrium model of overlapping generations. The macroeconomic and welfare effects of alternative pension policies during the transition to an aging Japan are evaluated. The benchmark simulation uses a public pension schedule based on the 2004 pension reform, which reflects the current pension program in Japan. Alternative simulations involve different public pension policies.

This paper considers two alternative reform plans relevant to current debate on the public pension scheme in Japan. One reform plan is to finance the basic pension benefit entirely by a consumption tax; currently, general tax revenue finances half of the total basic pension benefit, and contributions from the current public pension program finance the remaining half. The other reform plan is to abolish the earnings-related pension benefit. The paper focuses on the combined case where the public pension system consists only of a basic pension financed by a consumption tax, because the pension reform plan is attracting most debate among researchers and politicians.

To analyze the problem, this paper examines the Japanese tax and public pension systems using an extended lifecycle general equilibrium model. Many papers have used 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), Ihori et al. (2006, 2011), and Okamoto (2007). However, nearly all of these studies have concentrated on analyzing the effects of an aging population on production and consumption, and, thus, on economic growth. It is vital, however, when dealing with tax and social security reforms, to evaluate equity as well as efficiency.

There are three themes in this paper. First, this paper expands the conventional Auerbach and Kotlikoff model by incorporating the heterogeneity of earning ability into the simulation model, to comprehensively assess the alternative pension reform plans. The paper includes three representative households, with different earning abilities, in a dynamic lifecycle general equilibrium model with an elastic labor supply. This allows us to examine both efficiency and equity issues. The paper thus considers both intergenerational and intragenerational equity, and hence presents comprehensive and useful guidelines for public pension reform. This is one of the main contributions of the paper to the existing literature, which includes many studies that have exclusively examined efficiency issues related to the aging population of Japan.

Second, the paper considers an additional government institution, the Lump Sum

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1 Homma et al. (1987), Uemura (2001), and Ihori et al. (2006, 2011) use a lifecycle model with just one representative household, while Altig et al. (2001) deal with differences in lifetime earning ability by incorporating 12 lifetime-income groups into a lifecycle model. Furthermore, Okamoto (2005b) uses numerous representative households with continuous income distribution in each cohort.
Redistribution Authority (below, LSRA). Public pension reforms generally improve the welfare of some generations but reduce that of others. If combined with redistribution from winning to losing generations, they may offer the prospect of a Pareto improvement. Without implementing the intergenerational redistribution, however, potential efficiency gains or losses cannot be estimated. Therefore, to evaluate potential efficiency gains or losses from alternative pension reforms, we introduce a hypothetical government institution, namely, the LSRA, as in Auerbach and Kotlikoff (1987) and Nishiyama and Smetters (2005). The introduction of the LSRA helps distinguish potential efficiency gains or losses from possibly offsetting changes in the welfare of different generations.

Third, when dealing with alternative pension reforms, this paper addresses the problems that actually arise at the onset of pension reforms. Specifically, in the case where the earnings-related pension benefit is eliminated, transition relief is considered for generations that paid contributions to the public pension scheme prior to the reform. Moreover, the paper takes account of the social welfare function with an intergenerational discount factor, which helps evaluate the effect of different weights between the welfare of current generations and that of future generations on the social welfare level across alternative pension reform plans.

This paper is organized as follows. The next section identifies the basic model employed in the simulation analysis. Section 3 then explains the method of simulation analysis and the assumptions adopted. Section 4 evaluates the simulation findings and discusses policy implications. Finally, Section 5 presents a summary and conclusions.

II. Theoretical Framework

The lifecycle 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 includes 80 overlapping generations. Three types of agents are considered: households, firms and the government. The following subsections describe the basic structures of households, firms and the government, as well as the market equilibrium conditions.

II-1. Household Behavior

Each household is assumed to consist of a couple of the same age. Each household enters the economy as a decision-making unit at age 21 years and lives to a maximum age of 100
years. People aged below 21 years do not participate in the economy. Households face an age-dependent probability of death. Let \( q'_{j+1|j} \) be the conditional probability that a household born in year \( t \) lives from age \( j \) to \( j + 1 \). Then the probability of a household aged 21 years, born in year \( t \), surviving until \( s \) can be expressed by

\[
p'_s = \prod_{j=21}^{s-1} q'_{j+1|j}.
\]  

The probability \( q'_{j+1|j} \) 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. Households that belong to the same cohort share the same mortality rate and utility function. Unequal labor endowments, however, create different income levels. Individual household utility depends on levels of consumption and leisure. A household born in year \( t \) works from age 21 years to a maximum of \( RE \), the compulsory retirement age. The labor supply is elastic, but decreases to zero after the retirement age. Each household maximizes expected lifetime utility and makes lifetime decisions at age 21 years regarding enjoying leisure versus supplying labor, and wealth allocation 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

\[
U^{i,j} = \frac{1}{\gamma} \sum_{s=21}^{100} p'_s (1 + \delta)^{-(s-21)} \left( C^{i,j}_s \right)^\phi \left( l^{i,j}_s \right)^{1-\phi},
\]

where \( C^{i,j}_s \) and \( l^{i,j}_s \) represent consumption and leisure, respectively, for a household belonging to income class \( i \), with age \( s \), born in year \( t \); \( \phi \) is the consumption share parameter, \( \delta \) the adjustment coefficient for discounting the future, and \( \gamma \) the intertemporal elasticity of substitution in the consumption–leisure composite. The superscript \( i (= l, m, h) \) denotes low, medium and high income classes, respectively.

The flow budget constraint equation for each household with age \( s \) at time \( t \) is

\[
A^{i,j}_{s+1} = \{1 + r_{t+s}(1-\tau^c)\} A^{i,j}_s + [1 - \tau^w \{w_{t+s}x'e_s(1-l^{i,j}_{s+1}) - \tau^p_{t+s}\}]w_{t+s}x'e_s(1-l^{i,j}_{s+1}) + a^{i,j}_s + b^{i,j}_s \left( l^{i,j}_s \right)_{RE} \]  

\[
- (1 + \tau^p_{s}) C^{i,j}_s,
\]

where \( A^{i,j}_s \) represents the value of assets held by households belonging to income class \( i \) born in year \( t \) at the beginning of age \( s \), \( r_{t+s} \) is the interest rate at time \( t \), \( w_t \) represents the wage rate per efficiency unit of labor at time \( t \), and \( e_s \) is the age profile of earning ability. For a household belonging to income class \( i \), with age \( s \), born in year \( t \), \( 1-l^{i,j}_{s+1} \) is the labor supply, \( b^{i,j}_s \left( l^{i,j}_s \right)_{RE} \) is the public pension benefit, and \( a^{i,j}_s \) is the bequest to be inherited. \( \tau^w \{w_{t+s}x'e_s(1-l^{i,j}_{s+1})\} \) is the tax rate on labor income at time \( t \), \( \tau^c_{s} \) is that on consumption at time \( t \), \( \tau^p_{t+s} \) is the contribution rate to the public pension
scheme at time $t$. Finally, $x^i$ is the weight coefficient corresponding to the different levels of labor endowments across the three income classes.

The tax system comprises labor income, capital income, consumption and inheritance taxes. Labor income is taxed progressively on an annual basis. The progressive tax schedule is incorporated as in Auerbach and Kotlikoff (1987). If the tax base is the gross wage, $w_{t+s}x^s e_s (1 - l^i_s)$, we choose two parameters, $\alpha$ and $\beta$, and set the average tax rate, $T^w$, to $\alpha + 0.5 \beta w_{t+s}x^s e_s (1 - l^i_s)$. The corresponding marginal tax rate, $\tau^w$, is $\alpha + \beta w_{t+s}x^s e_s (1 - l^i_s)$. Setting $\beta = 0$ amounts to proportional taxation. The tax system can be made more progressive, holding revenue constant, by simultaneously increasing $\beta$ and decreasing $\alpha$. The symbol, $\tau^w w_{t+s}x^s e_s (1 - l^i_s)$, in Equation (3) means that $\tau^w$ is a function of $w_{t+s}x^s e_s (1 - l^i_s)$. The taxes on capital income, consumption and inheritances are proportional.

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

$$b_s^i (t^i_s \{l^i_j \}_{j=2}^{RE}) = \begin{cases} m_t + \theta H^i (t^i_s \{l^i_j \}_{j=2}^{RE}) & (s \geq ST) \\ 0 & (s < ST) \end{cases},$$

where

$$m_t = \frac{F_{t+s}}{\sum_{i} \sum_{k=ST}^{100} N_{i+k-s-k,j}},$$

$$H^i (t^i_s \{l^i_j \}_{j=2}^{RE}) = \frac{1}{RE - 20} \sum_{s=2}^{RE} w_{t+s}x^s e_s (1 - l^i_s).$$

The age at which a household born in year $t$ starts to receive the public pension benefit is $ST$, the basic pension benefit per household is $m_t$, the average annual labor income for each income class is $H^i (t^i_s \{l^i_j \}_{j=2}^{RE})$, the weight coefficient of the part proportional to $H^i$ is $\theta$, $F_t$ is the total basic pension benefit, and $N_{i+s-k,j}$ is the number of households belonging to income class $i$, of age $s$, and born in year $t$. Thus, $b_s^i (t^i_s \{l^i_j \}_{j=2}^{RE})$ reflects different earning abilities across the three income classes. The symbol $b_s^i (t^i_s \{l^i_j \}_{j=2}^{RE})$ in Equation (3) signifies that the amount of public pension benefit is a function of the age profile of leisure, $t^i_s \{l^i_j \}_{j=2}^{RE}$.

The model includes accidental bequests that result from uncertainty over length of life. The bequests, which comprise assets previously held by deceased households, are distributed among all surviving households within the same income class at time $t$. When

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2 Using a two-tier model in Japan, Yamada (2011) investigates the welfare implications and political feasibility of social security reforms.
$BQ^i_s$ is the sum of bequests inherited by households with age $s$ years belonging to income class $i$ at time $t$, $a^i_s$ is defined by

$$a^i_s = \frac{(1 - \tau^h)BQ^i_s}{\sum_{k=21}^{100} N^i_{s+1-k,j}}.$$  

(7)

where

$$BQ^i_s = \sum_{s=21}^{100} (N^i_{s+1-i} - N^i_{s+1}) A^i_{s+1}.$$  

(8)

The tax rate on inheritances of bequests is $\tau^h$. The amount of such inheritances received is linked to the age profile of assets for each household.

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

$$\left\{
\begin{array}{ll}
0 \leq l^i_s \leq 1 & (21 \leq s \leq RE) \\
l^i_s = 1 & (RE + 1 \leq s \leq 100)
\end{array}
\right.$$  

(9)

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

Let us consider the case where each household maximizes expected lifetime utility under two constraints. Each household maximizes Equation (2) subject to Equations (3) and (9) (see Appendix A for further details). From the utility maximization problem, the equation expressing the evolution of the consumption–leisure composite over time for each household is characterized by

$$V^i_s = \left(\frac{p^i_s}{p^i_{s-1}}\right) \left[\frac{1 + \delta}{1 + r_{t,s}(1 - \tau^i)}\right] V^{i+1}_s.$$  

(10)

where

$$V^i_s = \frac{\left(C^i_s\right)^{\phi} \left(l^i_s\right)^{1-\phi}}{1 + \tau^i_s}$$  

(11)

If the initial level of the consumption–leisure composite, $V^{i+1}_s$, is specified, the level at each age, $V^i_s$, can be derived from Equation (10). By specifying $V^i_s$, the levels of consumption, $C^i_s$, and leisure, $l^i_s$, at each age can be obtained. The 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 earning abilities
and thus provides different levels of the consumption–leisure composite, is given by

$$W^i = U_1^i + U_2^i + U_3^i.$$  \tag{12}

This function is derived from a simple summation of the expected lifetime utilities at age 21 years 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.

Social welfare is defined as the discounted sum of the lifetime utilities of all generations. The social welfare function, $SW(\varphi)$, is given by

$$SW(\varphi) = \sum_{t=0}^{\infty} \varphi^t W^i,$$  \tag{13}

where $\varphi (0 < \varphi < 1)$ is the intergenerational discount factor. As $\varphi$ is larger, the welfare is more weighted for future generations than for current generations.

Empirical evaluation of each simulation from Cases B and C in comparison with the benchmark (i.e., Case A) is made by the following formulation of $RWC^i$ (relative welfare changes by percentage figures):

$$RWC^i = -100 \times \frac{(U_{j}^i - U_{A}^i)}{U_{A}^i},$$  \tag{14}

where $U_{A}^i$ signifies the lifetime utility for the generation born in year $t$ in Case A, and $U_{j}^i$ ($J = B$ and $C$) represents the lifetime utility for the generation born in year $t$ in each pension reform case (i.e., Cases B and C). The minus sign was added so that improvements in $RWC^i$ show positive numerical changes in welfare.

II-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 efficiency. All forms of labor are perfectly substitutable. Households with different income classes or ages, however, supply different amounts of some standard measure per unit of labor input.

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

$$Y_t = K_t^\varepsilon L_t^{1-\varepsilon},$$  \tag{15}

where $Y_t$ is total output (national income), $K_t$ is total capital, $L_t$ is total labor supply measured by the efficiency units, 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:
\[ Y_t = (r_t + \delta^k)K_t + w_tL_t, \]

where \( \delta^k \) is the depreciation rate.

II-3. Government Behavior

The government sector consists of a narrow government sector and a public pension sector. A portion of tax revenues collected by the narrow government sector goes to finance general government expenditure while the remainder is transferred to the public pension sector. Besides taxation, general account expenditure is also financed by the issue of government bonds. The public pension program consists of a basic pension (i.e., a flat part) and another part proportional to the average annual labor income for individual recipient households (i.e., the second-floor part). Pension account expenditure is financed by both contributions and a transfer from the general account.

Although the budget constraints of the two sectors should be given separately to reflect the actual Japanese system, for simplicity, our study assumes an integrated constraint. Therefore, the budget constraint of the whole government sector at time \( t \) is given by

\[ G_t + F_t + P_t + (1 + r_t)\bar{D}_t = R_t + T_t + \bar{D}_{t+1}, \]

where \( G_t \) is total government spending on goods and services, other than transfers to the public pension sector, \( F_t \) is total spending on the basic pension benefit (i.e., a flat part), \( P_t \) is total spending on the pension benefit as a proportion of labor income (i.e., the second-floor part), \( \bar{D}_t \) is net government debt at the beginning of year \( t \), \( R_t \) is total revenue from contributions to the pension program, and \( T_t \) is total tax revenue from labor income, capital income, consumption and inheritances.

Here, \( G_t, F_t, P_t, R_t, T_t, \) and \( \bar{D}_t \) are defined by

\[ G_t = gY_t, \]

\[ F_t = fY_t, \]

\[ P_t = \theta \sum_{s=S}^{T} (N_s^{t-s}H^{t-s} + N_s^{t-s,m}H^{t,s} + N_s^{t-s,b}H^{t,b}), \]

\[ R_t = \tau^p w_tL_t, \]

\[ T_t = LX_t + \tau^r r_t AS_t + \tau^c AC_t + \tau^b BQ_t, \]

3 The general account and the public pension account are separated in Japan, although half of the total basic pension benefit is financed by the tax revenue. However, there is also an opinion, held for example by Broda and Weinstein (2005), that the net deficit of Japan is not high if government debts and the public pension fund are fully substitutable.
where $g$ is the ratio of government expenditure to national income, and $f$ is that of the total basic pension benefit to national income. $LX_t$ is tax revenue from labor income and $BQ_t$ is the sum of bequests inherited at time $t$:

$$LX_t = \sum_{t} \sum_{s=21}^{100} N_s^{t-s,l} \left[ \alpha w_i x_s^i (1-l_s^{t-s,l}) + 0.5 \beta \{w_i x_s^i (1-l_s^{t-s,l})\}^2 \right].$$  \hspace{1cm} (24)

$$BQ_t = BQ_t^l + BQ_t^m + BQ_t^h.$$  \hspace{1cm} (25)

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

$$AS_t = \sum_{s=21}^{100} \left\{ N_s^{t-s,l} A_s^{t-s,l} + N_s^{t-s,m} A_s^{t-s,m} + N_s^{t-s,h} A_s^{t-s,h} \right\},$$  \hspace{1cm} (26)

$$AC_t = \sum_{s=21}^{100} \left\{ N_s^{t-s,l} C_s^{t-s,l} + N_s^{t-s,m} C_s^{t-s,m} + N_s^{t-s,h} C_s^{t-s,h} \right\}.$$  \hspace{1cm} (27)

The stock of outstanding debt is $D_t$ and the accumulated public pension fund is $Q_t$, and each is represented as a ratio to national income:

$$\tilde{D}_t = \tilde{d} Y_t,$$  \hspace{1cm} (28)

$$D_t = d Y_t,$$  \hspace{1cm} (29)

$$Q_t = q Y_t,$$  \hspace{1cm} (30)

where $\tilde{d}$ is the ratio of net public debt to national income, $d$ is that of gross public debt to national income, and $q$ is that of the public pension fund to national income.

### II-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 equal the sum of real capital and net government debt,
\[ AS_t = K_t + D_t. \]  

2) **Equilibrium condition for the labor market**

Measured in efficiency units, because aggregate labor demand by firms equals aggregate labor supply by households,

\[ L_t = \sum_{s=21}^{100} \left[ N_{s}^{t-s-j} x_s^j (1 - I_{s}^{t-s-j}) + N_{s}^{t-s,m} x_s^m (1 - I_{s}^{t-s,m}) + N_{s}^{t-s,h} x_s^h (1 - I_{s}^{t-s,h}) \right]. \]

3) **Equilibrium condition for the goods market**

Because aggregate production equals the sum of private consumption, private investment and government expenditure,

\[ Y_t = AC_t + \{ K_{t+1} - (1 - \delta^k) K_t \} + G_t. \]

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

### III. Simulation Analysis

#### III-1. Method of Simulation

The simulation model presented in the previous section is solved under the assumption that households have perfect foresight and correctly anticipate interest, wage, tax and contribution rates, and other factors. 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).

The present paper deals with the Japanese transitional economy, where the initial steady state is in 2009 and the final steady state is in 2300. Alternative public pension reform plans are assumed to be implemented at the end of 2009. For the simplicity of discussion, we set the year 2009 as an initial steady state because we are interested in the future economy. For the generations that were alive in 2009 and survive in 2010, we need to pay attention to their formation of expectations regarding the future. In 2010, these generations realize that their previous expectations no longer apply and, thus, once again maximize their remaining lifetime utility under the hypothesis of perfect foresight. Based on the ex-post age profiles of consumption and leisure for these generations, we calculated their lifetime utility at age 21 years.
III-2. Simulation Cases

The current Japanese public pension system fulfills two functions of insurance and aid. Recent studies have argued that the government should concentrate on fulfilling the aid function, and the public pension system should be limited to the basic pension benefit that guarantees each citizen a minimum standard of living after retirement. For example, on grounds of both efficiency and equity, Tachibanaki (2005) advocates fully financing the basic pension benefit through a consumption tax; currently, the basic pension is funded partly by pension contributions.4 Based on such arguments, we consider the following pension reform cases.

In the benchmark simulation (i.e., in Case A), which reflects the present situation of Japan, the public pension schedule is based on the 2004 pension reform. Notably, the present study does not aim to assess the public pension reform conducted in 2004. The purpose of the 2004 reform was to balance pension benefits and contributions over the next 100 years. First, public pension contributions were to be raised by 0.354% annually, and from 2017 were to be fixed at 18.3% of individual annual wage income, a feature called the “fixed contribution.” Second, the 2004 reform incorporated the automatic adjustment of benefit levels, a feature referred to as the “macroeconomic indexation.” This feature enables the pension program to adapt flexibly to social and economic changes, particularly demographic changes and, thus, helps minimize future revisions of benefits and contributions. Third, the 2004 reform also provides a road map for raising the ratio of tax transfer in financing the basic pension from one-third to half of the total. The rate of tax transfer was to be gradually raised from 2004, and was to reach half no later than 2009. In addition, the decision was made to gradually draw down the public pension fund over a century according to a long-term schedule to stabilize pension financing during that period.

This paper also presents several simulation scenarios involving different pension reform plans, where alternative public pension scheme policies are evaluated based on welfare. Case B is the reform case in which the basic pension benefit is entirely financed by a consumption tax and the earnings-related pension benefit is retained. Case C is the case in which the earnings-related pension benefit from Case B is abolished, and thus involves only a basic pension financed by a consumption tax.5 The pension reforms in Cases B and C make some generations better off, while an additional consumption tax burden makes others worse off. To distinguish potential efficiency gains or losses from possibly offsetting changes in the

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4 Using a simulation model with the risk of volatility of return on assets, Miyazato (2010) investigates the optimal size of Japan’s public pensions. Working within a different framework from these lifecycle general equilibrium models, Auerbach and Lee (2011) use stochastic simulations to analyze how public pension structures spread the risks arising from demographic and economic shocks across generations.

5 Okamoto (2010) analyzes public pension reform cases in a model with a steady state and suggests that if a public pension program with the same scale as the current Japanese system is considered, economic welfare is maximized with a public pension system that consists only of a basic pension financed by a consumption tax.
welfare of different generations, we introduce LSRA transfers in conjunction with the redistribution from winning to losing generations. This helps assess the potential efficiency gains or losses from implementing the intergenerational redistribution, and examine whether these pension reforms attain a Pareto improvement.

We follow Auerbach and Kotlikoff (1987) and Nishiyama and Smetters (2005) by measuring the pure efficiency gains from alternative public pension reforms using a hypothetical LSRA. The LSRA first transfers to each household alive at the time of the reform just enough resources (possibly a negative amount) to return its expected remaining lifetime utility to its prereform level. In other words, it makes a lump-sum transfer to each household that is alive when a pension reform is implemented (i.e., at the end of 2009), to bring its expected remaining lifetime utility back to its prereform level in the benchmark simulation, namely, in Case A. Next, the LSRA makes a lump-sum transfer to each future household that enters the economy after a pension reform (i.e., from 2010 onward), to bring its expected entire lifetime utility to its prereform level in the benchmark simulation. Here, it should be noted that the net present value of these transfers in the 2009 initial steady state across living and future households will generally not sum to zero. Therefore, finally, the LSRA makes an additional lump-sum transfer to each future household so that the net present value across all transfers is zero. For illustrative purposes, we assume that these additional transfers are uniform across future generations. If the transfer is positive, then the reform has produced extra resources after the expected remaining lifetime utility of each household has been restored to its prereform level. In this case, we can interpret that the reform has generated efficiency gains. On the other hand, if the transfer is negative, then the reform reduces efficiency. Thus, the present value of the total net lump-sum transfer to current and future generations amounts to zero in the initial steady state in 2009, which implies that the budget constraint of the LSRA is satisfied (see Appendix B in Nishiyama and Smetters (2005) for further details).

Through lump sum taxes and transfer payments, the LSRA transfers resources across generations. In Cases B-L and C-L the LSRA transfers are conducted within each income class, while in Cases B-L’ and C-L’ the transfers are implemented across the three income classes, namely, among all income classes, as in Nishiyama and Smetters (2005). Therefore, the following seven simulation cases are considered (see Figure 1 for diagrams of the public pension system in each simulation case).

1) **Case A (benchmark simulation)**
The public pension schedule is based on the 2004 pension reform, which reflects the present situation in Japan. Half (i.e., 50%) of the total basic pension benefit in the public pension program is financed by general tax revenue from 2009 onward. The contribution rate in 2009 is 15.704%, the actual rate in employee pension plans (*Kosei Nenkin*) in 2009, and gradually increases until 2017. From 2017 onward, the rate is fixed at 18.3% (see Table 1 for the contribution rates after 2009 for each simulation case).
2) **Case B** *(basic pension financed by a consumption tax)*

In Case B, from 2010 onward, half of the basic pension benefit is financed by a consumption tax instead of pension contributions, and, therefore, the basic pension benefit is entirely financed by a consumption tax.\(^6\) Meanwhile, the earnings-related pension benefit remains financed by contributions. Compared to the contribution rate in Case A, from 2010 onward, it decreases by 2.765% annually, which is equivalent to half of the total basic pension benefit in the 2009 initial steady state.

---

\(^6\) Strictly speaking, the basic pension benefit is not always entirely financed by a consumption tax. Half of the total basic pension benefit is currently financed by general taxes. However, we can assume that this part of the basic pension benefit is also financed by a consumption tax, and thus regard the basic pension benefit as entirely financed by a consumption tax in Cases B and C.
3) **Case B-L (Case B with LSRA)**
The LSRA is introduced in Case B, which yields Case B-L. The LSRA transfers are performed within each income class, which creates the three welfare gains or losses for each future household.

4) **Case B-L’ (uniform welfare gain or loss across each income class)**
In Case B the LSRA transfers are implemented among all income classes, which produces a common welfare gain or loss for each future household.

5) **Case C (earnings-related pension eliminated)**
In Case B the earnings-related pension is abolished at the end of 2009, which yields Case C. Thus, in Case C, from 2010 onward the public pension system consists only of a basic pension financed by a consumption tax. From 2010 onward, the contribution rates become zero. Transition relief is considered for generations that paid contributions before 2010.

6) **Case C-L (Case C with LSRA)**
The LSRA is incorporated in Case C, which provides Case C-L. The LSRA transfers are conducted within each income class, which generates the three welfare gains or losses for each future household. As in Case C, transition relief is considered for generations that paid contributions before 2010.

7) **Case C-L’ (uniform welfare gain or loss across each income class)**
In Case C the LSRA transfers are performed among all income classes, which produces a common welfare gain or loss for each future household. As in Case C, transition relief is considered for generations that paid contributions before 2010.

Case B deals with the substitution from contributions (i.e., a tax on labor income) to a consumption tax, to finance half of the total basic pension benefit. In a simple setting such as our model, the switch from Case B to C can be interpreted as changing from a pay-as-you-go system to a funded system for the earnings-related pension.\(^7\)

In Cases C, C-L and C-L’, the earnings-related pension is abolished from 2010 onward. Regarding transition relief, the generations that paid contributions before 2010 can receive the earnings-related pension benefit until they die, with the amount received corresponding to the number of years for which they paid contributions. The average annual labor income for households belonging to income class \(i\) born in year \(t\) \((t \leq 1988)\) is

\[
H^{t,i}(\{y^{t,i}_{s}\}_{s=21}^{t,t,RE}) = \frac{1}{RE - 20} \sum_{s=21}^{\min\{2009 \rightarrow t,RE\}} w^{t,s} x^{j} e^{s}(1-t^{t,i}_{s}).
\]

\(^7\) Aso (2002, 2005, 2008) suggests that a choice between a funded pension system and a pay-as-you-go system should be considered as the problem of how the pension debt that now exists in Japan should be shouldered between the current generations and the future generations.
In Cases C, C-L and C-L’, Equation (6’) replaces Equation (6). Regarding the weight coefficient, \( \theta \), given on average annual labor income, the value in Case A is applied for all simulation cases.

### III-3. Specification of Parameters

This paper examines the implications of several public pension policies in an aging Japan. We chose parameter values that are realistic for the Japanese economy. Parameter values were assigned with reference to previous research, such as Braun et al. (2005, 2009), Hayashi and Prescott (2002), and Nishiyama and Smetters (2005). Table 2 shows the parameter values assigned in the simulations and the data source referred to in calibration. We chose parameter values so that the calculated values of endogenous variables within the model approach the actual values obtained from the data.

In order to make the simulation analysis feasible, we simplify the assumption of the

<table>
<thead>
<tr>
<th>Parameter description</th>
<th>Parameter values</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share parameter for consumption</td>
<td>( \phi = 0.5 )</td>
<td>Nishiyama and Smetters (2005): ( \phi = 0.47 )</td>
</tr>
<tr>
<td>Adjustment coefficient for discounting the future</td>
<td>( \delta = 0.001 )</td>
<td></td>
</tr>
<tr>
<td>Intertemporal substitution elasticity</td>
<td>( \gamma = 0.3 )</td>
<td>Altig et al. (2001): ( \gamma = 0.25 )</td>
</tr>
<tr>
<td>Capital share in production</td>
<td>( \varepsilon = 0.362 )</td>
<td>Hayashi and Prescott (2002)</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>( \delta^k = 0.0759 )</td>
<td>Braun et al. (2005, 2009)</td>
</tr>
<tr>
<td>Parameters of a progressive labor income tax</td>
<td>( \alpha = -0.04628, \beta = 0.215 )</td>
<td></td>
</tr>
<tr>
<td>Tax rate on capital income</td>
<td>( \tau' = 0.48 )</td>
<td>Hayashi and Prescott (2002)</td>
</tr>
<tr>
<td>Tax rate on inheritance</td>
<td>( \tau^k = 0.1 )</td>
<td>Ihori et al. (2006, 2011)</td>
</tr>
<tr>
<td>Ratio of government expenditure to national income</td>
<td>( g = 0.1665 )</td>
<td></td>
</tr>
<tr>
<td>Ratio of total basic pension to national income</td>
<td>( f = 0.0353 )</td>
<td></td>
</tr>
<tr>
<td>Ratio of gross public debt to national income</td>
<td>( d = 1.0723 )</td>
<td></td>
</tr>
<tr>
<td>Ratio of public pension fund to national income</td>
<td>( q = 0.3161 )</td>
<td></td>
</tr>
<tr>
<td>Ratio of net public debt to national income</td>
<td>( \bar{d} = 0.7562 )</td>
<td></td>
</tr>
<tr>
<td>Compulsory retirement age</td>
<td>( RE = 64 )</td>
<td></td>
</tr>
<tr>
<td>Starting age for receiving public pension benefit</td>
<td>( ST = 65 )</td>
<td></td>
</tr>
</tbody>
</table>
model and parameters. For example, in our model the narrow government sector and the public pension sector have one integrated budget constraint as shown in Equation (17), although the budget constraints of these different accounts should be given separately. It should be also noted that we do not analyze whether the Japanese government is sustainable.

**III-3-1. Demography**

**Figure 2** presents the transition of Japan’s dependency ratios (“aging rates”), namely, the ratio of the people at 65 and over to total population. This is based on the “medium variant” population data from the National Institute of Population and Social Security Research (2007). Regarding population projections until 2300, we employ the “medium variant” population data in a transitional process. The data projects that the aging rate in Japan will peak around 2070.

For the data on survival probabilities and the transition of the number of people aged 21 years, from 2009 onward we used medium projection life table data from the above data. We assume survival probabilities after 2055 are fixed at 2055 levels because the life table data provides estimates of future survival probabilities only up to 2055. Our model does not distinguish by sex and, therefore, the present study used male–female average values. The number of people aged 21 years and survival rates determine population size and age composition for each year.8 We assume the number of people aged 21 years after 2105

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8 Shimasawa and Oguro (2010) explicitly consider the effect of immigration. They examine the impact of immigration on the Japanese economy using a dynamic computable general equilibrium model with an overlapping-generations structure. Furthermore, Oguro et al. (2011) analyze the relationship between child benefit and fiscal burden using an OLG simulation model with endogenous fertility.
remains fixed at the 2105 level because the data provide estimates of future population only until 2105.

III-3-2. Age profile of labor efficiency

Data for the age profile of earning ability, $e_a$, were obtained from Braun et al. (2005, 2009). The labor efficiency profile is constructed from Japanese data on employment, wages and weekly work hours from 1990 to 2000 (see the data appendix in Braun et al. (2005) for further details).

III-3-3. Taxes and expenditures

The progressive tax system on labor income in the 2009 initial steady state has been fixed until 2300. Tax rates on capital income and inheritance are also fixed at 2009 levels (namely, 48 and 10%, respectively). Tax rates on consumption are endogenously determined to satisfy Equation (17). Total government expenditure, $G_t$, is proportional to national income, $Y_t$. The ratio of general government expenditure to national income, $g$, is held at the 2009 level (i.e., 0.16651). The ratio was assigned so that the endogenous tax rate on consumption in the 2009 initial steady state is 5.00%, which is the actual rate in 2009.

Next, we explain the method of assigning the parameter values that determine tax progressivity on labor income; namely, $\alpha$ and $\beta$. Table 3 lists the data from the Ministry of Finance (2008a). The table presents the effective tax rates of wageworkers on a national income tax and a residence tax for the three income classes, for the case of a couple with two children. The parameter values on labor income were set so that for each income class the calculated tax rate in 2009 for the benchmark simulation approaches the effective tax rate shown in Table 3.

III-3-4. Public pension system

The public pension program is assumed to be a pay-as-you-go system similar to the current

<table>
<thead>
<tr>
<th>Income class</th>
<th>Total amount of annual income (million yen)</th>
<th>Weight on labor endowments</th>
<th>Total amount of annual taxes: national income tax and residence tax (thousand yen)</th>
<th>Effective tax rates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>5</td>
<td>$x' = 0.7143$</td>
<td>195</td>
<td>3.90</td>
</tr>
<tr>
<td>Medium</td>
<td>7</td>
<td>$x = 1$</td>
<td>459</td>
<td>6.56</td>
</tr>
<tr>
<td>High</td>
<td>10</td>
<td>$x^b = 1.4286$</td>
<td>1,130</td>
<td>11.30</td>
</tr>
</tbody>
</table>

Data given are for a couple with two children.

Source: Ministry of Finance (2008a).
Japanese system. The public pension system is two-tiered, and consists of a basic pension (i.e., a flat part) and another part proportional to the average annual labor income for each household (i.e., the second-floor part). In the benchmark simulation, general tax revenue finances half of the flat part, and contributions fund both the remaining half of the flat part and the whole part proportional to labor income.

The ratio of the total basic pension benefit \( F_t \) to national income \( Y_t \) (i.e., \( f \)) is exogenous and constant. The ratio is chosen so that the proportion of total pension benefit \( F_t + P_t \) to national income in 2009 is the value suggested by the data from the Ministry of Health, Labor and Welfare (2008). The amount of the basic pension benefit per representative household, \( m_t \), depends on both national income and the number of people who receive pension benefits for each year. The weight coefficient \( \theta \) on the earnings-related pension is chosen so that the ratio of the earnings-related pension benefit to the basic pension benefit is 0.762 in 2009, which matches estimates using the above data. This value of the coefficient is constant from 2009 onward.

Table 1 presents the contribution rates assigned for each year after 2009 in each simulation case. The benchmark simulation used the scheduled rates from the 2004 pension reform. As explained in Subsection III-2, from 2010 onward, the contribution rate in Cases B, B-L and B-L’ is reduced by 2.765% annually, and in Cases C, C-L and C-L’ the rate is zero.

The age at which households start to receive public pension benefits, \( ST \), is constant from 2009 onward. The compulsory retirement age, \( RE \), is the starting age of public pension benefits, \( ST \), minus one. Thus, after households retire at the end of the year in which they reach the compulsory retirement age, they immediately start to receive pension benefits.

### III-3-5. Government deficits and pension funds

\( \tilde{D}_t \) is net government sector debt, which is gross public debt, \( D_t \), minus the pension fund, \( Q_t \). For the ratio of gross government debt, \( D_t \), to national income, we assigned the parameter value based on data from the Ministry of Finance (2008b). For the ratio of the public pension fund, \( Q_t \), to national income, we set the parameter value using data from the Ministry of Health, Labor and Welfare (2008). Therefore, the ratio of net government debt, \( \tilde{D}_t \), to national income is obtained as a difference between the above two ratios, and from 2009 onward the ratio is constant at the 2009 level.\(^9\) As Figure 8 shows, the future GDP is expected to decrease dramatically, and thus these assumptions imply that the government can successfully reduce the future government deficits as well. In order to make our simulation feasible, we have set this assumption.

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\(^9\) In this paper, the ratio of the net government debt to national income is assumed to be constant throughout the time regardless of a demographic transition, to make the simulation analysis feasible. If we change the assumption of this ratio, the change may substantially affect the welfare level for each generation. For the ratio of the net government debt to GDP, Ihori et al. (2006) assume three scenarios, namely, the benchmark case and two variants (i.e., “high” and “low”).
III-3-6. Differences in earning ability

In our model, the three representative households, namely the low, medium and high income classes, have different earning abilities. The three groups are assumed to have equal population sizes. Here, we explain the method of assigning the weight given to labor endowments across the three income classes. Table 3 shows that each income class 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 each 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 so as to reflect different earning abilities across the three income classes.\(^{10}\)

III-3-7. Share parameter on consumption in utility

We assign the value of the consumption share parameter (\( \phi \)) in the utility function, with reference to Altig et al. (2001). The value is set such that, on average, the medium-income class devotes approximately 50% of the available time endowment (of 16 hours per day) to labor during its working years (ages 21–64 years) in the 2009 initial steady state.

III-3-8. Technological progress

The technological progress of private production is significant because it greatly affects economic growth. Thus, careful attention should be paid to related assumptions. Technological progress is assumed to be zero in our simulation, reflecting Japan’s experience during the past two decades, as in Ihori et al. (2006).

IV. Simulation Results

The benchmark simulation (i.e., Case A) is based on the 2004 public pension reform. We consider two pension reform plans: one is Case B, in which the basic pension is financed by a consumption tax, and the other is Case C, in which the earnings-related pension is eliminated from Case B; namely, in Case C the public pension system consists only of a basic pension financed by a consumption tax.\(^{11}\) The simulation results described below depend on the given parameters. Hence, we must be careful about the effects of parameter changes.

Our simulation analysis yields the following main results:

\(^{10}\) Auerbach and Kotlikoff (1983a) use a lifecycle model with three representative households, similar to our model. Their model assigns weights to labor endowments for low, medium and high income households of 0.5, 1.0 and 1.5, respectively.

\(^{11}\) In this paper, Case C has the same basic pension as in Case B, which is financed entirely by a consumption tax. Meanwhile, to isolate the effect of the conversion from a pay-as-you-go system to a funded system, Okamoto (2013) deals with an additional case in which the earnings-related pension is eliminated with the basic pension in benchmark case (A) retained.
(1) These two reforms do not accomplish Pareto improvements. This result is consistent with the results obtained by the foregoing literature. It has been widely shown in the literature, even in different contexts, that policies affecting intergenerational (and at the same time intragenerational) income distribution do not accomplish Pareto improvements. For instance, Brunner (1996) has shown that, if individuals are sufficiently different, the use of arbitrary lump-sum contributions or of a linear rule in general represents an act of redistribution within a generation and therefore makes at least one individual worse off, and thus that it cannot accomplish Pareto improvements.

(2) Even with the LSRA transfers, there is little room for Pareto improvements. These results show that although the pension reform plan in which the basic pension benefit is entirely financed by a consumption tax is presently receiving considerable attention in Japan, this plan might not attain a Pareto improvement. However, the reform might substantially enhance the utility of future generations, through increasing economic output by inducing capital formation.

IV-1. Findings in Each Simulation Case

Table 4 shows the simulation results on the initial steady state in 2009. Table 5 presents the simulation results for the benchmark case and the four public pension reforms, corresponding to Case A and Cases B, B-L', C and C-L', respectively. Table 5 shows variables of interest for the four transition years (2010, 2020, 2070 and 2300) to illustrate short-run, medium-run and long-run effects. Around 2070 Japan will face its peak aging rate. Several variables are indexed with a value of 1.000 in the benchmark simulation (i.e., Case A) for each transition year.

Table 4 Endogenous variables in the 2009 initial steady state

<table>
<thead>
<tr>
<th>Parameter description</th>
<th>Parameter values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax rate on labor income, $\tau^*{w_{x</td>
<td>x}(1-l_0^t)e^t}$</td>
</tr>
<tr>
<td>Tax rate on consumption, $\tau^*$</td>
<td>0.05</td>
</tr>
<tr>
<td>Interest rate, $r$</td>
<td>0.0400</td>
</tr>
<tr>
<td>Wage rate, $w$</td>
<td>1.2174</td>
</tr>
<tr>
<td>Capital stock, $K$</td>
<td>3.3923</td>
</tr>
<tr>
<td>Labor supply, $L$</td>
<td>0.5693</td>
</tr>
<tr>
<td>National income, $Y$</td>
<td>1.0863</td>
</tr>
<tr>
<td>Capital-income ratio, $K/Y$</td>
<td>3.1228</td>
</tr>
<tr>
<td>Weight coefficient on earnings-related pension, $\theta$</td>
<td>0.08267</td>
</tr>
</tbody>
</table>

* The tax rate is progressive, and an average rate is presented.
IV-1-1. Case A: Benchmark simulation

In Case A, the public pension schedule is based on the 2004 pension reform. From 2009 onward, general taxes finance half of the total basic pension benefit. Meanwhile, the contribution rates gradually increase until 2017. From 2017 onward, the contribution rate remains fixed at the 2017 level (i.e., 18.3%). The balance of the whole government sector account is adjusted by a consumption tax in our model.

Figure 3 presents the transition of the aging rates defined in our study; namely, the ratio of the population aged 65–100 years to that aged 21–100 years. The aging rates gradually increase, peak around 2070 and thereafter gradually decrease. Figure 4 shows the transition of the total population defined in our analysis; that is, the population aged 21–100 years.

Table 5 Simulation results for public pension reform cases

<table>
<thead>
<tr>
<th>Case</th>
<th>2010</th>
<th>2020</th>
<th>2070</th>
<th>2300</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>B</td>
<td>1.004</td>
<td>1.010</td>
<td>1.016</td>
<td>1.016</td>
</tr>
<tr>
<td>B-L’</td>
<td>1.004</td>
<td>1.012</td>
<td>1.011</td>
<td>1.010</td>
</tr>
<tr>
<td>C</td>
<td>1.024</td>
<td>1.076</td>
<td>1.165</td>
<td>1.183</td>
</tr>
<tr>
<td>C-L’</td>
<td>1.020</td>
<td>1.118</td>
<td>1.114</td>
<td>1.122</td>
</tr>
</tbody>
</table>

* Indexed with a value of 1.000 for each transition year in Case A.
Case A: Benchmark simulation. Case B: Basic pension financed by consumption tax, with earnings-related pension retained. Case B-L’: Case B with LSRA transfers. Case C: Basic pension only, funded by consumption tax. Case C-L’: Case C with LSRA transfers.
total population continues to gradually decrease from 2009 onward, and ultimately reaches merely half of its peak level.¹² These drastic changes significantly influence the macroeconomic variables discussed below.

Figures 5 and 6 illustrate the transitions of interest rates and wage rates, respectively. The interest rates in Case A decrease from 2009, bottom out (2.4%) around 2070, and then gradually increase. Meanwhile, the wage rates in Case A increase from 2009, peak around 2070, and then gradually decrease. The main reason for this phenomenon is that when the aging rates are high the aggregate labor supply becomes scarce relative to the capital stock,

Figure 3 Transition of aging rates in the model

Figure 4 Transition of total population in the model

In this paper, total fertility rates are assumed to be lower than the population replacement rates in Japan (2.07 in 2010). Therefore, the total population continues to decrease from 2009 onward. However, the total population in the model is ultimately not below approximately half of its peak level because we assume a final steady state.
Figure 5 Transition of interest rates in Cases A, B and C

Figure 6 Transition of wage rates in Cases A, B and C

* Indexed with a value of 1.000 in 2009.

Figure 7 Transition of tax rates on consumption in Cases A, B and C
which generates low interest rates and high wage rates.

**Figure 7** presents the transition of the tax rates on consumption that clear the consolidated government budget. The tax rates on consumption first decrease until 2017 (from 5% in 2009 to 2.4% in 2017), and then gradually increase. The first decrease depends mainly on the increases in contribution rates because in our model the narrow government sector and the public pension sector have one integrated budget constraint (see Table 1 and Equation (17)). The rates on consumption peak around 2070 (6.7% in 2070), and thereafter gradually decrease. Ultimately, the tax rate settles at 2.2%. The peak tax rate corresponds to the peak aging rate around 2070. This result suggests that Japan will face its heaviest tax burden around 2070 when the aging rate peaks.

**Figures 8, 9 and 10** illustrate the transitions of national income, capital stock and aggregate labor supply, respectively. In Case A, from 2010 onward these macroeconomic

---

**Figure 8** Transition of national income in Cases A, B and C

![Graph showing national income transition](image)

* Indexed with a value of 1.000 in 2009.

**Figure 9** Transition of capital stock in Cases A, B and C

![Graph showing capital stock transition](image)

* Indexed with a value of 1.000 in 2009.
variables gradually decrease, eventually reaching approximately half of their peak values. This drastic change reflects the transition of the total population, which is shown in Figure 4.

IV-1-2. Case B: Basic pension financed by consumption tax

In Case B, the basic pension benefit is entirely financed by a consumption tax. The switch from Case A to B thus means the substitution of a consumption tax for pension contributions (i.e., a tax on labor income) for half of the total basic pension benefit. From 2010 onward the contribution rate in Case B is reduced by 2.765% annually, compared with that in Case A, as shown in Table 1. The reduction rate of 2.765% is equivalent to half of the total basic pension benefit in the 2009 initial steady state. The substitution from contributions to a consumption tax stimulates capital accumulation. Table 5 suggests that the conversion from Case A to B promotes capital accumulation. In the switch from Case A to B, the capital stock increases by 1.6% in 2020 and 3.6% in 2300. Simultaneously, the aggregate labor supply slightly increases by 0.6% in 2020 and 0.5% in 2300. Consequently, national income increases by 1.0% in 2020 and 1.6% in 2070 and 2300.

Figure 11 presents the welfare changes represented by Equation (14) for each generation in the switch from Case A to B. The switch improves the welfare of generations born from 1975 onward. Ultimately, the welfare of each future generation improves by 0.87%. However, the switch worsens the welfare of the generations born from 1910 to 1974 off. In particular, the switch reduces the welfare of the generations born around 1950 by 0.77%. A possible reason for this phenomenon is that the tax rate on consumption is higher in Case B than in Case A. Figure 7 shows that from 2010 the tax rate is approximately 3% higher each year in Case B compared with Case A.

The transition from contributions (i.e., a tax on labor income) to a consumption tax creates intergenerational income transfers. At the onset of this policy reform, elderly...
individuals who have paid their pension contributions (or a labor income tax) face an additional consumption tax. Because these generations suffer a double burden, the transition to a consumption tax is not Pareto improving. Although the shift to a consumption tax might ultimately improve the welfare of many generations (especially future generations), measures need to be suggested to avoid the problem of some generations facing a double burden during the transition. One of the solutions to the problem may be to consider the income transfer from the future generations that are made better off to the current generations that suffer a double burden, by introducing the LSRA.

**Figure 12** illustrates the changes in the utility for each income class in the conversion from Case A to B. The figure shows that, for the generations born after roughly 1975, the utility-enhancing positive effects from earnings-related benefits exceed the negative effects from consumption-tax financing. The figure also suggests that the magnitude of changes in
the utility differs across the three income classes. The pension reform in Case B makes the high income class relatively better off, while for the low income class the magnitude of the utility improvement is smaller. A possible reason for this result is that an increase in wage rates benefits the high income class more than the low income class, because of the higher earning ability of the former. The switch from Case A to B increases the wage rate by 0.4% in 2020, 1.0% in 2070 and 1.1% in 2300, as shown in Table 5.

**IV-1-3. Cases B-L and B-L’: Introduction of LSRA transfers**

It is certain that the pension reform in Case B enhances the welfare of future generations. However, the reform makes the generations born from 1910 to 1974 worse off. Especially, it makes the generations born around the 1950s much worse off at the onset of the reform. In Cases B-L and B-L’, LSRA transfers are introduced. Table 5 shows that, in the switch from Case B to B-L’, national income increases in 2020 but decreases in 2070 and 2300. This reflects that the LSRA transfers resources from future generations to current generations, to compensate for the deterioration in the utility of the generations suffering from a double burden.

In Case B-L the transfers are performed within each income class, which creates the three welfare gains or losses. On the other hand, in Case B-L’ they are implemented among all income classes, which generates a uniform welfare gain or loss. Table 6 presents welfare gains or losses for each future household in the cases with the LSRA. Case B-L makes the low and medium income classes worse off but the high income class better off, with regard to the welfare for each future household. The efficiency losses for the low and medium income classes are ¥143,000 and ¥118,000, respectively, while the efficiency gain for the high income class is ¥6,000. The public pension reform in Case B-L is not a Pareto-improving one, because Pareto criterion requires that no individual of any generation is made worse off.

<table>
<thead>
<tr>
<th>Income class</th>
<th>Case B-L</th>
<th>Case B-L’</th>
<th>Case C-L</th>
<th>Case C-L’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>-0.01431</td>
<td>-0.00784</td>
<td>-0.09706</td>
<td>-0.11681</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.01178</td>
<td>-0.00784</td>
<td>-0.13175</td>
<td>-0.11681</td>
</tr>
<tr>
<td>High</td>
<td>0.00059</td>
<td>-0.00784</td>
<td>-0.18725</td>
<td>-0.11681</td>
</tr>
<tr>
<td>(average)</td>
<td>-0.00850</td>
<td></td>
<td>-0.13869</td>
<td></td>
</tr>
</tbody>
</table>

Unity in our model corresponds to approximately 10 million yen.

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13 In 2008, the GDP of Japan was 496.6 trillion yen and the labor force aged 20 to 64 years was 59.8 million, according to the Ministry of Internal Affairs and Communications (2009). We calculated the income per worker using these data and also derived the value for national GDP in 2009 in our model, yielding a conversion rate between actual amounts of yen and values in the model. Consequently, in 2009 unity in the model corresponds to approximately 10 million yen (1 = 9.999 million yen).
Case B-L’ makes each future household worse off and the efficiency loss is ¥78,000. It should be noted that in Case B-L the average welfare loss for the three income classes is ¥85,000. This result indicates that economic welfare is more enhanced when a uniform welfare gain or loss is calculated across all the income classes (i.e., in Case B-L’).

**IV-1-4. Case C: Earnings-related pension eliminated**

In Case C, the earnings-related pension is abolished from Case B at the end of 2009. In Case C, from 2010 onward, the public pension system consists only of a basic pension financed by a consumption tax, and the contribution rates become zero. Our analysis considers transition relief by which the generations that paid contributions before 2010 receive the earnings-related pension benefit until they die. The earnings-related pension benefit received is proportional to the number of years for which individuals paid contributions. The value of the weight coefficient, $\theta$, on the earnings-related pension is the same as in Case A.

**Figure 9** illustrates that the pension reform in Case C strongly stimulates capital accumulation and, thus, substantially increases national income, as shown in **Figure 8. Table 5** shows that, in the switch from Case A to C, the capital stock substantially increases by 12.8% in 2020 and 38.6% in 2070. Regarding the earnings-related pension, the pension reform in Case C means the conversion from a pay-as-you-go system to a funded system, which promotes household savings. In the conversion from Case A to C, aggregate labor supply also increases by 4.7% in 2020 and 5.5% in 2070. Consequently, national income increases by 7.6% in 2020, 16.5% in 2070 and 18.3% in 2300. Therefore, the simulation results predict substantial long-run increases in economic output when the public pension system consists only of a basic pension financed by a consumption tax.

**Figure 11** shows the welfare changes for each generation in switching from Case A to C. The switch improves the welfare of generations born from 1993 onward, and for these generations the utility-enhancing positive effects from earnings-related benefits exceed the negative effects from consumption-tax financing. Welfare in Case C ultimately improves by 6.15%, a magnitude that exceeds that in Case B (0.87%). However, the pension reform in Case C reduces the welfare of the generations born from 1910 to 1992 and, therefore, negatively affects many more generations than Case B. In particular, the Case C scenario severely damages the welfare of the generations born around 1955, with a magnitude of 5.67%. One possible reason for this phenomenon is that the tax rate on consumption is much higher in Case C than in Case B. **Table 5** indicates that the tax rates in 2010 are 7.4% in Case B and 21.6% in Case C. **Figure 7** also illustrates that the rate in Case C increases to an extremely high 21.6% in 2010, before gradually decreasing to eventually settle at 19.2%.

We explain the reason why the tax rate on consumption in Case C increases sharply. This occurs mainly because the contribution rates in Case C are zero and, as represented by Equation (17), in our model, the deficit in revenue is financed by a consumption tax; for the left side of the equation, the total benefit of the part proportional to labor income ($P_l$) becomes zero after the reform (strictly speaking, after the end of transition relief). Both the
government expenditure ($G_t$) and the total amount of basic pension benefit ($F_t$) significantly increase because they are assumed to be proportional to national income ($Y_t$). For the right side of the equation, the total contribution to the pension program ($R_t$) is zero after the reform. Therefore, to balance the equation, the total tax revenue ($T_t$) increases, resulting in a substantial increase in the endogenous tax rate on consumption.

**Figure 13** illustrates the changes in utility for each income class in switching from Case A to C, and shows that the magnitude of changes in utility differs across the three income classes. In Case C, ultimately, the improvement in utility is greater for the low income class and smaller for the high income class. Interestingly, this study observes an opposite result between Cases B and C: in Case B, the improvement in utility is greater for the high income class and smaller for the low income class. A possible reason for the result in Case B is that an increase in wage rates benefits the high income class more than the low income class, because of the higher earning ability of the former.

Meanwhile, a possible reason for the result in Case C is as follows. The basic pension benefit per representative household ($m_t$) substantially increases in Case C. Ultimately, the basic pension benefit in Case C is a considerable 18.3% larger than that in Case A, while that in Case B is only 1.6% larger. Because of our assumption of a constant ratio of the total basic pension benefit to national income, a large increase in national income in Case C substantially increases the basic pension benefit per representative household, resulting in a strong income redistribution effect through basic pension benefits.¹⁴ This strong income redistribution effect in Case C helps greatly improve the welfare of the low income class.

¹⁴ To minimize future revisions of benefits and contributions, the 2004 pension reform incorporated the automatic adjustment of benefit levels, the so-called “macroeconomic indexation,” into the pension system, which enables the pension program to adapt flexibly to social and economic changes, particularly demographic changes. Our assumption of a constant ratio of the total basic pension benefit to national income roughly reflects this automatic adjustment of benefit levels.
IV-1-5. Cases C-L and C-L’: Introduction of LSRA transfers

Certainly, the pension reform in Case C substantially enhances the welfare of future generations. However, the reform makes the generations born from 1910 to 1992 worse off. Especially, it makes the generations born around the 1950s awfully worse off at the onset of the reform. In Cases C-L and C-L’, LSRA transfers are introduced. Table 5 shows that, in the conversion from Case C to C-L’, national income increases in 2020 but decreases in 2070 and 2300. This reflects that the LSRA transfers resources from future generations to current generations, to compensate for the deterioration in the utility of the generations suffering from a double burden.

In Case C-L the transfers are performed within each income class, while in Case C-L’ they are implemented among all income classes. Table 6 presents the welfare gains or losses for each future household in the cases with the LSRA. The leveled welfare gains for each future household are all negative for both Cases C-L and C-L’, and thus these public pension reforms do not attain a Pareto improvement. In Case C-L, the efficiency losses for the low, medium and high income classes are ¥971,000, ¥1,318,000 and ¥1,873,000, respectively. The average welfare loss of the three income classes in Case C-L is ¥1,387,000, while in Case C-L’ the efficiency loss for each future household is ¥1,168,000. This result indicates that economic welfare is more enhanced when a uniform welfare gain or loss is calculated across all the income classes (i.e., in Case C-L’), which is qualitatively the same result as in Cases B-L and B-L’.

IV-2. Social Welfare Function

The simulation results show that both of public pension reform plans presented in this paper, namely, the case in which the overall basic pension benefit is financed by a consumption tax (i.e., Case B) and the case in which additionally the earnings-related pension is abolished (i.e., Case C), do not attain a Pareto improvement. In these reform cases, an increase in the tax rate on consumption makes current generations, especially the generations born around the 1950s, worse off, while future generations are made better off. When the potential efficiency gains or losses from the pension reforms are evaluated in the discounted present value at the point of 2009, the losses of current generations exceed the gains of future generations.

At first glance of Figure 11 which presents the welfare changes for each generation in switching from Case A to Cases B and C, the total welfare gain of future generations may seem to exceed the total welfare loss of the current generations that suffer an additional tax burden on consumption. Here, it should be noted that this figure shows the welfare changes for each household. As shown in Figure 4, the total population is expected to decrease dramatically and in the long run amounts to approximately half of the present level. The population weight of future generations is substantially lower than that of current generations, and thus even the pension reform with LSRA transfers cannot achieve a Pareto improvement.
Two possible explanations for this result are considered. One explanation is our assumption concerning the formation of household expectations in terms of the future. For the generations that were alive in the 2009 initial steady state and survive in 2010, these generations are assumed to realize in 2010 that their expectations regarding the future are wrong, and, thus, in 2010 they once again maximize their remaining lifetime utility under the hypothesis of perfect foresight. Therefore, an unexpected and substantial increase in tax rates on consumption, which is induced by alternative pension reforms, is likely to make the generations that suffer an additional tax burden on consumption severely worse off. Restated, in 2010, these generations are assumed to face completely unexpected shocks as a result of sudden drastic reforms in Cases B and C. This extreme assumption may severely reduce the utility of these generations, and, therefore, the benchmark scenario (i.e., Case A) may be superior to other pension reform cases in terms of overall economic welfare.

The other explanation is that this result might suggest that the public pension reform conducted in 2004 was fairly good, and, therefore, that more drastic reforms, such as the pension reform with the introduction of a progressive expenditure tax, would be required to attain Pareto-improving pension reforms.\textsuperscript{15}

The two public pension reform plans (dealt with in Cases B and C), which are currently receiving much attention in Japan, do not achieve a Pareto improvement. This implies that these plans are not justified unless the welfare of future generations is weighted more heavily than that of the generations that suffer an additional tax burden on consumption. Therefore, we examined the effect of different weights between the welfare of current generations and that of future generations on the social welfare level across alternative pension reform plans, considering the social welfare function with an intergenerational discount factor, $\phi$, which is represented by Equation (13). Table 7 shows the relation between the values of the intergenerational discount factor and the social welfare level across Cases A, B and C.

The table suggests that as the value of the discount factor is little, that is, as the welfare of current generations is more weighted than that of future generations, Case A has a higher

<table>
<thead>
<tr>
<th>Intergenerational discount factor</th>
<th>Social welfare level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi = \cdots, 0.980, 0.981$</td>
<td>Case A &gt; Case B &gt; Case C</td>
</tr>
<tr>
<td>$\phi = 0.982, 0.983, \cdots, 0.986$</td>
<td>Case B &gt; Case A &gt; Case C</td>
</tr>
<tr>
<td>$\phi = 0.987$</td>
<td>Case B &gt; Case C &gt; Case A</td>
</tr>
<tr>
<td>$\phi = 0.988, 0.989, \cdots$</td>
<td>Case C &gt; Case B &gt; Case A</td>
</tr>
</tbody>
</table>

\textsuperscript{15} Seidman (1997) and Okamoto (2004, 2005a) advocate the introduction of a progressive expenditure (or consumption) tax.
level of social welfare but Case C has a lower level of social welfare. On the contrary, as the value is large, namely, as the welfare of future generations is more weighted, Case C has a higher level of social welfare but Case A has a lower level of social welfare. This is because, as illustrated in Figure 11, the conversion from Case A to C improves the welfare of future generations but worsens that of current generations.

V. Conclusions

This paper analyzed the effects of public pension reforms mainly on intergenerational and intragenerational income distribution, keeping in mind the rapidly aging population in Japan. To establish guidelines for public pension reforms in an aging Japan, the paper examined the effects of demographic change and public pension policies on economic welfare using a dynamic lifecycle general equilibrium simulation model. In particular, the incorporation of heterogeneity of earning ability into the model enabled us to explicitly consider both efficiency and equity issues.

The model dealt with the benchmark case based on the 2004 pension reform and the two reform cases: the case with the basic pension benefit financed by a consumption tax (this means the substitution of a consumption tax for a labor income tax) and the case without any earnings-related pension (this signifies the conversion from a pay-as-you-go system to a funded system). To distinguish potential efficiency gains or losses from these pension reforms, the paper introduced a hypothetical government institution (i.e., the LSRA). The simulation analysis yielded four main results:

1. The simulation results show that the substitution from contributions (i.e., a tax on labor income) to a consumption tax stimulates capital accumulation, and that, for the earnings-related pension, the conversion from a pay-as-you-go system to a funded system also promotes capital formation. Therefore, the results predict substantial long-run increases in economic output when the public pension system consists only of a basic pension financed by a consumption tax.

2. Both reform cases (with the basic pension benefit financed by a consumption tax and with only a basic pension financed by a consumption tax) improve the welfare of future generations but worsen the welfare of the current generations that suffer an additional tax burden on consumption. The simulation results show that even with the LSRA transfers, there is little room for Pareto improvements for these pension reforms. This suggests that although these pension reform plans are presently hotly debated in Japan, they are not justified unless the welfare of future generations are weighted more heavily than that of current generations.

3. Using the social welfare function with an intergenerational discount factor, the paper investigated the effect of different weights between the welfare of current generations and that of future generations on the social welfare level across the alternative pension reform plans. Consequently, if the welfare of current generations is more weighted than that of future generations, the current pension system scheduled by the 2004...
reform provides a higher level of social welfare, while if the welfare of future generations is more weighted, the pension reform plan with only a basic pension financed by a consumption tax generates a higher level of social welfare.

(4) The pension reform with the basic pension benefit financed by a consumption tax benefits the high income class relative to the low income class. On the contrary, the reform with only a basic pension financed by a consumption tax relatively benefits the low income class. The result of the former reform mainly depends on the fact that an increase in wage rates benefits the high income class more than the low income class, because of the higher earning ability of the high income class. The result of the latter reform mainly depends on the income redistribution effect through the basic pension under a constant ratio of the total basic pension benefit to national income.

Appendix A: Utility Maximization Problem

The utility maximization problem over time for each income class in Section 2 is regarded as the maximization of $U^{t,j}$ in Equation (2) subject to Equations (3) and (9). Let the Lagrange function be

$$L^{t,j} = U^{t,j} + \sum_{s=1}^{100} \lambda_x^{t,j} \left[ - A^{t,j}_s + \{1 + r_{t,s} (1 - \tau^{p})\} A^{t,j}_s + \{1 - \tau^{w} \{w_{t,s} x^{t}_s e_s (1 - l^{t,j}_s)\} - \tau^{p}_s\} w_{t,s} x^{t}_s e_s (1 - l^{t,j}_s) \right]$$

$$+ b^{t,j}_s \left( l^{t,j}_s \right)^{RE} + a^{t,j}_s - (1 + \tau^{p}_s) C^{t,j}_s \right] + \sum_{s=1}^{RE} \eta^{t,j}_s (1 - l^{t,j}_s), \quad (A1)$$

where $\lambda_x^{t,j}$ and $\eta^{t,j}_s$ represent the Lagrange multiplier for Equations (3) and (9), respectively.

The first-order conditions on consumption $C^{t,j}_s$, leisure $l^{t,j}_s$ and assets $A^{t,j}_s$ for $s = 21, 22, \cdots, 100$ can be expressed by

$$p^{t,j}_s (1 + \delta)^{-(s-1)} (C^{t,j}_s)^{\phi} \left( l^{t,j}_s \right)^{1-\phi} \frac{1}{\tau} \phi(C^{t,j}_s)^{\phi-1} \left( l^{t,j}_s \right)^{1-\phi} = \lambda_x^{t,j} (1 + \tau^{c}_s), \quad (A2)$$

$$p^{t,j}_s (1 + \delta)^{-(s-1)} \left( C^{t,j}_s \right)^{\phi} \left( l^{t,j}_s \right)^{1-\phi} \frac{1}{\tau} (1 - \phi)(C^{t,j}_s)^{\phi} \left( l^{t,j}_s \right)^{-\phi} = \lambda_x^{t,j} \left[ (1 - \alpha - \tau^{p}_s) w_{t,s} x^{t}_s e_s - \beta(w_{t,s} x^{t}_s e_s)^{2} (1 - l^{t,j}_s) \right] + \sum_{k=S}^{100} \lambda_x^{t,j} \frac{\theta}{RE} \frac{w_{t,s} x^{t}_s e_s}{RE - 20} + \eta^{t,j}_s \quad (s \leq RE), \quad (A3)$$

$$\lambda_x^{t,j} = \left\{ 1 + r_{t,s} (1 - \tau^{p}) \right\} A^{t,j}_s, \quad (A4)$$

$$\eta^{t,j}_s (1 - l^{t,j}_s) = 0 \quad (s \leq RE), \quad (A5)$$

$$1 - l^{t,j}_s = 0 \quad (s > RE), \quad (A6)$$

$$\eta^{t,j}_s \geq 0. \quad (A7)$$
The combination of Equations (A2) and (A4) produces Equations (10) and (11). If the initial value, \( V_{s}^{i,j} \), is specified, the value of each age, \( V_{s}^{i,j} \), can be derived from Equation (10). If \( V_{s}^{i,j} \) is specified, the values of consumption, \( C_{s}^{i,j} \), and leisure, \( l_{s}^{i,j} \), at each age are obtained in the method that follows.

For \( s = 21, 22, \ldots, RE \), the combination of Equations (A2) and (A3) yields the following expression:

\[
C_{s}^{i,j} = \frac{\phi \left( (1 - \alpha - \tau_{i,s}) w_{i,s} x_{s} e_{s} \right)}{(1 - \phi)(1 + \tau_{i})} \left[ 1 + \sum_{k=1}^{100} \frac{\theta_{i,s}^{k} w_{i,s} x_{s} e_{s}}{k} \right] \left[ \beta \left( 1 - l_{s}^{i,j} \right) w_{i,s} x_{s} e_{s} \right] + \frac{\eta_{i,s}^{j}}{k} \left. \frac{\theta_{i,s}^{n} w_{i,s} x_{s} e_{s}}{k} \right. \left. \beta \left( 1 - l_{s}^{i,j} \right) w_{i,s} x_{s} e_{s} \right] \]

(A8)

If the value of \( l_{s}^{i,j} \) is given under \( \eta_{i,s}^{j} = 0 \), the value of \( C_{s}^{i,j} \) can be obtained using a numerical method, and then the value of \( V_{s}^{i,j} \) can be derived from Equation (11). The value of \( l_{s}^{i,j} \) is chosen so that the value of \( V_{s}^{i,j} \) obtained in the simulation is the closest to that calculated by evolution from \( V_{s}^{i,j} \) through Equation (10). If the value of \( l_{s}^{i,j} \) chosen is unity or higher, the value of \( C_{s}^{i,j} \) is obtained from Equation (11) under \( l_{s}^{i,j} = 1 \). If it is less than unity, the value of \( C_{s}^{i,j} \) is derived from Equation (A8).

For \( s = RE + 1, RE + 2, \ldots, 100 \), the condition of \( l_{s}^{i,j} = 1 \) leads to the following equation:

\[
V_{s}^{i,j} = \frac{\phi (C_{s}^{i,j})^{\phi - 1}}{1 + \tau_{i}}.

(11')

The value of \( C_{s}^{i,j} \) is chosen to satisfy this equation.

References


Data

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