# Effects of Direct Underwriting of Public Bonds by the Central Bank in Japan

**Motonori Yoshida**
Associate Professor
Graduate School of Economics
Osaka Prefecture University
1-1 Gakuen-cho, Naka-ku, Sakai-city
Osaka, 599-8531
Japan

## Abstract

*This study uses a dynamic computable general equilibrium OLG (overlapping generations) model to elucidate the effects of direct underwriting of public bonds (DUPB) by the central bank, which has the potential to support the Japanese economy and government finance and to improve the efficiency of added-value distribution. The results demonstrate that the Japanese economy and government finance become sustainable through DUPB by the central bank but, on the other hand, collapse when public bonds are absorbed by the market. This is due to the fact that in the former case, payment of the central bank's seignior age to the national treasury improves the government's finance situation.*

**Keywords:** Fiscal sustainability, Direct underwriting of public bonds, Central bank, Seignior age, Dynamic computable general equilibrium, overlapping generation's model.

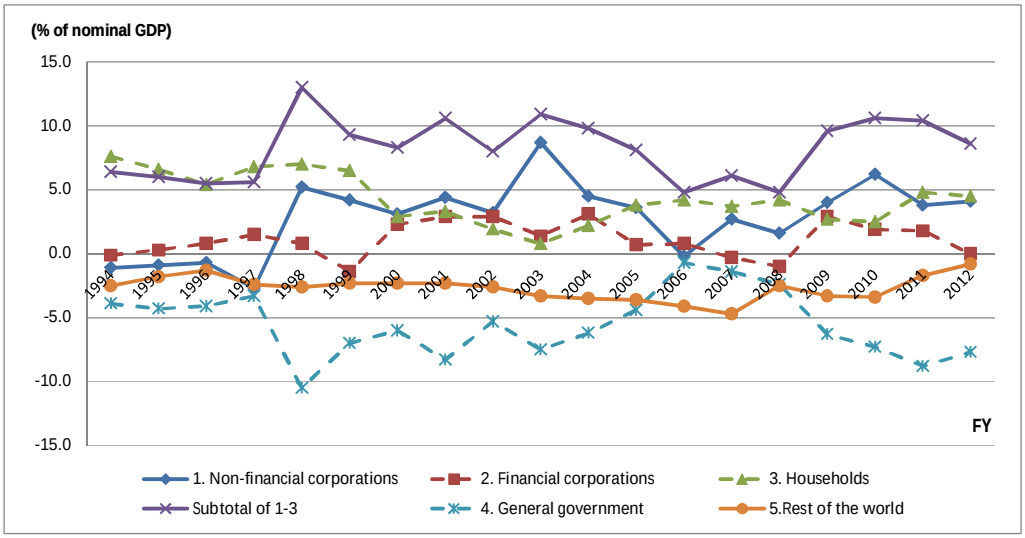
## *1. Introduction*

Currently, many experts are questioning the sustainability of the Japanese economy and government finance. In fact, the ratio of fiscal balance of the general government[1] to GDP and that of the general government's outstanding debt to GDP were approximately -9.8% and 218.8%, respectively, in 2012. Moreover, both figures were the worst among the G7 countries.[2] Accordingly, in order to examine this issue in detail, I show the transitions in the balance of net lending (+)/net borrowing (-) in Figure 1, which explains the following points: 1) Among the various sectors in Japan, the public sector's balance of flow continues to be in extremely poor condition. 2) However, in the Japanese economy as a whole, the buoyant financial situation of the private sector sufficiently compensates for the poor performance of the public sector. 3) In particular, as a result of 2), Japan's external asset balance is the highest in the world as of 2012 (concretely, Japan has the largest amount of net balance at 3,423,625 million U.S. dollars, which is approximately 1.83 times that held by China, having the second largest amount).[3]Hence, taking all these points into consideration, we can perceive the fact that Japan is poorly distributing its own added value under its global top-class economic power.

Furthermore, the following key points must be considered:[4] 1) The monetary-easing policy implemented continuously by the Bank of Japan (BOJ) since 1998 has kept rapidly increasing the outstanding Japanese government bonds (JGBs) among the BOJ's assets; the amount of outstanding JGBs held by the BOJ soared from 64,266 to 198,337 billion yen during FY2008-13 (the ratio of JGB to BOJ's total assets grew from 0.519 to 0.821).[5] 2) Most of the BOJ's receipt of interest on JGBs (the BOJ's seignior age) is paid to the national treasury,[6] and this amount increased from 255 to 579 billion yen during FY2008–13. 3) At the same time, expenditure on public bonds accounts for an extremely high proportion of the central government's annual expenditure (this proportion is 0.240 in FY 2013). On the basis of the above observations, Japan needs to consider the implementation of direct underwriting of public bonds[7] (DUPB) by the BOJ, although this policy may initially seem reckless.[8] Such a policy seems necessary because it has the potential to support the Japanese economy and government finance and to improve the efficiency of added-value distribution in Japan as a whole, via the channel of the BOJ's-seignior age payment to the national treasury.

Many prior studies have demonstrated negative simulation results in relation to the sustainability of Japanese government finance, including Ihori et al. (2001), Doi et al. (2011), Hoshi and Ito (2014), Ihori et al. (2006), and Shimazawa and Oguro (2010). Moreover, such studies have indicated the need for Japan to raise the ratio of government revenue by taxes and pension contributions (referred to as "GRTPC") to GDP to roughly 50% or to drastically cut public annual expenditure in order to maintain government finance. However, to the author's knowledge, no research has used a dynamic computable general equilibrium OLG (overlapping generations) model (DCGE-OLG model) to examine the effects of DUPB by the BOJ. Therefore, I have decided to attempt this approach. The rest of the paper is organized as follows. In Section 2, related literature and the aim of this study are explained. Section 3 describes the model used in this study. Section 4 provides an explanation of the parameters and data used in the study. Section 5 presents the simulation results. Finally, Section 6 concludes the paper.

**Figure 1: Net Lending (+) / Net Borrowing (-) by institutional sectors of Japan**




Note: Households include private unincorporated enterprises and private non-profit institutions serving households.

Source: By the author, using data from the National Accounts (Cabinet Office).

## *2. Related Literature and Aim of Study*

This study is related to the following research fields: 1) fiscal sustainability analysis in the context of population aging, 2) monetization of government debt, and 3) analysis using the DCGE-OLG model. Accordingly, Section 2.1 provides an overview of the related literature in these areas. Next, Section 2.2 states the position and aim of this study.

### 2.1 Related literature

#### 2.1.1 Government fiscal sustainability

First, Hamilton and Flavin (1986) indicated that if the discounted present value of indefinitely rolled-over outstanding government debt converges to zero, such fiscal management is sustainable. Furthermore, they demonstrated that the U.S. government implemented sustainable fiscal management during the period of 1960–84 by empirical analysis based on their theory. In addition, Fukuda and Teruyama (1994) used Hamilton and Flavin (1986)'s method to analyze the sustainability of Japanese government finance between 1888 and 1992, and they rejected the fiscal sustainability during the prewar and wartime periods. Next, Bohn (1998) presented a method for examining the sustainability of government finance by regressing the ratio of outstanding public debt (OPD) to GDP on the ratio of primary balance to GDP. His empirical analysis demonstrated that if the ratio of OPD to GDP rose, the U.S. government would improve the primary balance to a surplus during the period of 1956–98. Furthermore, Ihori et al. (2001) utilized Bohn (1998)'s method to examine the sustainability of Japanese central-government (general account) finance and rejected any such sustainability during the period of 1956–98. Then, Broda and Weinstein (2005) demonstrated a ratio of GRTPC to GDP that could ensure the sustainability of Japanese government finance.

Here, they used a simulation analysis based on the government's intertemporal budget constraint and the given socioeconomic variables (simulation period of 2000–2100). They indicated that the required ratio of GRTPC to GDP remains at the level of typical EU nations (i.e., the Japanese economy and government finance will not collapse if Japan's tax rate is raised from the current relatively low level, in comparison to the average of developed nations, to a reasonable level). Furthermore, Doi et al. (2011) considered additional real-world constraints, such as social-security payment obligations, and updated Broda and Weinstein (2005)'s analysis. Consequently, they argued the need for a higher ratio of GRTPC to GDP compared with Broda and Weinstein (2005). Next, Hoshi and Ito (2014) simulated the dynamics of Japan's OPD and private financial assets by assigning various socioeconomic variables exogenously to the transition equations of OPD and private financial assets. Accordingly, they demonstrated that OPD will exceed private financial assets in 2024 and also that it is necessary to raise the ratio of GRTPC to GDP to 43–50% in order to attain fiscal sustainability. Finally, Kato (2002), Ihori et al. (2006), and Shimazawa and Oguro (2010) used a DCGE-OLG model to analyze various issues related to the sustainability of Japanese government finance. These works argued the need for drastically raising taxes and cutting annual expenditures to achieve fiscal sustainability. For example, Ihori et al. (2006) demonstrated that the ratios of tax burden and social-security burden to GDP will rise significantly to 35.93% (2002 actual value = 15.62%) and to 23.27% (2002 actual value = 9.69%), respectively, by 2050.

### 2.1.2 Monetization of government debt

First, Sargent (1999) explained the basic concept of monetization of government debt as follows. Although government annual expenditure (including payment of interest on public bonds) should be covered first by tax revenue and then by revenue from public bonds, the residual that these two forms of revenue cannot cover has to be met by revenue gained by increasing the money supply (namely "seignior rage"); in other words, in this case, the central bank is inevitably forced to monetize government debt. Next, Detken (1999) used an OLG model to explain how intergenerational wealth redistribution changes in the case where the government relies on seignior rage revenue, via the monetization of government debt by the central bank, and demonstrated the occurrence of wealth redistribution from the current generation to future generations. Finally, Broda and Weinstein (2005) also inspected the impact of monetization of Japanese government debt on the sustainability of government finance. They measured the effect of the BOJ monetizing 50% of the initial OPD during the first five years of the simulation period and showed that the monetization of government debt is not particularly effective in terms of enabling sustainable finance. [9]

### 2.1.3 DCGE-OLG model

The DCGE-OLG model,[10] which was developed by Auerbach and Kotlikoff (1983, 1987), has been used in various prior works, especially in the context of population aging because it has the following advantages, differing from simulation analysis which only assigns various socioeconomic variables exogenously. 1) This model is able to closely observe and examine reactions of the respective economic agents to changes in exogenous variables such as fiscal policy, repeated effects of endogenous variables on the government sector, mutual influences between economic agents and changes in society as a whole, the transition process of society, and welfare and financial burdens of each generation. Furthermore, 2) being a numerical simulation model, it is possible to construct a model that conforms to actual social structure in accordance with the analysis objective.

## 2.2 Position and aim of this study

As reviewed so far, existing studies, in the context of the sustainability of the Japanese economy and government finance, have analyzed only the effects of raising various national-burden ratios, lowering public expenditures, and partial monetization of government debt. Accordingly, I aim to analyze the effects of DUPB by the BOJ as another policy to maintain the current level of government expenditure and the public pension system and to prevent the collapse of the Japanese economy and government finance. The detailed reasons for examining this policy are as follows. 1) In spite of the existence of the market-absorption principal of JGBs stipulated by Article 5 of the Public Finance Act, in practice, the BOJ has continued to purchase JGBs from the market for intense monetary easing (Section 1). 2) The BOJ pays the majority of its seigniorage,[11] namely the difference between interest revenue on interest-bearing financial assets (of which JGBs account for the vast majority) and the cost of administrating issued currency (liabilities, i.e., BOJ banknotes) to the national treasury, based on Article 53 of the Bank of Japan Act (Section 1).[12] 3) As shown in points 1) and 2), DUPB by the BOJ has both positive and negative effects on Japan's economic mechanism.

Thus, quantitative measurement of these effects in both directions is extremely meaningful in evaluating the effectiveness of this policy for the sustainability of the Japanese economy and government finance and for Japanese citizens' welfare over generations. In addition, I chose a DCGE-OLG model to quantitatively measure the above effects because of its advantages as explained above.

## *3. Model*

This section describes the study's model, i.e., a DCGE-OLG model with six main parts: 1) households, 2) firms, 3) government, 4) public pension, 5) central bank, and 6) market equilibrium. In addition, each respective market is in perfect competition; this model adopts the closed economy model based on the study aim; and the model does not explicitly handle the issue of bequests for simplification.

### 3.1 Households

Respective households exist in each generation and are considered as follows. 1) Their preferences are the same throughout all generations. 2) They originate at age 21 (1st period), retire at age 64 (44th period), and decease at age 105 (85th period);[13] each household in elastically supplies one unit of labor during the 1st–44th periods. 3) They possess perfect foresight and form rational expectations in a forward-looking manner. 4) Their utility function with constant relative risk aversion is additive and separable over time.

Consequently, their life-cycle utility function is specified as follows:

$$U^i = \sum_{j=1}^{d} \left(\frac{1}{1+\rho}\right)^{j-1} \frac{1}{1-\frac{1}{\gamma}} u_{ij}^{\,1-\frac{1}{\gamma}} = \sum_{j=1}^{d} \left(\frac{1}{1+\rho}\right)^{j-1} \frac{1}{1-\frac{1}{\gamma}} c_{ij}^{\,1-\frac{1}{\gamma}} \quad , \tag{1}$$

where $i$ and $j$ denote the generation and the life period, i.e., age ($20 + j$ years old at the $j$th period). Furthermore, $u_{ij}$and $c_{ij}$represent the utility and the consumption of the $j$th period of generation $i$, respectively. ρ represents the rate of time preference,γ the intertemporal elasticity of substitution, and $d$ the assumed final period of each household (here, $d = 85$). Next, the budget constraint equation of generation $i$ in year $t$ is as follows:

$$\begin{aligned}&(1 - RD2_{t+1})a_{ij+1}\\ &= [1 + (1-\tau r_t)r_t(1 - RD2_t)]a_{ij-1} + (1 - rp_{it})(1-\tau w_t)w_t e_j - (1+\tau c_t)c_{ij}\\ &\quad +(1-\tau p_t)p_{ij},\end{aligned} \tag{2}$$

where $a_{ij}$ represents the assets at the end of the $j$th period,$e_j$ the wage profile in the $j$th period,$p_{ij}$the pension benefit,[14]$rp_{it}$ the public pension contribution rate in the $j$th period,$r_t$ the interest rate, $w_t$ the wage rate, $\tau r_t$ the interest income tax rate,$\tau w_t$ the labor income tax rate, $\tau c_t$ the consumption-based tax rate,$\tau p_t$ the pension income tax rate in year $t$, and $RD2_t$ the ratio of OPD held by the central bank (i.e., BOJ) to outstanding national assets (ONA, $RD2_t = 0$ in the scenario of not implementing DUPB by the BOJ).[15]In addition, the relationship between year, generation, and age is as follows: $t = i + j - 1$. Moreover, $e_j$ specified as a function of age and $p_{ij}$ are as follows:

$$e_j = \phi_0 + \phi_1(20 + j) + \phi_2(20 + j)^2 \quad , \tag{3}$$

$$p_{ij} = pf_{ij} + pr_{ij} = pf_{ij} + \theta_t PVAW_{ij} \quad , \tag{4}$$

where $pf_{ij}$ represents the fixed amount portion,$pr_{ij}$ the remuneration-based portion in the $j$th period,$PVAW_{ij}$ the average annual labor income of working period converted into the value at the pension-receipt time using the interest rate, and $\theta_t$ the rate used to calculate the remuneration-based portion in year $t$. Furthermore, the in tertemporal budget constraint of generation $i$ from Equation (2) is obtained as follows. In the equations below, $DF_{ij}$ is a discount factor for converting the value of generation $i$ in the $j$th period into the value at the time of the 1st life period:

$$\sum_{j=1}^{d}(1+\tau c_t)c_{ij}DF_{ij} = \sum_{j=1}^{d}(1 - rp_{it})(1-\tau w_t)w_t e_j DF_{ij} + \sum_{j=1}^{d}(1-\tau p_t)p_{ij}DF_{ij} \quad , \tag{5}$$

$$DF_{ij} = \begin{cases} \dfrac{1}{\prod_{m=2}^{j}[1 + (1 - \tau r_{i+m-1})r_{i+m-1}(1 - RD2_{i+m-1})]} & \text{if } j \geq 2 \\ 1 & \text{if } j = 1 \end{cases}, \quad (6)$$

Maximizing Equation (1) subject to Equation (5),households obtain the following Eular equation on consumption per period:

$$c_{ij} = \left[\frac{1+(1-\tau r_t)r_t(1-RD2_t)}{1+\rho}\right]^{\gamma} \left(\frac{1+\tau c_{t-1}}{1+\tau c_t}\right)^{\gamma} c_{ij-1} \ . \quad (7)$$

**3.2 Firms**

A representative firm exists in the private sector. Its productive structure is expressed by the Cobb-Douglas production function with constant return to scale, and its structure and the transition of physical capital stock (PCS) are as follows.

$$Y_t = AK_t^{\alpha}L_t^{1-\alpha} = AK_t^{\alpha}[(1 + \lambda)^t L_t]^{1-\alpha}, \quad (8)$$

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

where $Y_t$ represents output, $K_t$ the PCS, $L_t$ effective labor (labor measured by efficient-labor units),$I_t$ the gross private investment in year $t$, $A$ the scale parameter, $\alpha$ the capital share in production, $\lambda$ the rate of Harrod-neutral technological progress, and $\delta$ the depreciation rate of physical capital. In addition, the products are used both as consumer and investment goods; $K_t$ and $L_t$ are supplied by households. Moreover, profit maximization behavior generates the following production-factor demand equations, where $k_t$ represents the PCS per efficient-labor unit:

$$r_t = \alpha A\left[\frac{K_t}{(1+\lambda)^t L_t}\right]^{-(1-\alpha)} - \delta = \alpha A {k_t}^{-(1-\alpha)} - \delta \ , \quad (10)$$

$$w_t = (1 - \alpha)A(1 + \lambda)^t\left[\frac{K_t}{(1+\lambda)^t L_t}\right]^{\alpha} = (1 - \alpha)A(1 + \lambda)^t {k_t}^{\alpha} \ . \quad (11)$$

**3.3 Government**

The central government, local governments, and social security funds excluding the pension are specified as the government. Accordingly, the factors of the government are set in turn. First, total tax revenue and total annual revenue in year $t$ are expressed as follows.

$$T_t = \sum_{j=1}^{d} GEN_{tj}\left[\tau w_t w_t e_j + \tau r_t r_t(1 - RD2_t) + \tau c_t c_{ij} + \tau p_t p_{ij}\right] \ , \quad (12)$$

$$TR_t = T_t + r_t DEBT2_{t-1}. \quad (13)$$

In these equations, $T_t$ represents the total tax revenue, $TR_t$ the total annual revenue in year $t$ , $GEN_{tj}$ generation $i's$ population in the $j$th period, and $DEBT2_{t-1}$the OPD held by the BOJ in year $t - 1$. In addition, $r_t DEBT2_{t-1}$in Equation (13) is the payment of the BOJ's seigniorage: however, this is zero in the scenario of not implementing DUPB by the BOJ. Next, total annual expenditure in year $t$ is expressed as follows:

$$G_t = NG_t + PFTR_t = \left[\sum_{j=1}^{44} GEN_{tj} g_{base}^{noold} + \sum_{j=45}^{d} GEN_{tj} g_{base}^{old}\right] + sr_t \sum_{j=45}^{d} GEN_{tj} pf_{ij} \ , \quad (14)$$

where $G_t$ represents the total annual expenditure,$PFTR_t$ the fiscal transfer to the public pension, $NG_t$the total annual expenditure except $PFTR_t$, $sr_t$ the national subsidy rate on the fixed payment portion of public pensions in year $t$,$g_{base}^{old}$the annual expenditure per person over age 65 in the base year (referred to as "EAE"), and $g_{base}^{noold}$ the annual expenditure per person over age 21 excluding EAE in the base year(referred to as "GAE").

In addition, $g_{base}^{noold}$ and $g_{base}^{old}$ are fixed at the base year value. From the above, the government's budget constraint equation, the public bonds issued, the fiscal balance, and the primary balance are expressed as follows.

$$TDEBT_t = (1 + r_t)TDEBT_{t-1} + (G_t - TR_t) \quad , \tag{15}$$

$$BOND_t = r_t TDEBT_{t-1} + (G_t - TR_t) \quad , \tag{16}$$

$$FB_t = TR_t - G_t - r_t TDEBT_{t-1} \quad , \tag{17}$$

$$PB_t = TR_t - G_t \quad . \tag{18}$$

In these equations, $TDEBT_t$ represents the total OPD at the end of year $t$, $BOND_t$ the public bonds issued in year $t$, $FB_t$ the fiscal balance, and $PB_t$ the primary balance.

### 3.4 Public pension

Since the pension system is managed via a modified funding method, its budget constraint equation is expressed as follows.

$$\begin{aligned}(1 - RD2_{t+1})PFUND_t &= (1 + r_t)(1 - RD2_t)PFUND_{t-1} + \sum_{j=1}^{44} GEN_{tj}\tau p_{it} w_t e_j \\ &+ sr_t \sum_{j=45}^{d} GEN_{tj} pf_{ij} - \sum_{j=45}^{d} GEN_{tj} p_{ij} \quad .\end{aligned} \tag{19}$$

In this equation, $PFUND_t$ represents the assets held by the pension sector at the end of year $t$, the first term on the right-hand side the interest revenue on the assets, the second term the public pension contribution revenue, the third term the government transfer, and the fourth term the pension payment in year $t$.

### 3.5 Central bank

In order to describe two scenarios of implementing or not implementing DUPB by the BOJ, I formulate the ratio of OPD held by each agent to ONA:

$$TDEBT_t = DEBT1_t + DEBT2_t \quad , \tag{20}$$

$$RD_t \equiv \frac{TDEBT_t}{TA_t} \quad , \tag{21}$$

$$RD1_t \equiv \frac{DEBT1_t}{TA_t} \quad , \tag{22}$$

$$RD2_t \equiv \frac{DEBT2_t}{TA_t} \quad . \tag{23}$$

In these equations, $DEBT1_t$ represents the OPD held by households at the end of year $t$, $DEBT2_t$ the OPD held by the BOJ, and $TA_t$ the ONA. Furthermore, for simplification, instead of explicitly handling the money supply, the effect of DUPB by the BOJ is considered via the situation where the amount directly underwritten by the BOJ does not become household assets [Equation (20)].

### 3.6 Aggregation and market equilibrium

Total consumption in year $t$, $C_t$, total assets held by households at the end of year $t$, $PA_t$, and the total effective labor supply in year $t$, $L_t^s$, are expressed as follows.

$$C_t = \sum_{j=1}^{d} GEN_{tj} c_{ij} \quad , \tag{24}$$

$$PA_t = \sum_{j=1}^{d} GEN_{tj} a_{ij} (1 - RD2_t) \quad , \tag{25}$$

$$L_t^S = \sum_{j=1}^{d} GEN_{tj} e_j \quad . \tag{26}$$

Finally, the following market-equilibrium conditions on the effective labor market, the capital market,[16] and the goods market must hold in order to close the model structure:

$$L_t^S = L_t \ , \tag{27}$$

$$PA_t + PFUND_t = K_t + TDEBT_t = K_t + (DEBT1_t + DEBT2_t) \ , \tag{28}$$

$$Y_t = C_t + I_t + NG_t \ . \tag{29}$$

## *4. Parameters (estimation and calibration) and Data*

Tables 1–3 show the parameter values, how to set the values, and the exogenous-data sources used in this study. For additional details on these issues, see Section 4 and Appendix in Yoshida (2015),except the parts on data of total national assets, total assets held by households, and total PCS at initial time. Furthermore, the following points should be taken under consideration. 1) Since this study considers the government's fiscal system, the year units are essentially fiscal years.[17] 2) The money amount data were deflated by the GDP deflator (2005 = 100) from the National Accounts (NA, Cabinet Office). 3) The respective generations aged 22 or older at the simulation base year (FY2012) are referred to as "transition generations."

**Table 1: Parameter values**

| Parameter | | Value | Parameter | | Value |
|---|---|---|---|---|---|
| Utility function [see Equation (1)] | | | Tax policy parameters [see Equation (2)] | | |
| Time preference rate | ρ | -0.001 | Labor income tax rate (%) | $\tau w$ | 11.5 |
| Intertemporal elasticity of substitution | γ | 2.00 | Interest income tax rate (%) | $\tau r$ | 15.4 |
| Wage profile function [see Equation (3)] | | | Consumption-based tax rate (%) | $\tau c$ | 9.6 - 13.1 |
| Constant term | $\varphi_0$ | 5.436 | Pension income tax rate (%) | $\tau p$ | 11.5 |
| Coefficient of first-degree term | $\varphi_1$ | 0.099 | Pension policy parameters | | |
| Coefficient of second-degree term | $\varphi_2$ | -0.001 | [see Equations (2), (4), and (14)] | | |
| Production function [see Equations (8) and (9)] | | | Public contribution rate (%) | $rp$ | 16.6 - 18.3 |
| Scale parameter | $A$ | 0.765 | Rate to annual average labor income : for remuneration-based pension | θ | 0.233 - 0.313 |
| Technology progress rate | λ | 0.013 | | | |
| Capital share in production | α | 0.300 | National treasury subsidy rate for basic pension benefits | $sr$ | 0.500 |
| Depreciation rate of physical capital | δ | 0.056 | | | |

## Table 2: Setting Parameter values

| Parameter | Value/Year | Method | Data Sources and Notes |
|---|---|---|---|
| Parameters of utility function | | Cited | Prior studies (see Table A1 for details) |
| Parameters of wage profile function | | Estimated | Using Mincer (1974)'s model |
| Capital share in production | 2012 | Calculated | "National Accounts" (NA, Cabinet Office) |
| Depreciation rate of physical capital | Mean of 2000-12 | Calculated | "Gross Capital Stock of Private Enteprises" (Cabinet Office) |
| Scale parameter | 2012 | Calibrated | Parameters in the model, total physical capital stock (see Table 3), total effective labor (see Table 3), Gross National Income (GNI) from NA |
| Technology progress rate | | Estimated | Using Solow residuals [see Solow (1957)] and following Kameda and Masuda (2001) and Miyazawa (2008) |
| Labor income tax rate = Pension income tax rate | FY2012 | Calculated | NA |
| Interest income tax rate | | | |
| Consumption-based tax rate (1) | Mean of FY2010-12 | Calculated | "Ministry of Finance Statistics monthly" (Ministry of Finance) and NA |
| Public pension contribution rate on the labor income | | Cited and Calculated | Default values of Japan's Employee's Pension Insurance and values planned to be raised |
| Rate used to calculate remuneration-based pension benefits from average annual labor income (2) | | Calculated | Default values of Japan's Emplyee's Pension Insurance |
| National-treasury-subsidy rate for basic pension benefits | From FY2009 | Cited | Value under implemented system |

Notes: (1)Values were set to be consistent with the government's plan to revise the consumption tax rate.
(2) Rate for the generations born in and before 1944 was set to be the same as that of the generation born in 1945.

## Table 3: Exogenous-data sources

| No. | Data | Data/Year | Method | Sources |
|---|---|---|---|---|
| 1 | Population: combined total of men and women of each age group in for ages 21-105 | | | "Population Projections for Japan"(PPJ, National Institution of Population and Social Security Research, 2012) |
| 2 | Public pension assets | At end of FY2011 | Calculated | Outstanding financial assets and liabilities from NA |
| 3 | OPD | | | |
| 4 | OPD related to construction and to deficit-finance | At end of FY2011 | Calculated | Outstanding financial assets and liabilities from NA, data from "Debt Management Report 2014"(Ministry of Finance) and "White Paper on Local Public Finance, 2014"(Ministry of Internal Affairs and Communications) |
| 5 | Total national assets (except tangible non-produced assets) | At end of FY2011 | Calculated | Closing stocks of assets and liabilities for the nation from NA, data of items 2-4 |
| 6 | Total assets held by households | | | |
| 7 | Total PCS (for private sector) | | | |
| 8 | Effective labor | | Calculated | Population of each age group from PPJ, the wage profile function |
| 9 | PCS per efficient-labor unit | At end of FY2011 | Calculated | Data of items 7-8 |
| 10 | Assets held by transition generations | At end of FY2011 | Calculated | Savings and liabilities per household (for each age category) from "Annual Report on the Family Income and Expenditure Survey" (Ministry of Internal Affairs and Communications), data of items 1 and 6 |
| 11 | Fixed payment portion in pension benefits | | Cited and Calculated | Default values of National Pension (Basic Pension) and values planned to be lowered. |
| 12 | Average annual labor income for transition generations | | Calculated | See below |
| | Labor income in and prior to FY2011 is calculated from the standard labor income in FY2012 in accordance with the number of years worked until FY2011; the standard labor income is cited from the "Overview of the Employee's Pension Insurance and National Pension Service" (Ministry of Health, Labour and Welfare).<br><br>Labor income in and after FY2012 is endogenously determined within the simulation. | | | |
| 13 | GAE, EAE | FY2012 | Calculated | Data from NA and data of item 1 |

Notes: Regarding population data: 1) the data of medium-fertility and medium-mortality case were used, 2) the population of each age group in and after 2111 was assumed to be the same as the 2110 values

## *5. Simulation*

This section explains the simulation scenarios, the sensitivity analysis, and the analysis results.

### 5.1 Scenarios

I prepared the following two scenarios to examine the effects of DUPB by the central bank (BOJ).[18]

**Scenario 1** (referred to as "UWCB scenario")
In this scenario, DUPB is implemented by the BOJ from FY2013 onward.

**Scenario 2** (referred to as "NOTUWCB scenario")
In this scenario, DUPB is not implemented by the BOJ. Public bonds are absorbed by the market even after FY2013, as has been the case until now.

In addition, the following points should be noted. First, fiscal years were used, with the starting (base) year as FY2012. Second, transition generations are handled as follows: 1) their actual asset values at the end of FY2011 are given; 2) their contributions to the remuneration-based portion of the public pension prior to FY2011 were set to have been paid under the same income amount as the standard labor income of FY2012; and 3) their behaviors from FY2012 were endogenously decided. Third, outstanding amounts of national assets, public pension assets, and public debt (total on both central and local government debt) at the end of FY2011 were given.

Fourth, in order to focus our attention on the effects of DUPB by the BOJ, I did not incorporate factors other than the predetermined increase of the consumption tax rate and revisions of the public-pension contribution rates and benefits. Fifth, this study's main objective is not to observe the steady state but the transition process of the Japanese economy and government finance, in order to examine the possibility of their sustainability. Accordingly, a simulation was set to be terminated if the calculation led to the following two situations: 1) their sustainability has become no longer secured; 2) all public debt has been cleared. Sixth, this study used the PPJ data without any processing to prevent information loss regarding population. As a result, households leaving the model before the assumed death age are considered to consume their outstanding net assets at the time of leaving.

### 5.2 Sensitivity analysis

In order to confirm the robustness of this research, I also simulated the cases in which the parameter value of the time-preference rate of the life-cycle utility function was changed because a shift in this rate effectively influences the intertemporal consumption and saving patterns of representative households. Table 4 shows the details of the sensitivity analysis.

**Table 4: Sensitivity analysis cases and sustainability**

| Case | Time preference rate | Intertemporal elasticity of substitution | Economy and public finance sustainability | |
|---|---|---|---|---|
| | $\rho$ | $\gamma$ | UWCB | NOTUWCB |
| A1 | 0.021 | 2.000 | No | No |
| A2 | 0.010 | 2.000 | No | No |
| Base | -0.001 | 2.000 | Yes | No |
| A3 | -0.002 | 2.000 | Yes | No |

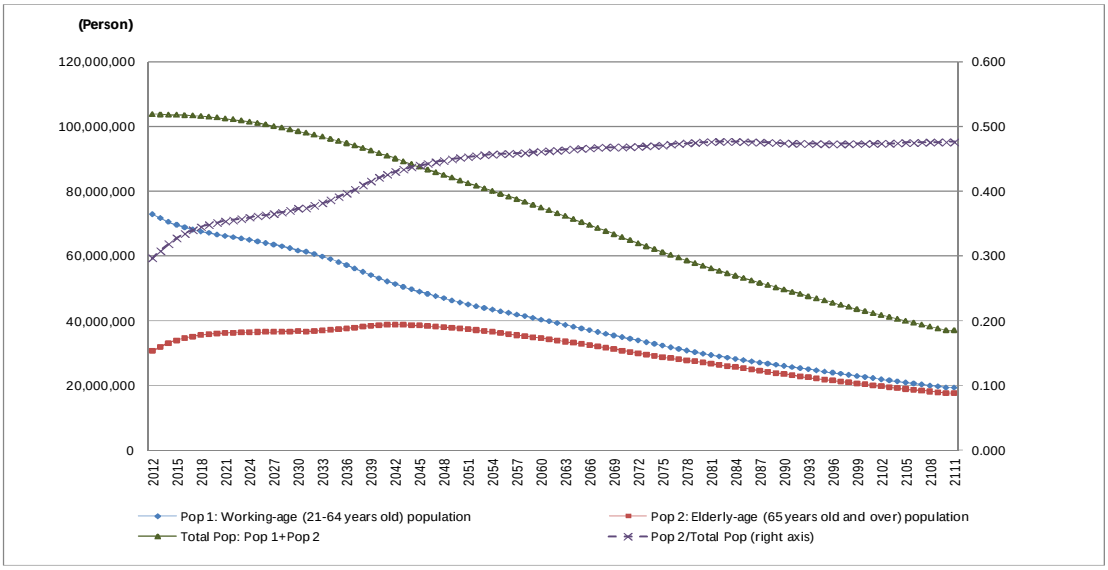
Note: Yes and No indicate "sustainable" and "not sustainable", respectively

### 5.3 Results of simulation and sensitivity analysis

#### 5.3.1 Future population structure

Figure 2's graph depicts the future population structure of Japan: 1) Japan's total adult population (aged 21 and over) will decline from the current level of over 100 million persons to fewer than 40 million persons; 2) the aging ratio, i.e., the ratio of the elderly population (aged 65 and over) to the total adult population, will rise from the current level of approximately 0.300 to a little under 0.500 after approximately 100 years (a society where each worker supports one elderly person will arise); and 3) the aging speed will be relatively fast until around the mid-2040s and then become relatively slow.

**Figure 2: Future population structure of Japan**




### 5.3.2 Sustainability

Figure 3 shows changes in the OPD ratio to GNI for the respective cases (see also Table 4). This figure illustrates the following facts: 1) The Japanese economy and government finance are sustainable in only the UWCB scenario of the Base and A3 cases. 2) Under the higher time-preference rate, even the UWCB scenario cannot bring sustainability, and a rise in this rate rapidly threatens economic collapse. In other words, it is necessary for sustainability that households assign, to a certain extent, large weight to their future financial condition, and to that of future generations.

### 5.3.3 Changes in main economic variables

Changes in GNI, total PCS, GNI per capita, and PCS per efficient-labor unit are shown in Figures 4–7. These figures show the following facts. 1) GNI basically continues to grow until the mid-2030s (the era prior to society reaching the highest aging level) and subsequently continues to decline after then (see also Figure 2); GNI rapidly falls after the advent of an economic-failure tendency. 2) In the sustainable cases, GNI starts to grow again from around FY2110. 3) GNI per capita and PCS per efficient-labor unit continuously rise in the sustainable cases. 4) The A3 case attains higher values of GNI than the Base case. The results of items 1)–3) are thought to be generated by the population's aging, the population structure fixed at the level of FY2110 after FY2111, and the Harrod-neutral technical progress. In addition, we can consider the result of item 4) to be produced by a process in which a downward shift of the time-preference rate prompts a decline in consumption closer to the present; subsequently, the decline prompts PCS accumulation, and finally this cycle increases production.

**Figure 3: Ratio of OPD (outstanding public debt) to GNI**

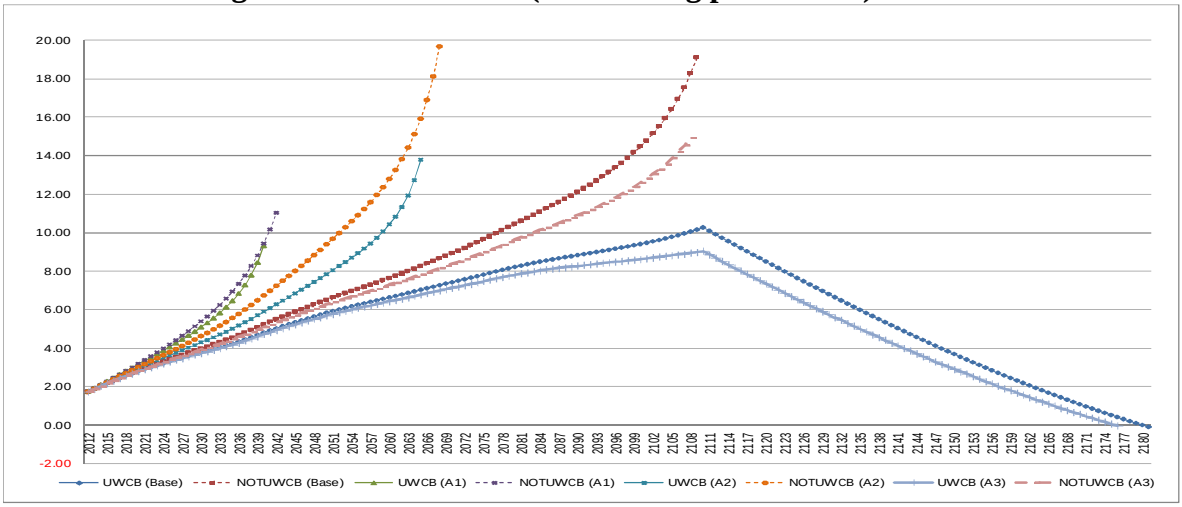


**Figure 4: GNI**

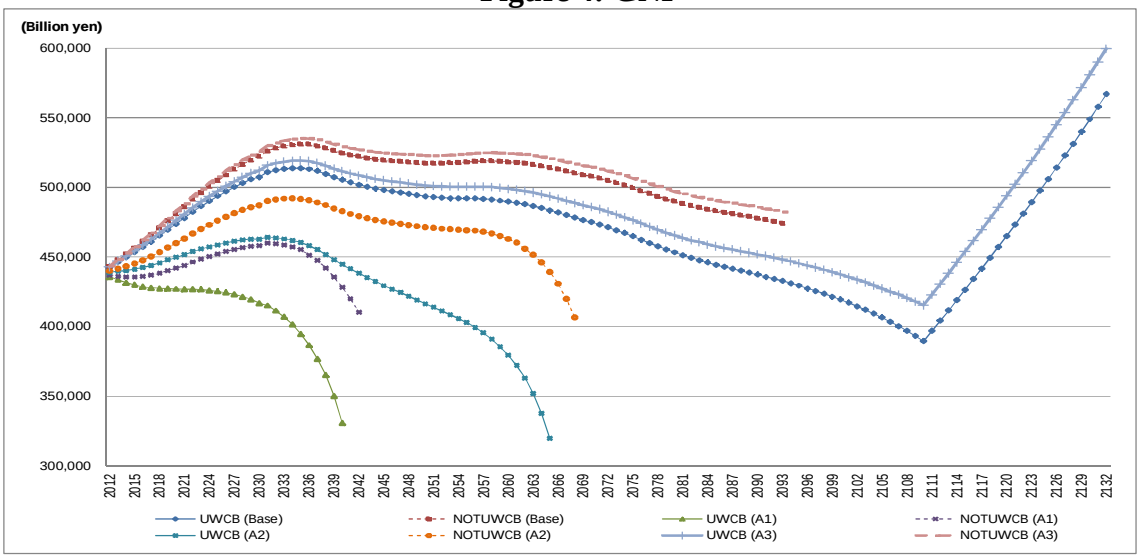



**Figure 5: Total PCS (physical capital stock)**

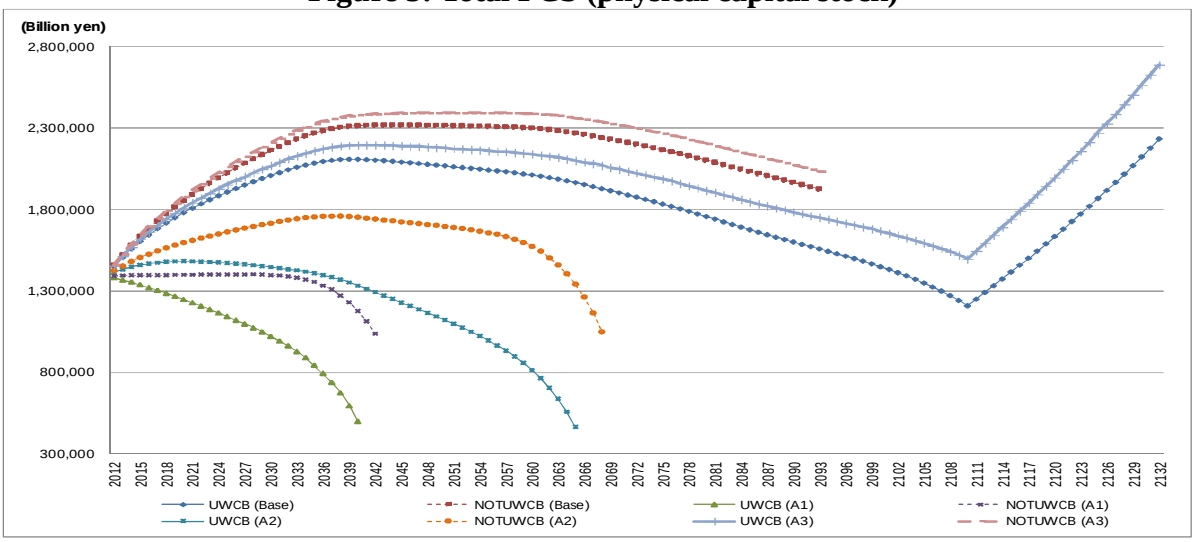



**Figure 6: GNI (per capita)**

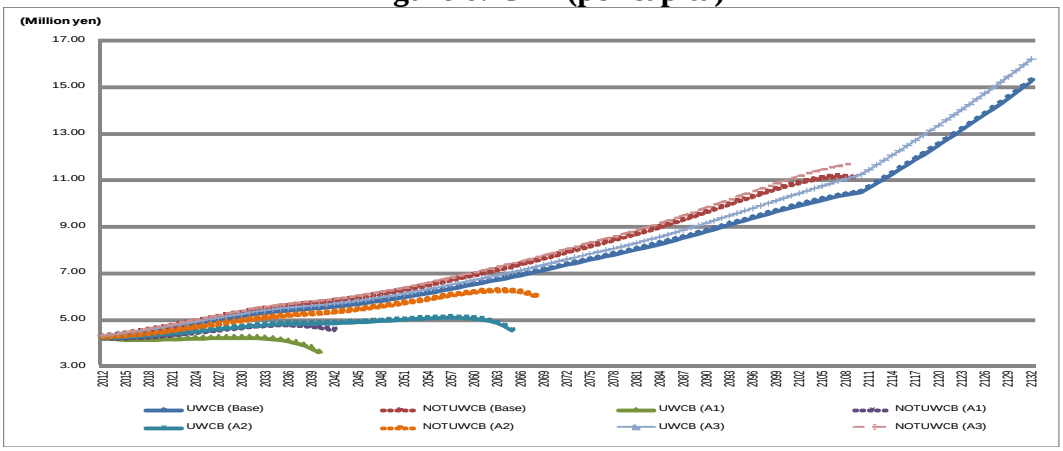
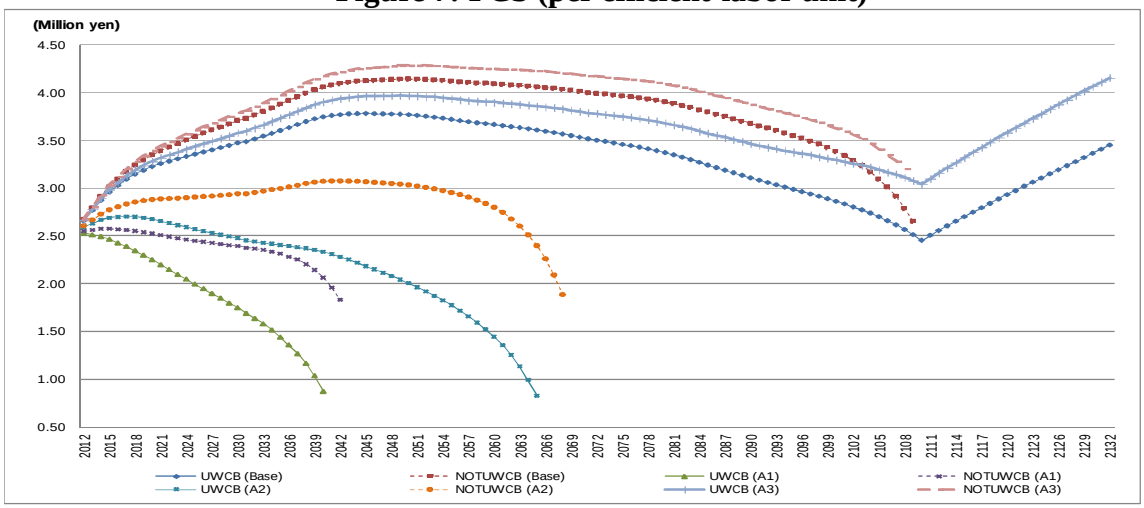


**Figure 7: PCS (per efficient-labor unit)**




### 5.3.4 Base case

In the following, I explain the simulation results in detail, focusing on the Base case. First, the actual values and the calculated values of the UWCB scenario on key variables in FY2012 are shown in Table 5. This table says that the calculated value of PCS per efficient-labor unit exceeds the actual value, especially in the Base case.

We can assume that this result is caused by intensive physical-capital accumulation that depends on households with perfect foresight behaving more rationally than in the real-world case. In addition, the comparison of real and calculated values indicates that the A1 case's setting more closely fits the real situation than does the Base case's setting. Next, Figure 8 shows the changes in OPD, and Table 6 shows the changes in the ratios of OPD to ONA and PCS per efficient-labor unit. Figure 8 indicates the divergence of OPD in the NOTUWCB scenario. On the other hand, Figure 8 and Table 6 show that OPD will reach zero in the 2180s in the UWCB scenario; that is, the government's continuous fiscal surplus will first pay off the public debt held by the BOJ in the 2170s and then also pay off the initial public debt in the 2180s.

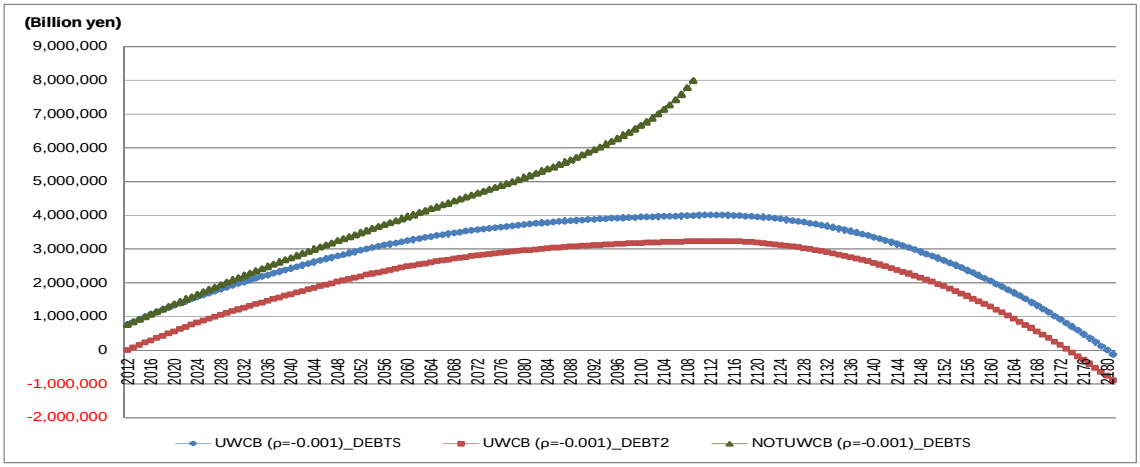
Then, in order to confirm the above facts in detail, I show in Figure 9 the changes in the primary balance (of the government budget) that does not include interest payment on outstanding public bonds and in the final balance that does include such payment (each balance is defined as the ratio to GNI). This figure explains the following facts. 1) Although the NOTUWCB scenario achieves a primary balance surplus, it cannot prevent the final fiscal-deficit divergence in the final balance due to the significant burden of interest payment caused by the cumulative increase in OPD (see also Figure 8). 2) On the other hand, the UWCB scenario first achieves the primary surplus in the 2060s and subsequently the final surplus in the 2110s. We can assume that this UWCB scenario's results are generated by the following process: DUPB by the BOJ creates the central bank's seignior rage, then the BOJ pays it to the national treasury, and this payment finally improves the government's finance situation.

**Table 5: Economic and public finance variables in FY2012**

| Variables | Actual values | Calculated values of UWCB | |
|---|---|---|---|
| | | (A1 case) | (Base case) |
| PCS (million yen) per efficient-labor unit | 2.503 | 2.527 | 2.658 |
| GNI (billion yen) | 439,904 | 435,811 | 442,460 |
| Savings rate to GNI | 0.231 | 0.238 | 0.411 |
| Ratio of primary balance to GNI | -0.075 | -0.097 | -0.114 |
| Ratio of Government debt to TA | 0.336 | 0.356 | 0.346 |

Note: TA indicates "Total assets (except tangible non-produced assets) held by Japanese people."

**Figure 8: OPD (outstanding public debt, Base Case)**




**Note:** DEBTS and DEBT2 indicate "Total OPD " and "OPD held by the BOJ," respectively.

**Table 6 Public debt ratio and PCS (per efficient-labor unit)**

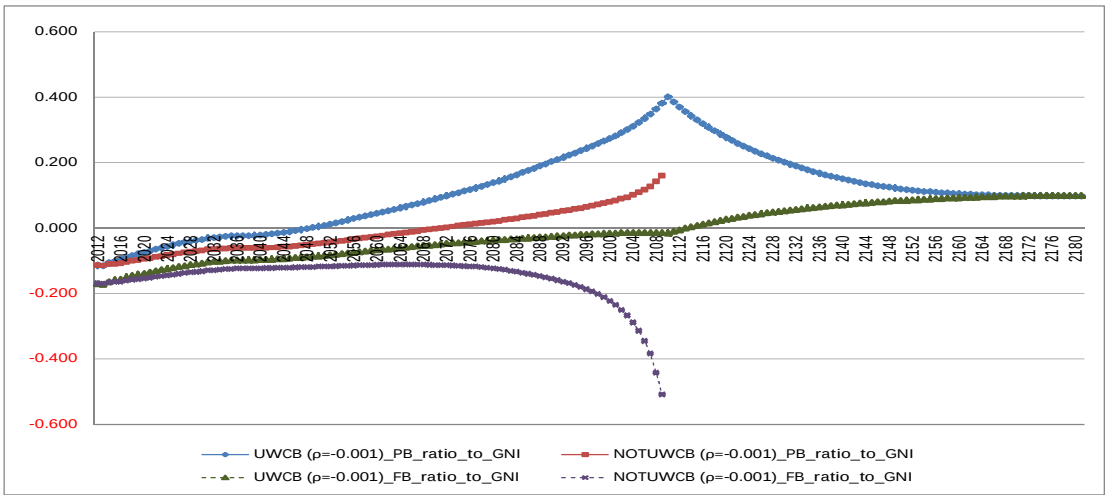
| FY | UWCB | | | | NOTUWCB | |
|---|---|---|---|---|---|---|
| | k | DEBT1 ratio | DEBT2 ratio | DEBTS ratio | k | DEBTS ratio |
| | (Million yen) | (to TA) | (to TA) | (to TA) | (Million yen) | (to TA) |
| 2011 | 2.503 | 0.333 | | 0.547 | 2.503 | 0.333 |
| 2012 | 2.658 | 0.346 | 0.000 | 0.346 | 2.670 | 0.345 |
| 2020 | 3.225 | 0.247 | 0.181 | 0.428 | 3.347 | 0.424 |
| 2030 | 3.473 | 0.195 | 0.294 | 0.489 | 3.707 | 0.490 |
| 2040 | 3.744 | 0.169 | 0.366 | 0.535 | 4.055 | 0.542 |
| 2050 | 3.768 | 0.155 | 0.427 | 0.582 | 4.141 | 0.592 |
| 2060 | 3.665 | 0.146 | 0.471 | 0.617 | 4.092 | 0.633 |
| 2070 | 3.532 | 0.141 | 0.508 | 0.649 | 4.009 | 0.671 |
| 2080 | 3.371 | 0.140 | 0.539 | 0.679 | 3.903 | 0.709 |
| 2090 | 3.107 | 0.141 | 0.566 | 0.707 | 3.674 | 0.747 |
| 2100 | 2.862 | 0.142 | 0.589 | 0.731 | 3.384 | 0.788 |
| 2110 | 2.455 | 0.148 | 0.620 | 0.768 | | |
| 2120 | 2.931 | 0.137 | 0.570 | 0.708 | | |
| 2130 | 3.363 | 0.131 | 0.506 | 0.638 | | |
| 2140 | 3.814 | 0.126 | 0.425 | 0.552 | | |
| 2150 | 4.283 | 0.123 | 0.323 | 0.446 | | |
| 2160 | 4.759 | 0.120 | 0.200 | 0.320 | | |
| 2170 | 5.248 | 0.117 | 0.054 | 0.171 | | |
| 2180 | 5.830 | 0.001 | 0.000 | 0.001 | | |

Notes: (1) "k" indicates PCS per efficient-labor unit.

(2) DEBT1, DEBT2, and DEBTS indicate "OPD held by public sector," "OPD held by the central bank (BOJ)," and "Total OPD," respectively.

(3) TA indicates "Total assets (except tangible non-produced assets) held by Japanese people."

**Figure 9:PB-ratio and FB-ratio to GNI (Base Case)**



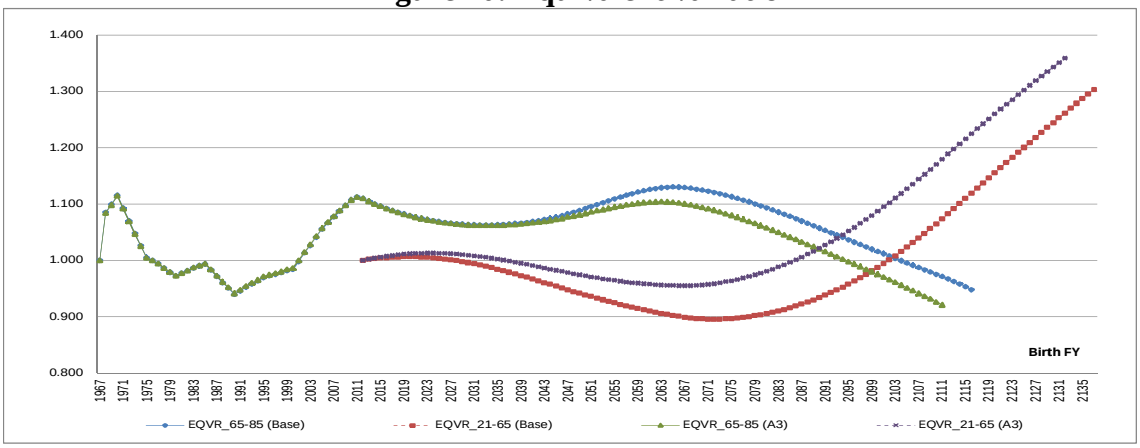

Note: PB and FB indicate "Primary balance of government budget" and "Final balance," respectively.

### 5.3.5 Life-cycle utility level by generation

Finally, this section explains the life-cycle utility level of respective generations in the UWCB scenario of the Base and A3 cases, in which the Japanese economy is sustainable, using an index[19] of 1 plus the equivalent variation of each generation's utility level (compared to the base generation's utility level).

The above equivalent variation excludes the influence of advances in production technology. Then, to help understand the utility level, the utility level index is divided into two segments: working period (ages 21–64) and retirement period (ages 65–85).[20] Furthermore, the former base generation is the generation born in FY2012, and the latter is that born in FY1967. Figure 10 shows the changes in the utility-level index. This figure explains the following facts. 1) In both the Base and A3 cases, the working-period utility level of future generations exceeds that of the base generation on a long-run basis, even after excluding the influence of advances in production technology. We can assume that this is due to the growth of PCS per efficient-labor unit along with the population aging (see Figure 7). This fact implies that DUPB by the BOJ improves the efficiency of added-value distribution in Japan. 2) In comparison to the Base case, the A3 case shows higher utility level in the working period of future generations but lower utility level in their retirement period. We can assume that this is generated by a process in which a downward shift of the time-preference rate prompts a decline in consumption closer to the present; subsequently, the decline prompts PCS accumulation, and finally this cycle increases production.

**Figure 10: Equivalent variation**




Note: EQVR indicates "Equivalent variation."

## *6. Concluding Remarks*

This study used a DCGE-OLG model to examine whether DUPB by the central bank (BOJ), which has the potential to support the Japanese economy and government finance and to improve the efficiency of added-value distribution, is effective. The results are summarized as follows. First, economic collapse occurs in the case where public bonds are absorbed by the market. On the contrary, under the relatively low time-preference rate of representative households, the economy and government finance are sustainable in the case where public bonds are directly underwritten by the BOJ. Accordingly, the payment of the BOJ's seignior rage to the national treasury improves the Japanese government's finance and the economy. Moreover, in the sustainable case, GNI per capita rises continuously due to the growth of PCS per efficient-labor unit along with the population's aging and the advances in production technology. Second, a downward shift in the time-preference rate brings good effects for economic sustainability and efficiency. That is, this shift promotes the accumulation of physical capital stock, and thus the stock increment promotes production. Third, in the sustainable case, the utility level in the working period of future generations will exceed that of the base generation on a long-run basis. This fact implies that DUPB by the BOJ improves the efficiency of added-value distribution in Japan. Finally, some remaining issues need to be mentioned. First, the rational-expectation assumption (the optimization behavior of representative households with perfect foresight) may be too strong. Therefore, an analysis under the adaptive-expectation assumption, and a comparison between its results and this study's results, should be conducted. Second, a model that explicitly handles a bequest element should be developed.

Third, this study's model should also be expanded into an open-economy model that considers the capital flow between Japan and other countries.

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**Notes**

1. General government consists of the central government, local governments, and social security funds.
2. These financial indicators are based on those of the Ministry of Finance: http://www.mof.go.jp/tax_policy/summary/condition/(accessed on January 7, 2015).
3. This is based on data from the Principal Global Indicators (IMF): http://www.principalglobalindicators.org/Pages/Default. aspx (accessed on December 16, 2014).
4. These are based on data from the Ministry of Finance: http://www.mof.go.jp/jgbs/reference/gbb/data.htm (accessed on December 17, 2014), data from the Bank of Japan: http://www.boj.or.jp/about/account/index.htm/(accessed on December 17, 2014), and "Debt Management Report"(issued each fiscal year, Ministry of Finance).
5. FY represents fiscal year.
6. This measure is based on Article 53 of the Bank of Japan Act.
7. Hereinafter, as explained here, "public bonds" includes local government bonds, while "government bonds" refers to bonds issued by the central government.
8. Market absorption of JGBs is obligatory under Article 5 of the Public Finance Act.
9. They explained the reason for this as follows: the main cause of the government's intertemporal budget constraint becoming stricter is not the current OPD, which has been reduced by the recent increase in inflation, but future debt, which is not reduced by this factor.
10. This model has the following characteristics: 1) the respective economic agents possess perfect foresight; 2) owing to 1), the respective economic agents utilize all currently available information and form expectations in a forward-looking manner (i.e., a forward-looking model); 3) in 2), the respective economic agents carry out optimization behavior, based on a micro-foundation.
11. For the definition of seignior rage, see Neumann (1992), Baltensperger and Jordan (1997, 1998), and Schobert (2000). In regards to the actual magnitude of seignior rage, see Neumann (1992), Reserve Bank of Australia (1997), Schobert (2000), and Oguri (2006).
12. For an explanation of the central bank's seignior rage and the actual situation in Japan, see Oguri (2006).
13. The age of death is adjusted to the population projection data used in the simulation. Details of this data are explained in Section 4.
14. Pension benefit strictly means the amount of pension benefit. Hereinafter, owing to space limitations, I omit the phrase of "the amount of" in the expression of variables implying "amount" in this manner.
15. Such DUPB by the central bank is assumed to have an equal ratio of impact on household assets and on public pension assets (see Section 3.4).
16. Fundamentally, $TA_t = PA_t + PFUND_t$. However, if $TDEBT_t < 0$, then $TA_t = PA_t + PFUND_t + (-TDEBT_t)$.
17. However, in the cases where fiscal year data cannot be used, I used calendar year data instead.
18. In order to create the simulation program, I referred to programs released online, including a program created by Hashimoto, K. (http://www2.ipcku.kansai-u.ac.jp/~hkyoji/kenkyu/download.htm) and one created by Oguro, S. and Shimazawa, M. (http://www.nippyo.co.jp/download/535-55664-5/index.php).
19. This index will be 1 if the utility level of the targeted generation is the same as that of the base generation.
20. Although this study sets households to live over ages 21-105 (85 periods), this lifespan is too long for calculating the life-cycle utility level. Consequently, I adopted the retirement period of ages 65-85 for the utility-level index.

**Appendix**

**Table A1: Parameter values of preceding studies**

| No. | Author | Year | Time preference rate $\rho$ | Intertemporal elasticity of substitution $\gamma$ | Technological progress rate : Harrod neutral type $\lambda$ |
|---|---|---|---|---|---|
| 1 | Auerbach and Kotlikoff | 1983 | 0.020 | 1.000 | 0.020 |
| 2 | Auerbach and Kotlikoff | 1987 | 0.015 | 0.250 | |
| 3 | Auerbach et al. | 1989 | -0.040 | 0.350 | |
| 4 | Iwamoto et al. | 1993 | -0.040 | 0.300 | |
| 5 | Hviding and Mérette * | 1998 | 0.003 | 0.250 | 0.024 |
| 6 | Kato | 1998 | -0.075 | 0.200 | |
| 7 | Fougère and Merette * | 1999 | 0.003 | 0.250 | 0.024 |
| 8 | Miles * | 1999 | 0.015 | 0.750 | |
| 9 | Supan et al. | 2001 | 0.080 | 1/3 | |
| 10 | Kato | 2002 | -0.035 | 0.450 | |
| 11 | Sadahiro and Shimazawa | 2002 | 0.020 | 1/1.2 | |
| 12 | Supan et al. | 2005 | 0.011 | 0.500 | 0.015 |
| 13 | Shimazawa and Oguro | 2010 | 0.010 | 2.000 | 0.010 |

Notes: (1) "*" indicates studies that cited the values of ρ or γ from Auerbach and Kotlikoff (1987).
(2) If the study uses various values, the base value is indicated.
Source: By the author, using data from preceding studies.

## *References*


Auerbach, A. J. and L. J. Kotlikoff (1983). National Savings, Economic Welfare, and the Structure of Taxation. In Feldstein, M. (Eds), Behavioral Simulation Methods in Tax Policy Analysis (pp. 459-498), Chicago: University Chicago Press.

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

Auerbach, A. J., L. J. Kotlikoff, R. P. Hagemann, and G. Nicoletti (1989). The Economic Dynamics of an Aging Population: The Case of Four OECD Countries. OECD Working Papers, 62.

Baltensperger, E. and T. J. Jordan (1997). Principles of Seigniorage. Swiss Journal of Economics and Statistics, 133, 133-152.

Baltensperger, E. and T. J. Jordan (1998). Seignio rage and the Transfer of Central Bank Profits to the Government. KYKLOS, 51, 73-88.

Bohn, H. (1998).The Behavior of U.S. Public Debt and Deficits. The Quarterly Journal of Economics, 113, 949-963.

BÖrsch-Supan, A., A. Ludwig, and J. Winter (2001). Aging and International Capital Flows. NBER Working Paper 48553.

BÖrsch-Supan, A., A. Ludwig, and J. Winter (2005). Aging, Pension Reform, and Capital Flows: A Multi-country Simulation Model. NBER Working Paper 11850.

Broda, C. and D. E. Weinstein (2005). Happy News from the Dismal Science: Reassessing the Japanese Fiscal Policy and Sustainability. Ito, T., H. Patrick, and D. E. Weinstein (Eds.), Reviving Japan's Economy. (pp. 39-78).Cambridge: The MIT Press.

Detken, C. (1999). Fiscal Policy Effectiveness and Neutrality Results in a Non-Ricardian World.European Central Bank Working Paper Series, 3.

Doi, T., T. Hoshi, and T. Okimoto (2011). Japanese Government Debt and Sustainability of Fiscal Policy. Journal of the Japanese and International Economies, 25, 414-433.

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

Fukuda, S. and H. Teruyama (1994). The Sustainability of Budget Deficits in Japan. Hitotsubashi Journal of Economics, 35, pp. 109-119.

Hamilton, J. D. and M. A. Flavin (1986). On the Limitations of Government Borrowing: A Framework for Empirical Testing. American Economic Review, 76, 808-819.

Hoshi, T. and T. Ito (2014). Defying Gravity: Can Japanese Sovereign Debt Continue to Increase without a Crisis? Economic Policy January 2014, 5-44.

Hviding, K. and M. Mérette (1998). Macroeconomic Effects of Pension Reform in the Context of Aging Populations: Overlapping Generations Model Simulations for Seven OECD Countries. OECD Working Papers, 201.

Ihori, T., T. Doi, and H. Kondo (2001). Japanese Fiscal Reform: Fiscal Reconstruction and Fiscal Policy. Japan and the World Economy, 13, 351-370.

Ihori, T., R. R. Kato, M. Kawade, and S. Bessho (2006). Public Debt and Economic Growth in an Aging Japan. In Kaizuka, K. and A. O. Kruger (Eds.), Tackling Japan's Fiscal Challenges(pp. 30-68).New York: Palgrave Macmillan.

Iwamoto, Y., R. Kato, and M. Hidaka (1993). Public Pensions and an Aging Population. Review of Social Policy, 2, 1-10.

Kamada, K. and K. Masuda (2001). Effects of Measurement Error on the Output Gap in Japan. Monetary and Economic Studies (the Bank of Japan's Institute for Monetary and Economic Studies), 19,109-154.

Kato, R. (1998). Transition to an Aging Japan: Public Pension, Savings, and Capital Taxation. Journal of the Japanese and International Economies, 12, 204-231.

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

Miles, D. (1999). Modeling the Impact of Demographic Change upon the Economy. Economic Journal, 109, 1-36.

Mincer, J. A. (1974). The Human Capital Earnings Function. In Mincer, J. A. (Eds.), Schooling, Experiences, and Earnings (pp. 83-96), New York: Columbia University Press.

Miyazawa, K. (2008). The Decline in Capital Utilization and TFP in the 1990s. RIETI Discussion Paper Series (Research Institute of Economy, Trade & Industry), 08-J-054. (In Japanese)

Neumann, M. J. M. (1992). Seigniorage in the United States: How Much Does the U.S. Government Make from Money Production? Federal Reserve Bank of St. Louis Review, 74, 29-40.

Oguri, S. (2006). Central Banking and Seigniorage. The Annals of Human and Social Sciences (Faculty of Economics Shiga University), 13, 19-35. (In Japanese)

Reserve Bank of Australia (1997). Measuring Profits from Currency Issue. Reserve Bank of Australia Bulletin, July 1997, 1-4.

Sadahiro, A. and M. Shimazawa (2002). The Computable Overlapping Generations Model with an Endogenous Growth Mechanism. Economic Modelling, 20, 1-24.

Sargent, T. J. (1999). A Primer on Monetary and Fiscal Policy. Journal of Banking & Finance, 23, 1463-1482.

Schobert, F. (2000). Seigniorage: An Argument for a National Currency? Center for European Studies Working Document, 174.

Shimazawa, M. and K. Oguro (2010). Impact of Immigration on the Japanese Economy: A Multi-country Simulation Model. Journal of the Japanese and International Economies, 24, 586-602.

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. The Review of Economics and Statistics, 39, 312-320.

Yoshida, M. (2015). Is Direct Underwriting of Public Bonds by the Central Bank an Effective Policy in Japan? Discussion Paper New Series (Osaka Prefecture University, Japan), 2015-1.
[Online] Available:http://repository.osakafu-u.ac.jp/dspace/handle/10466/14310 (April 20, 2015)