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ACHIEVING FISCAL BALANCE IN JAPAN*

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Japan is aging and has the highest government debt-to-output ratio among advanced economies. In this article, we build a micro data-based, large-scale overlapping generations model for Japan in which individuals differ in age, gender, employment type, income, and asset holdings, and incorporate the Japanese pension rules. Using existing pension law, current fiscal policy, and medium variants of demographic projections, we produce future paths for government expenditures and tax revenues, with implications for government debt and the public pension fund. Additional pension reform, a higher consumption tax, and higher female labor force participation help achieve fiscal stability.

1. INTRODUCTION

Japan has the highest debt-to-GDP ratio among advanced economies and faces a fast and large demographic transition to an older society. In addition, recent government plans call for a continuation of primary deficits at least through 2020, renewing concerns over whether the Japanese government bonds (JGBs) may become a global problem. In the absence of a robust theory of government debt, it is difficult to evaluate statements regarding the massive quantity of the JGBs, their prices, and if and when bond market participants will stop buying them. One can, however, develop a model to measure what will contribute to the magnitude of the JGBs and the underlying reasons, and that is what we do in this article.

We build a micro data-based, large-scale overlapping generations model for Japan in which individuals differ in age, gender, employment status, income, and asset holdings and incorporate the Japanese pension rules in detail. We estimate age-consumption and age-earnings profiles from micro data and assume complete markets. We calibrate the model so that it matches main macroeconomic and fiscal indicators for 2010. Using existing pension law, current fiscal policy, and the medium variants of fertility and survival probability forecasts, we generate projections of future government expenditures, tax revenues, the pension fund, and JGBs. In addition, we decompose annual net borrowing requirements that integrate to the JGBs into nonpension primary deficit, pension deficit, and net interest payments on JGBs net of the pension fund.

Our analysis highlights the following key quantitative findings:

(1) Under current policies and absent any further reforms or changes, large pension and nonpension deficits will persist, with growing interest payments on government debt

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becoming a serious burden. The ratio of debt to GDP reaches 210% in 2030 and 370% in 2050.

   (a) Pension and nonpension deficits contribute about the same, just about 4% of GDP each, to new borrowing requirements over the next few years, with net interest on debt playing a much smaller role, thanks to the low real interest rate on JGBs in the current economic environment.
   (b) With the consumption tax rate scheduled to rise from 5% to 10% in 2014–2015, there is a significant improvement in the nonpension deficit and then a gradual rise of the deficit over time as the ratios of nonpension transfers and government expenditures to GDP start to rise.
   (c) There is an initial, significant decline and, later, a smooth decline in the pension deficit due to the pension reforms under way. However, in about 25 years the pension deficit starts to rise again, eventually stabilizing at about 5% of GDP annually.
   (d) Net interest payments on JGBs eventually dominate net borrowing requirements despite the low 1% interest rate assumed in the baseline scenario; the stock of debt becomes just too large.

(2) Among the outcomes and policies considered, three seem to have a large impact, although none of them by itself is able to restore fiscal balance.
   (a) Raising the retirement age to 70 and cutting pension benefits by 10% significantly reduces the pension deficit.
   (b) Raising the consumption tax to 20% produces a surplus in the nonpension balance.
   (c) Raising the female labor force participation rates to those of males and having the distribution of employment types converge to that of males impact the budget more significantly; both pension and nonpension deficits are reduced.

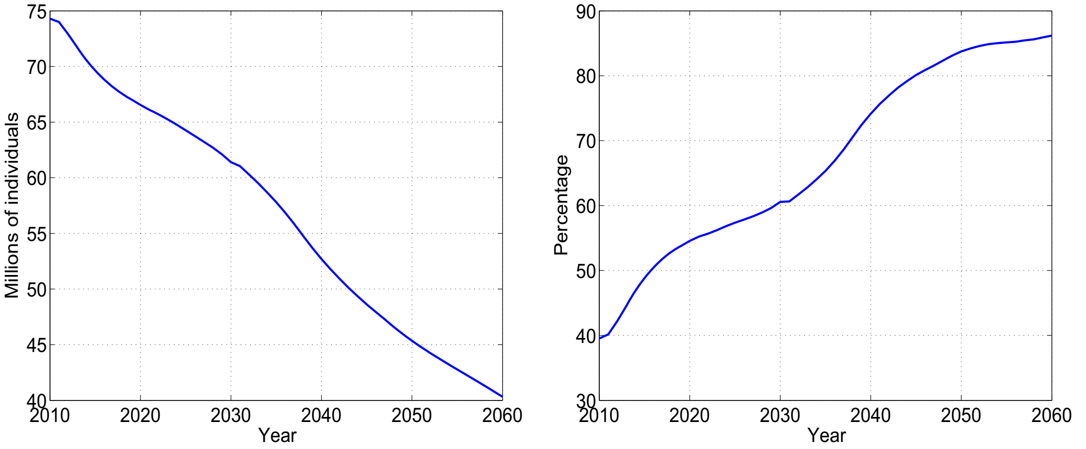
In addition to the policy simulations, we present a number of sensitivity analyses on variables that bring about changes in the deficit projections, including alternative assumptions on the productivity growth, the interest rate on the government debt, and the returns on the asset held in the pension fund. We also study various scenarios about how the female labor force participation rates will evolve over time and investigate the impact of a guest worker program to allow foreigners to supply labor in Japan. We note that outcomes and policies that are not considered in this article, such as comprehensive tax reform and public health insurance reform, may contribute to the solution of the fiscal problems, and these are left for future research.

The remainder of the article is organized as follows. We review the literature in Section 2 and present the model in Section 3. Details of the calibrated parameters are given in Section 4. The benchmark results are discussed in Section 5, and Section 6 conducts a sensitivity analysis. Policy experiments are presented in Section 7, and Section 8 concludes.

2. OVERVIEW OF THE LITERATURE

Our article contributes to a growing literature that relies on workhorse macro models to shed light on the severity of fiscal adjustment Japan needs to make, the policy options that are available, and the economic consequences of these alternative policy actions. We use Japan as our economic laboratory because aging and fiscal imbalance are arguably most severe in Japan among advanced economies. Therefore, a careful quantitative analysis of the impact of outcomes and policies on the Japanese economy will allow us to discuss similar events for other advanced economies.

The backdrop for this effort can be described as follows. The Japanese economy has essentially been stagnant since 1990. The policy interest rate has been lowered to essentially zero for more than a decade. Several rounds of fiscal stimulus packages since the early 1990s have resulted in the highest debt-to-GDP ratio in the developed world. According to the OECD, Japan's net debt to GDP is about 116%, and its gross debt to GDP is above 200% by the end of 2010.



(a) Working age population (b) Old-age dependency ratio

FIGURE 1

PROJECTED DEMOGRAPHICS: 2010–2060

In addition, Japan has the fastest aging population among the developed economies. Therefore, Japan serves as a laboratory for (i) how severe demographic and fiscal challenges are, and (ii) how various government policies and changes in economic environment may affect fiscal sustainability. The expected aging of the population will raise pension payments as more and more retirees will receive old age pensions, raising the transfers-to-output ratio.

Figure 1 shows the projected population in Japan at the working ages of 20 to 64 and the old-age dependency ratio defined as the ratio between the population above age 65 and 20–64.[2] With the increase in the fraction of 65 and older, the working age individuals will have to increasingly support the elderly through some combination of higher taxes, lower leisure, lower consumption, or lower future benefits for themselves, if current projections of future benefits to current cohorts are to be maintained.

Using a neoclassical growth model, İmrohoroğlu and Sudo (2011a) examine the impact of a rise in the consumption tax rate from 5% to 15% on the primary deficit-to-GDP ratio. Despite a temporary improvement in the primary balance, their quantitative results indicate that a much larger fiscal adjustment is needed to achieve fiscal sustainability. İmrohoroğlu and Sudo (2011b) explore whether faster productivity growth can increase the tax base sufficiently to reduce debt to GDP to manageable levels. They find that only a growth miracle, such as a 6% real growth rate over 10 years, could achieve a fiscal adjustment of the size that Japan is facing.

Braun and Joines (2015) build an overlapping generations model that incorporates the demographic transition and calculate economic projections for Japan. Their findings suggest that in the absence of any reform, the consumption tax rate will have to rise to about 30%–45% in order to achieve fiscal sustainability. They argue that a health-care reform that raises the co-pay for the elderly to that for working age individuals, which is 30%, would contain the increase in the consumption tax to 23%. Kitao (2015) uses a life-cycle model to quantify the fiscal cost of demographic transition and shows that pension reform to scale down benefits and raising the retirement age can significantly lower the required rise in consumption tax, assisted by a significant increase in private saving and labor force participation.

Hoshi and Kashyap (2012) use a narrative to argue that zombie financing and very large spending programs have significantly contributed to the already large projected fiscal burden

[2] Projections are based on the estimates of the survival rates and fertility rates by the National Institute of Population and Social Security Research. For details, see the following Web site: http://www.ipss.go.jp/site-ad/index_english/esuikei/gh2401e.asp

of the demographic transition. In addition to suggesting fiscal consolidation and major regulatory and microeconomic reforms, they also recommend opening up the Japanese economy. In particular, they suggest a stronger push to become a member of the Trans Pacific Partnership (TPP) and to take immigration seriously.

Hoshi and Ito (2014) use back-of-the-envelope calculations for sustainability. Emphasizing the seemingly unending appetite of the Japanese private sector for JGBs in the face of extremely high prices for such bonds, they argue that there is an upper bound on the private sector's ability to finance further new borrowing by the government. They predict that under certain assumptions this threshold will be reached in around 2022, and the yields on JGBs will start to rise even before 2022. This would then be followed by Greece-like events of fiscal austerity, financial instability, and even inflation.

Japan's high government debt is the result of several fiscal stimulus packages. Doi et al. (2011) pursue sustainability of fiscal policy using three complementary approaches. Broda and Weinstein (2005) estimate that fiscal sustainability is achievable with small changes in the tax-to-GDP ratio. Contrary to their findings, Doi et al. (2011) show that an extremely high tax rate, an additional 11% of GDP, is required to stabilize the debt-to-GDP ratio when they use more recent data. Two other approaches also show negative results on sustainability.

Hansen and İmrohoroğlu (2013) use a standard growth model, amended to include debt, to measure the size of the fiscal burden in the form of additional taxes required to meet these obligations that maintain current promised levels of per capita public pension and health services. The fiscal adjustment needed is about 30%–40% of total consumption expenditures. Using a distorting tax, such as a consumption or labor income tax, necessitates larger than European-level tax rates. They find that the latter is far more distortionary than the former, leading to a significant loss in welfare, highlighting the need to contain public spending and explore policies to enlarge the tax base.

In this article, we use a very rich, detailed overlapping generations structure to evaluate the severity of the demographic and fiscal challenges Japan is facing. Our approach is similar to Storesletten (2003), who uses a life-cycle model with complete markets to assess the impact of immigration policies in Sweden. We calculate projections of future government budget balances and debt and conduct counterfactual "accounting" exercises to assess the impact of possible fiscal responses to future shocks and how these policies change the fiscal sustainability in Japan.

We do not model individual decisions on consumption/saving and labor/leisure choices. As such, our model is not suitable to conduct a welfare analysis to study the effects of reforms or the demographic change. The model also abstracts from responses of individuals to various uncertainty that they face at the micro level over the life cycle, including risks of employment, labor productivity, and expenditures. Instead, we incorporate significant details of the pension system in Japan, including the distinction of three different categories of pension programs, eligibility, nonlinear functions of benefits, and contributions/premium in each program. We estimate age-consumption and age-earnings profiles from micro data and use these to produce asset holdings in the model. In addition, we capture the unique and important heterogeneity among the labor force, male versus female, regular, irregular (contingent), and self-employment, which have very important implications for the cash flow of the pension program. All of these important details are essential in understanding the current evaluation of the Japanese pension program, as well as its future projection.

Due to computational complexity, however, it is impossible to incorporate all of these in a model in which individuals are optimizing under incomplete markets. We view our article as a natural first step and develop a rich, detailed measurement device to identify which events or policies are more promising than the others. Then, as a second and critical step, we intend to develop an optimizing model with a manageable state space to a conduct welfare analysis in future research.

3. MODEL

In this section, we start with a description of the government accounts that will allow us to compute implications of policies and several scenarios on the future path of Japanese government macroeconomic outcomes. Later in the section, we will describe the economic environment and individual variables.

3.1. *Government and Fiscal Policies.*

The government raises revenues through taxation and issuance of one-period real debt to finance public consumption, transfer payments to individuals, as well as debt repayment and interest payments on outstanding debt. The government also runs a public pension program and provides pension benefits to retirees.

3.1.1. *Government budget.*

In each period the government finances its purchases of goods and services G_t, transfer payments to individuals TR_t, pension benefits to retirees P_t, and the cost of debt servicing through taxation T_t, issuance of new debt B_{t+1}, and collection of pension premium PR_t. At the beginning of period t, the government owes debt B_t and holds assets in the pension fund denoted as F_t, which can be used to pay for the pension benefits. Therefore the net debt of the government is $B_t - F_t$. The government budget constraint is given as follows:

$$B_{t+1} - F_{t+1} = (1 + r_{b,t})B_t - (1 + r_{f,t})F_t + G_t + TR_t + P_t - T_t - PR_t. \tag{1}$$

Here $(1 + r_{b,t})B_t$ is the principal and interest payments on the stock of government debt. We assume that the government issues one-period, real bonds at interest rate $r_{b,t}$, and we abstract from money creation and inflation. $r_{f,t}$ denotes the return on the pension fund.

Our objective is to calculate a time path for B_{t+1} between 2011 and 2100 under various assumptions about the economic environment, fiscal and monetary policies, demographics, labor force participation, and employment type. As such, we must pay careful attention to how we compute the right-hand side of Equation (1). In other words, we would like to tie these to data and observed behavior as much as possible.

We describe below how the aggregates in (1) are composed of individual variables. As we describe details in the following sections, $n_{i,j,e,t}$ denotes the number of individuals of age i, gender j, and employment type e at time t. The government accounts are given by

$$T_t = \tau_{c,t} \sum_{i,j,e} c_{i,j,t} n_{i,j,e,t} + \tau_{a,t} r_{a,t} \sum_{i,j,e} a_{i,j,t} n_{i,j,e,t} + \tau_{l,t} \sum_{i,j,e} y_{i,j,e,t} n_{i,j,e,t} + \tau_{ls,t} \sum_{i,j,e} n_{i,j,e,t},$$

$$TR_t = \sum_{i,j,e} tr_t n_{i,j,e,t},$$

$$G_t = \sum_{i,j,e} g_t n_{i,j,e,t},$$

$$P_t = \sum_{i,j,e} p_{i,j,t} n_{i,j,e,t},$$

$$PR_t = \sum_{i,j,e} \tau_{p,t}(y_{i,j,e,t}) n_{i,j,e,t}.$$

T_t represents taxes on four sources of revenues: consumption at rate $\tau_{c,t}$, capital income at rate $\tau_{a,t}$, labor income at rate $\tau_{l,t}$, and a lump-sum tax of $\tau_{ls,t}$. tr_t represents exogenous nonpension per-capita transfer payments given to individuals. g_t denotes exogenous per-capita government purchases for individuals at time t. $p_{i,j,t}$ represents the pension benefit to each retiree. $\tau_{p,t}(y_{i,j,e,t})$

is the contribution to the public pension system by each working-age insured individual, which depends on earnings $y_{i,j,e,t}$.

3.1.2. *Pension benefit.* Pension benefits in Japan follow a three-tiered structure: the basic pension (*Kiso Nenkin*), the employees' pension insurance (*Kosei Nenkin Hoken*), and an optional scheme.[3] The government runs the first two schemes jointly.[4] Individuals between the ages of 20 and 59 are eligible and required to participate in the basic pension, and the benefit is a fixed amount if an individual has been insured throughout the period of eligibility. The benefits from the employees' pension insurance are based on career earnings of an individual. To approximate the system, we assume that the pension benefits $p_{i,j,t}$ consist of two parts, a lump-sum component, which represents the basic pension, and a part that is proportional to average earnings of an individual, which approximates the employees' pension insurance. More details are provided in Section 4.3.

The payment of the public pension benefits is financed by the combination of the premium paid by the insured, contribution from the general government budget, and the pension fund. The law of motion for the pension fund is given as follows:

$$F_{t+1} = (1 + r_{f,t})F_t + PR_t + X_t - P_t. \tag{2}$$

Here X_t denotes the contribution from the general government budget to the payment of pension benefits.

These computations rely on estimates of income by an age i individual of gender j, with a type e employment at time t and how this object is related to the consumption and asset holding of the same individual. Once we specify these objects, then our aggregation rules above will yield the model's implications on the future path of government debt B_{t+1}.

3.2. *Demographics.* We denote the state vector of an individual at time t as $\{i, j, e\}$. i represents the age of an adult individual, $j \in \{m, f\}$ the gender (male or female), and e the employment status as discussed in Section 3.3. The age of an individual including dependent children is denoted as $\widetilde{i}$, differently from the adult age i.

Individuals can live up to $\widetilde{I}$ years. Life time is uncertain, and agents of age $\widetilde{i}$ and gender j at time t face a conditional probability of $s_{\widetilde{i},j,t}$ to survive from age $\widetilde{i}$ at time t to age $\widetilde{i}+1$ at time $t+1$. The fertility rate (the number of children per woman in a year) of an age $\widetilde{i}$ female at time t is given as $\phi_{\widetilde{i},t}$.

Individuals become adult and enter the market economy at age I_A and begin economic activities, participating in the labor market and making consumption and saving decisions.

We denote by $\widetilde{n}_{\widetilde{i},j,t}$ the number of individuals of age $\widetilde{i}$ and gender j at time t and by $\widetilde{\mathbf{n}}_t$ the $2\widetilde{I} \times 1$ vector of age groups by gender.

The law of motion of the population between time t and $t+1$ is given by $\widetilde{\mathbf{n}}_{t+1} = \Gamma_t \widetilde{\mathbf{n}}_t$, where Γ_t is a time varying matrix of size $2\widetilde{I} \times 2\widetilde{I}$ composed by fertility rates and survival probabilities of individuals of both genders.

$$\widetilde{\mathbf{n}}_t' = [\widetilde{n}_{1,m,t}, \widetilde{n}_{2,m,t}, \cdots, \widetilde{n}_{\widetilde{I},m,t}, \widetilde{n}_{1,f,t}, \widetilde{n}_{2,f,t}, \cdots, \widetilde{n}_{\widetilde{I},f,t}],$$

[3] Note that the terminology, the national pension (*Kokumin Nenkin*), is also used to represent the insurance premium payment to receive the basic pension benefit or sometimes the basic pension itself. To avoid confusion, we will only use the basic pension (*Kiso Nenkin*), which constitutes the first tier of the public pension system and is applicable for the entire population.

[4] The third optional retirement plan is a semiprivate plan, which is closer to a private saving plan, and we will not explicitly model it.

$$\Gamma_t = \begin{bmatrix} 0 & 0 & \cdots & \cdots & 0 & 0.5\phi_{1,t} & 0.5\phi_{2,t} & 0.5\phi_{3,t} & \cdots & 0.5\phi_{\widetilde{I},t} \\ s_{1,m,t} & 0 & \cdots & \cdots & 0 & 0 & 0 & \cdots & \cdots & 0 \\ 0 & s_{2,m,t} & \cdots & \cdots & 0 & 0 & 0 & \cdots & \cdots & 0 \\ \vdots & \ldots & \ddots & \ddots & \vdots & \vdots & \ddots & \ddots & \ddots & \vdots \\ 0 & 0 & \cdots & s_{\widetilde{I}-1,m,t} & 0 & 0 & \cdots & \cdots & \cdots & 0 \\ 0 & 0 & \cdots & \cdots & 0 & 0.5\phi_{1,t} & 0.5\phi_{2,t} & 0.5\phi_{3,t} & \cdots & 0.5\phi_{\widetilde{I},t} \\ 0 & 0 & \cdots & \cdots & 0 & s_{1,f,t} & 0 & \cdots & \cdots & 0 \\ 0 & 0 & \cdots & \cdots & 0 & 0 & s_{2,f,t} & \cdots & \cdots & 0 \\ \vdots & \ddots & \ddots & \ddots & \vdots & \vdots & \ddots & \ddots & \ddots & \vdots \\ 0 & 0 & \cdots & \cdots & 0 & 0 & \cdots & \cdots & s_{\widetilde{I}-1,f,t} & 0 \end{bmatrix}.$$

In what follows, we define the adult age i, which starts at age I_A. The age of an individual $\widetilde{i} \geq I_A$ is $i \equiv \widetilde{i} - I_A + 1$.

3.3. *Labor Force Participation and Earnings.* In each period an individual is employed at a regular job (R), a contingent job (C), self-employed (S), or not-working (U). The employment status is denoted as a state $e \in \{R, C, S, U\}$.[5] Earnings of type $\{i, j, e\}$ individuals at time t is $y_{i,j,e,t}$. Note that $y_{i,j,e,t} = 0$ for individuals that are not working.

In Section 4, we will describe in detail how we estimate six age-earnings profiles for three types of workers of each gender using Japanese data. These profiles will form the basis of our calculation of individuals' consumption and asset profiles in addition to calculating personal income tax revenues and pension premiums.

3.4. *Consumption and Asset Profiles.* In order to calculate revenues from consumption and capital income taxation, it is necessary to impute the path of consumption and wealth for each individual along the life cycle and over time, given their income profiles.

We assume that an individual's age-consumption profile relative to the life-time wealth defined as the discounted sum of disposable income is time-invariant. We allow, however, the number of dependent children to affect the consumption allocations. The factor of adjustment by an additional dependent child will be time-invariant, but the total adjustment will vary as the fertility rates and the number of dependent children at each age evolve over time. We assume that the consumption of both male and female individuals of the same age will be adjusted by the same fraction to account for the consumption of dependent children.

Individuals are assumed to be dependent children for $I_A - 1$ periods. Each dependent is supported by a pair of males and females (parents) of the same age for their consumption. Let $\tilde{d}_{t,\widetilde{i},k}$ denote the number of dependents of age k that parents of age $\widetilde{i}$ support at time t, which coincides with $\phi_{\widetilde{i}-k+1,t-k+1}$.[6] The total number of children for a mother of age $\widetilde{i}$ at time t is given as $d_{t,\widetilde{i}} = \sum_{k=1}^{I_A-1} \tilde{d}_{t,\widetilde{i},k}$.

We estimate the age-specific fraction of the discounted present value of income $\tilde{\lambda}_i$ consumed at each age i from the consumption data for individuals. The factor $\lambda_{i,t}$ takes into account the equivalence adjustment in consumption allocation for children implied by the path of fertility rates. $\lambda_{i,t} = \tilde{\lambda}_i(1 + d_{t,\widetilde{i}}\nu)$ where ν represents adult consumption equivalence for dependent children.

Individuals are assumed to own zero wealth as they enter the economy and start economic activities. We assume that there are annuity markets to cover the event of early death, and each

[5] The first represents full-fledge employment (*seishain* or *seiki-koyou*) and the second is employment at a nonregular, temporary, or dispatch job (*hi-seishain* or *hi-seiki-koyou*). Note that the second is different from a part-time job in the United States. It does not necessarily mean that an individual with a contingent job works less than full-time equivalent hours. It is employment under a different type of contract than in a regular job, where employment is guaranteed only a fixed period, and often the salary is significantly lower, as discussed in Section 4.2. The last employment status, not working, includes both unemployment and not in the labor force.

[6] In this computation, we abstract from the nonsurvival of children given their low mortality rates.

individual is entitled to keep the share of the assets of the deceased in the same cohort and gender. For simplicity, we also assume that the consumption profile is determined based on the expected life-time income and that individuals of a given cohort are assumed to have access to a technology that insures them against employment risks.

Therefore, consumption of an individual of gender j that belongs to cohort $t+1$ (that is, an individual "born" at the first adult age $i=1$ at time $t+1$) is given as follows:

$$(3)\; c_{i,j,t+i}(1+\tau_{c,t+i}) = \widehat{\lambda}_{i,j,t} \sum_{m=i_A}^{I} \frac{1}{\prod_{k=1}^{m}[1+r_{a,t+k}(1-\tau_{a,t+k})]} S_{m,j,t+m}$$
$$\times \sum_{e} \frac{n_{m,j,e,t+m}}{\sum_e n_{m,j,e,t+m}} \left[(1-\tau_{l,t+m})y_{m,j,e,t+m} - \tau_{p,t+m}(y_{m,j,e,t+m}) - \tau_{ls,t+m} + p_{m,j,e,t+m} + tr_{t+m}\right],$$

where $\widehat{\lambda}_{i,j,t} = \lambda_{i,t} S_{i,j,t+i} / \prod_{k=1}^{i}[1+r_{a,t+k}(1-\tau_{a,t+k})]$. $S_{i,j,t+i} \equiv \prod_{k=1}^{i} s_{k,j,t+k}$ is the unconditional survival probability of a gender-j agent born at time $t+1$ until age i at time $t+i$. The summation on the right-hand side of the equation represents the expected life-time net income discounted by the sequence of the interest rates and survival probabilities to reflect the access to the annuity markets.

The age-specific profile of assets can be computed recursively given the life-cycle profile of income net of taxes and transfers and the path of consumption, as shown below. Asset holdings will be used to compute the tax base for capital income taxation:

$$s_{i,j,t+i} a_{i+1,j,t+i+1} = \sum_{e} \frac{n_{i,j,e,t+i}}{\sum_e n_{i,j,e,t+i}} \{(1-\tau_{l,t+i})y_{i,j,e,t+i} - \tau_{p,t+i}(y_{i,j,e,t+i}) - \tau_{ls,t+i} + p_{i,j,t+i}$$
$$+ tr_{t+i} + [1+r_{a,t+i}(1-\tau_{a,t+i})]a_{i,j,t+i} - (1+\tau_{c,t+i})c_{i,j,t+i}\}.$$

4. PARAMETERIZATION OF THE MODEL

We calibrate parameters of the model to approximate the Japanese economy in 2010, which is the initial year to start simulation. The model period is one year. Table 1 summarizes the parameterization of the model.

We now turn to a more detailed description of the data sources of our econometric estimates and calibration.

4.1. *Demographics.* Individuals enter the economy at the age of 20 and live to a maximum age of 110, that is, $I_A = 21$ and $\tilde{I} = 111$. Conditional survival probabilities $s_{\tilde{i},j,t}$ and fertility rates $\phi_{\tilde{i},t}$ are based on the estimates and projections of the National Institute of Population and Social Security Research (IPSS) released in 2012. The IPSS provides the population projection for Japan between 2011 and 2060. As we focus on the transition dynamics from 2010 to 2100, we use the conditional survival probabilities and the fertility rate in 2060 to assume the same rates from 2060 to 2100. The projections of fertility rates and survival probabilities consist of three variants of estimates: low, medium, and high. We use the medium variants of both the fertility and survival probability rates in the benchmark projection and examine other projections in Section 6. Figure 2 shows the three variants of the total fertility rate (TFR).[7] In 2010, the TFR is 1.39 and it is projected to remain at around 1.35 until 2060, which accelerates the decline in population. Figure 3 plots the life expectancy by gender under the three variants. The life expectancy is projected to rise by more than 4 years by 2060, which further increases the old-age dependency ratio.

[7] The population projection by the IPSS provides future fertility rates of women between 15 and 49.

TABLE 1
PARAMETERS OF THE MODEL

Parameter	Description	Values/Source
Demographics		
$\{\phi_{\tilde{i},t}\}_{\tilde{i}=1}^{\tilde{I}}$	fertility rates	IPSS (2012)
$\{s_{\tilde{i},j,t}\}_{\tilde{i}=1}^{\tilde{I}}$	conditional survival probabilities	IPSS (2012)
$\tilde{I}$	maximum age	110 years old
I_A	initial adult age	20 years old
Labor market		
$\{y_{i,j,e,t}\}$	earnings	see text, Figure 5
Technology		
r_a	return on savings	3%
g^w	TFP and wage growth rate	1.5%
Government		
τ_l	labor income tax	10%
τ_c	consumption tax	5% (in 2010)
τ_a	capital income tax	35%
τ_p	pension contribution	see text
r_b	interest rate on government debt	1%
r_f	return on pension fund asset	2%
$i_{R,b}$,$i_{R,e}$	retirement age	see text

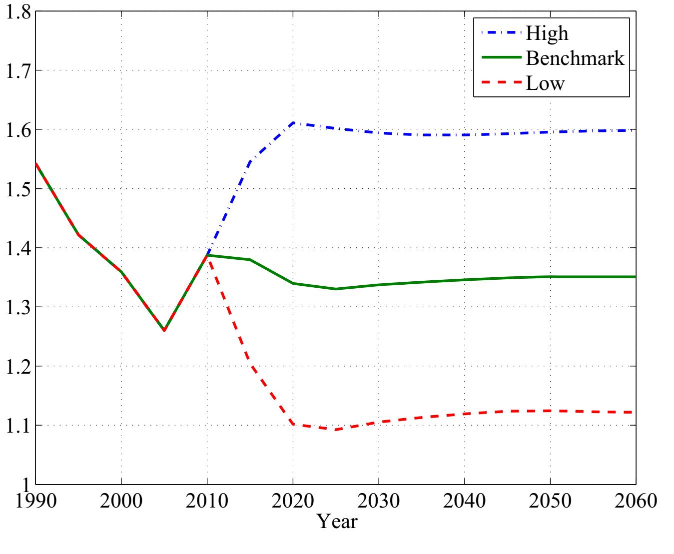


FIGURE 2

TOTAL FERTILITY RATE

For the population distribution in 2010, we use the actual distribution by age and gender from Population Census by the Ministry of Internal Affairs and Communications. We compute the population dynamics starting from the initial population distribution and then using the age-specific fertility rates and conditional survival probability rates, which evolve over time. The number of dependents $\{\tilde{d}_{t,\tilde{i},k}\}$ is also calculated from the projected population distribution and fertility rates.

4.2. *Labor Market and Earnings.* We compute the labor force participation rates of regular (R), contingent job (C), and self-employed (S) male and female workers from the Labor Force

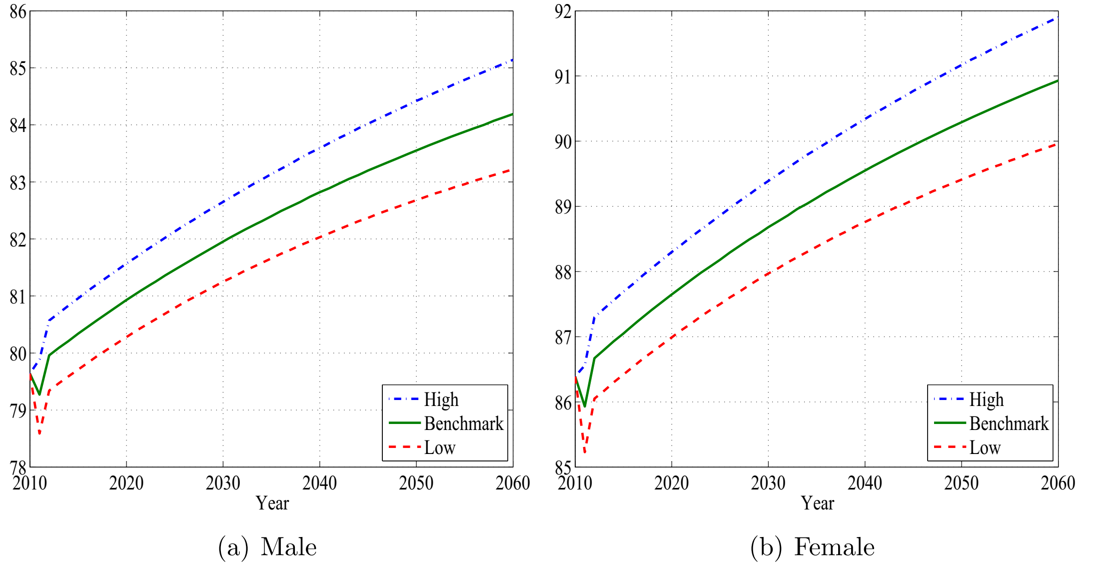


FIGURE 3

LIFE EXPECTANCY

Survey in 2010 by the Ministry of Internal Affairs and Communications.[8] Not working (U) is defined as the residual of the labor force participation rates of the three categories and includes individuals who are either unemployed or not in the labor force. Figure 4 shows the cumulated labor force participation rates by employment type and gender. Labor force participation rates of male workers are higher at most ages. The profile of female workers exhibits an M-shape due to withdrawals from the labor force at child-bearing ages in late 20s to around age 50.[9] We assume that some individuals continue to work beyond the retirement age when they start to collect pension benefits, consistent with the data as shown in the Figure 4. We also assume that the employment status distribution at each age does not vary over time. We have chosen to distinguish among the three types of employment since, as will be described later, public pension contributions and benefits depend on the employment status, and there is a significant difference in average earnings among them.

Earnings profiles of regular workers and contingent job workers are computed from the Basic Survey on Wage Structure (BSWS) in 2010, which is conducted by the Ministry of Health, Labor, and Welfare (MHLW). The BSWS collects survey data from private establishments, which implies that it targets regular/nonregular employees, and self-employed workers are not covered in the survey. We use the National Survey of Family Income and Expenditure (NSFIE) in 2004 to compute the earnings profile of self-employed workers.[10] The NSFIE collects data on annual income of both household head and spouse. As we can identify gender, age, and occupation of household head and spouse, we can calculate age-earnings profiles of

[8] We use the following categories for regular job workers, contingent job workers and self-employed workers respectively: Regular job workers consist of "regular employee (*seiki koyou*)" and "executive of company or corporation." Contingent job workers are defined as workers who are employed as "part-time worker," "side-job worker (*arbeit*)," "dispatched worker from temporary labor agency," "contract employee or entrusted employee," or "other." Self-employed are "self-employed worker with/without employee," "doing piecework at home," or "family worker." Not working is the sum of "unemployed person" and "not in labor force."

[9] Lise et al. (2014) provide a more detailed description of the gender-specific pattern of labor supply in Japan.

[10] The NSFIE aims to cover all Japanese households, which includes not only self-employed workers but employees and retirees. Thanks to its large sample of over 50,000, we can calculate earnings of self-employed workers by age. Genda and Kambayashi (2002) investigate income of self-employed workers using the NSFIE. For details on the NSFIE, see Lise et al. (2014).

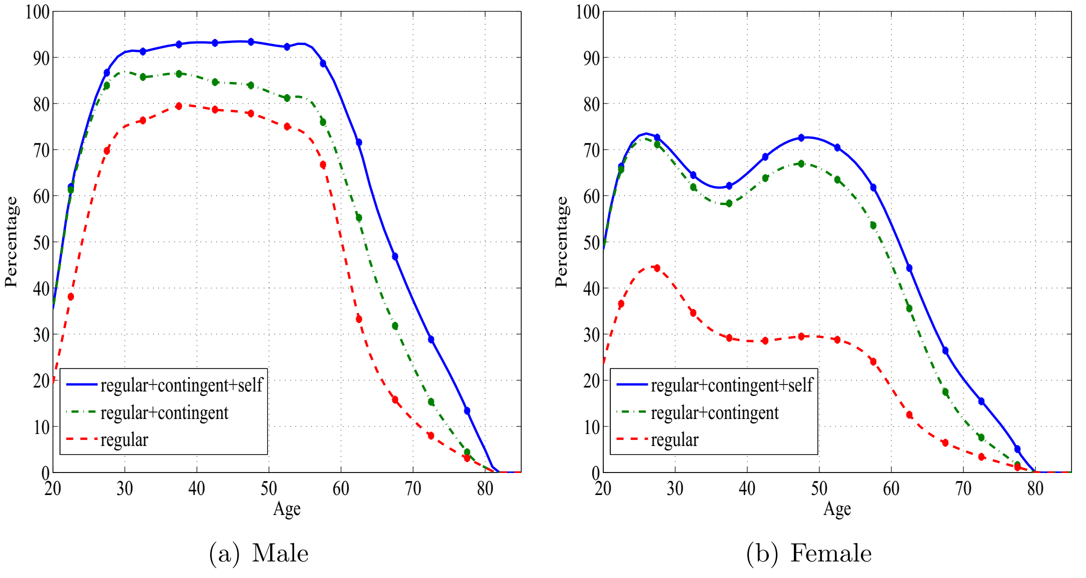


FIGURE 4

LABOR FORCE PARTICIPATION RATE

self-employed workers for males and females separately.[11] We assume that the shape of the earnings profiles is invariant over time although the economy-wide wage growth shifts up the profiles. Figure 5 shows the age-earnings profiles of the three types of employment for each gender, smoothed with polynomial functions.

In the baseline model, we assume that earnings are determined as a function of age, gender, and employment type. In Section 7, we add another dimension of heterogeneity in earnings, that is, the number of dependent children, and study the sensitivity of our results to this extension.

4.3. *Government.*

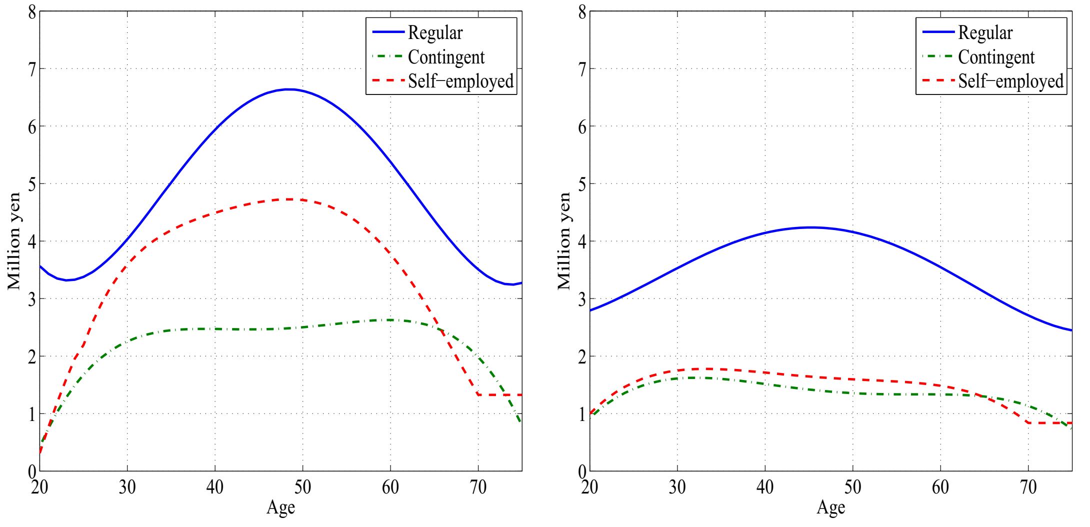
4.3.1. *Public pension.* The Japanese public pension system has three insurance categories of pension subscribers. The three categories are closely related to the employment types that we described in Section 4.2. Category 1 subscribers of the pension scheme are students, farmers, self-employed individuals, some nonregular (*hiseiki koyou*) workers that are not offered employees' pension insurance, and all others not in categories 2 or 3. Category 2 insured are regular (*seiki koyou*) workers in establishments with more than five employees and category 3 consists of nonworking spouses of category 2 workers, who essentially are housewives married to regular workers.

Individuals in each type of employment are assigned to the three categories of pension subscription, and we do so to match the distribution across categories by gender as reported in the subscription survey conducted by the MHLW.[12] Also, the retirement age has been changing over time and differently depending on the pension scheme.

The normal retirement age for the basic pension was 60 for both males and females, but it has been rising to 65 for both. The eligibility age for the employees' pension insurance has been rising from 60 (male) and 56 (female) and will reach 65 for a cohort born in 1961 (male) and

[11] We use the following categories of occupations for self-employed workers: "merchants and artisans," "private administrators," "households with income from agriculture, forestry, and fishery," and "professional services." Annual income is the sum of "wage and salaries," "income from agriculture, forestry, and fishery," "income from business other than agriculture, forestry, and fishery," and "homework."

[12] See Appendix A.1 for more details of how individuals are assigned to each type.



(a) Male (b) Female

FIGURE 5

ANNUAL EARNINGS PROFILES BY EMPLOYMENT TYPES

1966 (female).[13] The retirement ages are set to rise gradually, and they will all reach 65 for cohorts born after 1965. These transitional retirement ages that depend on cohort birth years will be incorporated in our computations.

We assume that all individuals between age 20 and 59 participate and contribute to the basic pension and start receiving benefits at age 65. The maximum annual benefit of the basic pension is 792,100 yen in 2010 for an individual who has contributed for the maximum of the 40 years. The benefit is reduced proportionally according to the number of months that the individual was not covered and did not contribute. Since not all individuals contribute for all years, actual benefits can be lower than the maximum amount. The average annual basic pension benefit for recipients at the normal retirement age of 65 was 679,572 yen in 2010, which is the amount that we use as the level of basic pension benefits in the simulations.

The second pillar of the Japanese pension system is the employees' pension insurance, and the benefits are tied to premium contributions that are linked to earnings. Only category 2 insured persons can receive the earnings-related part of the public pension.

We approximate the pension benefits of a retiree using a formula given below:

$$p_{i,j,t} = (1 + x_{t,t-i}) \left[p^b_{i,j,t} + \xi_{t,t-i} \times \bar{y}_{i,j,t} \right], \tag{4}$$

where $p^b_{i,j,t}$ is the basic pension for a retiree of age i and gender j at time t, $\xi_{t,t-i}$ affects the replacement rate, and $\bar{y}_{i,j,t}$ denotes their average past earnings. Due to past pension reforms, $\xi_{t,t-i}$ depends on the individual's birth year $t-i$. We set $\xi_{t,t-i}$ to match the total amount of the second-tier benefit payment with the data. $x_{t,t-i}$ is the macroeconomic slide factor that is explained below.

Contribution to the pension system $\tau_{p,t}(y_{i,j,e,t})$ depends on the three categories of insurance. Category 1 insured person pays a fixed amount to the basic pension system. The monthly

[13] It is possible to apply for early payment of pension benefits starting at age 60 or delayed payment after the pensionable age. The benefits are adjusted to reflect the penalty and credit associated with early and delayed withdrawal of benefits, respectively. We assume everyone starts to receive benefits at a common retirement age for simplicity.

premium for the basic pension will rise from the current 14,940 yen by 280 yen every year to 16,900 yen in 2017. Thereafter, the premium stays at 16,900 yen.[14]

Category 2 insured persons, who are typically salaried workers, contribute a constant fraction of labor earnings between ages 20 and 69. The tax rate on earnings for the employer pension is set to rise from the current 16.058% in 2010 by 0.354 percentage points every year to 18.3% in 2017. Thereafter, the rate stays at 18.3%. It includes both the first-tier and second-tier payments. Category 3 insured persons, who are dependent spouses of category 2 workers, contribute nothing, because the premium is considered as paid by her/his spouse.

4.3.2. *Macroeconomic slide.* Faced with the fiscal burden of aging, the Japanese government introduced an automatic adjustment scheme of pension benefits after the public pension reform in 2004, called the "macroeconomic slide," to attain budget balance for the public pension system. The main idea is that the growth rate of public pension benefit is kept less than the sum of the aggregate real wage growth rate and the inflation rate. Appendix A.1 provides more details of the macroeconomic slide and how it is adjusted over time.

4.3.3. *Public pension fund and Japanese government debt.* The pension fund F_t follows the dynamics described in Equation (2). The initial asset level F_{2010} at the beginning of 2010 is set at 178.3 trillion yen, the level of total assets in all public pension programs at the end of 2009.[15] We assume that the return on the pension fund, $r_{f,t}$, is 2.0%, which is close to the average real return of the fund in the last decade.[16]

The government debt B_t evolves according to formula (1). The initial debt level B_{2010} at the beginning of 2010 is set at 678.6 trillion yen, or about 140% of the GDP, which corresponds to the total liabilities of the central and local governments net of financial assets at the end of 2009. More concretely, from the SNA table "Closing Stocks of Assets/Liabilities classified by the Sub-sectors of General Government," liabilities of central and local governments in 2009 were 991 trillion yen, or 207% of GDP. To calculate the net government debt, we subtract financial assets of 490 trillion yen and exclude the total assets of 178 trillion yen held in the public pension fund from the net liabilities, since we compute the path of the pension fund separately as F_t in the model.[17] We assume that the interest rate paid on the government debt $r_{b,t}$ is 1% in the baseline case and also run simulations with alternative assumptions of the interest rate.

4.3.4. *Taxes.* The consumption tax rate $\tau_{c,t}$ in 2010 is set at 5%. As already scheduled by the government, we let the consumption tax rate rise to 8% in 2014 and 10% in 2015. Based on Hayashi and Prescott (2002) and updated by Hansen and İmrohoroğlu (2013), we set the capital tax rate $\tau_{a,t}$ at 35%. The labor income tax rate $\tau_{l,t}$ is set at 10% to match the tax revenue in the model with the data.[18] In addition to taxes on consumption and capital and labor income, we levy a lump-sum tax $\tau_{ls,t}$ on each individual to match the total tax revenues in 2010, 78.6 trillion yen.

[14] According to the annual report on the pension system by the MHLW ("*Kosei Nenkin Hoken Kokumin Nenkin Jigyo no Gaikyo*," 2010), the actual payment rate of the national pension (*Kokumin Nenkin*) was in the range of 67% to 71% in 2006 to 2008. Based on this, we adjust down the national pension premium of category-1 workers by a factor of 70%. Note that the model abstracts from the exemption from the premium payment for students and other low income individuals.

[15] The pension fund includes *Kiso Nenkin*, *Kosei Nenkin Hoken*, and three types of mutual-aid pension (*Kyosai Nenkin*). For details, see http://www.mhlw.go.jp/topics/nenkin/zaisei/04/ (in Japanese).

[16] More precisely the rate of return was 2.16% in 2002–2011 and it was 0.63% in 2006–2011 due to the global financial crisis. For details, see "*Nenkin tsumitatekin unyou houkokusho*" by the MHLW, 2011.

[17] The assets and liabilities include those of local and central governments as well as social security fund, except for the amount held in the public pension fund.

[18] Gunji and Miyazaki (2011) show that average *marginal* tax rates on labor incomes in Japan range from 14% to 21%. However the average tax rate, which is relevant in our model, is much lower than the marginal rates in general, and also a large number of workers pay less due to tax deduction and exemption. The total tax revenue from labor income is approximated by using a proportional tax rate of 10%.

4.3.5. *Government purchases.* We assume that g_t, per capita general government purchases of goods and services, is independent of age, gender, and employment status and grows at the TFP growth rate. Total general government net purchases which consist of central government purchases, local government purchases, and social security funds, in 2010 are 77.6 trillion yen, and we set g_t in 2010 to match this amount. Net government expenditures are the sum of "expenditures and payment," "other payment," and "asset expenses" after subtracting "net interest payment," "asset income," and "other receipt."

4.3.6. *Transfers.* Total transfers (excluding pension benefits) TR_t in 2010 is 18.2 trillion yen.[19] We set per-capita transfers, tr_t, to match the total transfer, and it grows thereafter at the TFP growth rate. The transfers include, in addition to social security benefits in cash, unfunded employee social benefits and social assistance benefits.

4.3.7. *Government budget balance during the transition.* Under the current public pension system in Japan, government transfers a part of tax revenues to the public pension budget for the purpose of supporting the basic pension system, which is represented as X_t in Equation (2). More precisely, 50% of the total benefit expenditures of the basic pension is supported by the transfer. Thus we set X_t at 1/2 of the basic pension expenditures in each year.

Once we have the premium PR_t, the contribution from the general government budget X_t, and the payment of the public pension benefit P_t, the dynamics of the pension fund F_t is endogenously determined from Equation (2). In the equation, the reserve funds F_{t+1} will adjust to absorb the gap between the contributions and benefits as long as the value is nonnegative. When the fund runs out, the deficit will be financed by the general government budget through a change in the value of X_t, which then rises above 1/2 of the basic pension benefits.

With the values of tax revenues T_t, government purchases G_t, transfers to individuals TR_t and the reserve fund F_{t+1}, we can compute the path of the JGBs B_t in the future using Equation (1).

4.4. *Technology.* We assume that the interest rate on individuals' saving is 3% on an annual basis, which is the average of the return on government bonds, 1%, and the return on private capital, 4%, using the weight of the size of the total capital and the outstanding government bond.[20]

We assume a wage growth rate of 1.5%, based on the historical average of the total factor productivity growth rate. We assume that both the interest rate and the wage growth rate are constant over the simulation period between 2010 and 2100. In Section 6, we run a sensitivity analysis on both rates and study how they affect the path of key macroeconomic variables.

4.5. *Consumption Profiles.* We assume that the markets are complete and individuals' consumption is determined by Equation (3), where the present discounted value of net income is allocated for consumption at each age using the weight parameter λ_i, following a similar method used in Attanasio et al. (2006, 2007) and Storesletten (2003). We match the individuals' consumption profile in the model with the empirical one, which is a hump-shaped profile as shown in Figure 6.

In general, consumption patterns differ across cohorts and also may be affected by business cycles. We remove such cohort and year effects following the approach by Aguiar and Hurst (2013). We use the Family Income and Expenditure Survey (FIES) by the Ministry of Internal Affairs and Communications, which is a monthly diary survey with information on earnings, income, and expenditures of Japanese households. See Appendix A.2 for more details about the database and estimation procedures.

[19] Adding the pension benefits P_t of 49.0 trillion yen, transfer payments are 67.2 trillion yen.

[20] Sakuragawa and Hosono (2010) discuss fiscal sustainability of Japan from the relationship between the interest rate and GDP growth rate.

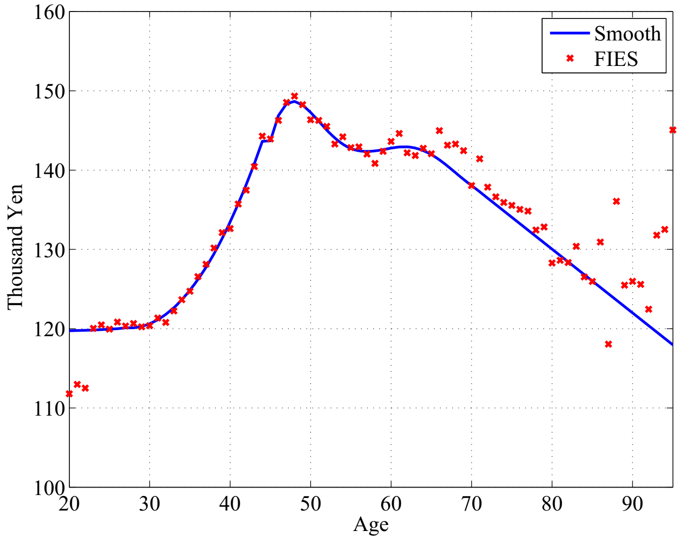


FIGURE 6

CONSUMPTION PROFILE (MONTHLY CONSUMPTION)

Following Aguiar and Hurst (2013), we run the following regression:

$$\ln C_{it} = \beta_0 + \beta_{\text{age}} D_{it}^{\text{age}} + \beta_c D_{it}^{\text{cohort}} + \beta_t D^{\text{time}} + \beta_{\text{fam}} \mathbf{X}_{it} + \epsilon_{it},$$

where we impose $\sum_{t=1981}^{2008} \beta_t = 0$ and $\sum_{t=1981}^{2008} t\beta_t = 0$. $\mathbf{X}_{it}$ represents a vector of household characteristics such as a gender dummy, a marital status dummy, the number of adults, and the number of children in each household. A vector of age dummies D_{it}^{age} represents adult-equivalent consumption profile over the life cycle.

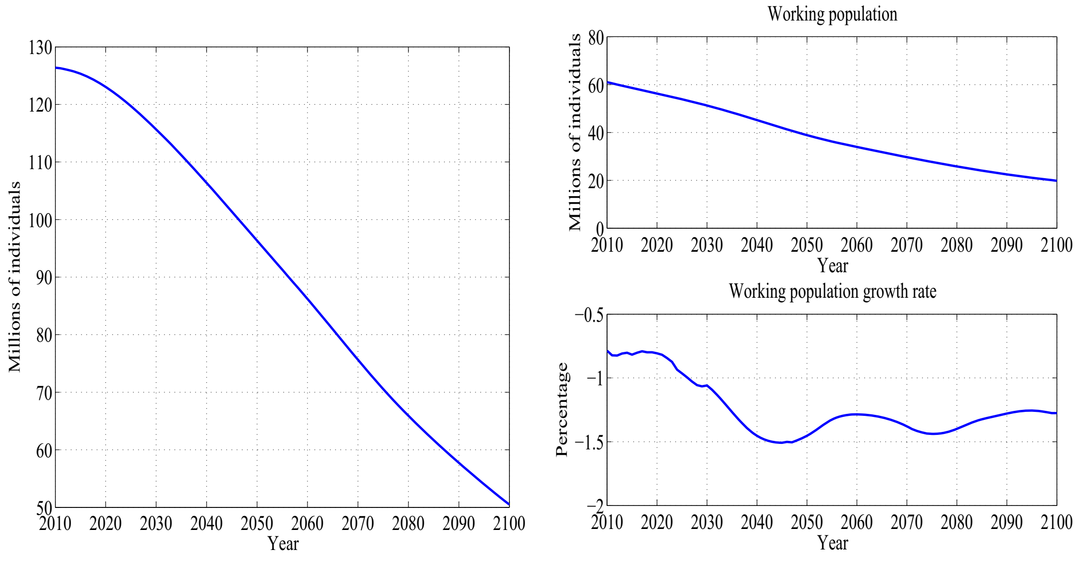
Figure 6 shows both the coefficients on age dummies D_{it}^{age} and the smoothed profile of adult consumption over the life cycle, $\widetilde{\lambda}_i$, that we use in the model.

5. NUMERICAL RESULTS

In this section, we present forecasts for future paths of net government bonds and the pension fund, $\{B_t, F_t\}_{t=2010}^{2100}$, and other endogenous macroeconomic indicators that are implied by our model, given exogenous demographics, government expenditures, and estimated consumption behavior in Japan. We would like to emphasize that our analysis is an accounting exercise based on the assumption of complete markets, taking the consumption and individual earnings behavior over the life cycle as exogenous and estimated from micro data. In this section, we will present our quantitative findings.

5.1. *Benchmark Transition.* In our model, the projected demographic transition and future policy actions drive the dynamics of the labor force, fiscal variables, and macroeconomic indicators. The time paths of total population and working population in our baseline case are shown in Figure 7(a).

For most of the years between 2010 and 2100, the rate of decline in the working age population is higher than 1% but less than 1.5%. The rate of decline of the population (not displayed) is smoother and less than that for the working age population mainly due to the rise in longevity.



(a) Total Population

(b) Working Population

FIGURE 7

PROJECTED DEMOGRAPHICS: 2010–2100

We mention the population dynamics because the behavior of GDP and GDP per capita are driven by demographics in our model. More concretely, we assume that the GDP grows by the following equation:

$$GDP_{t+1} = (1 + g_t^w)(1 + g_t^n)GDP_t,$$

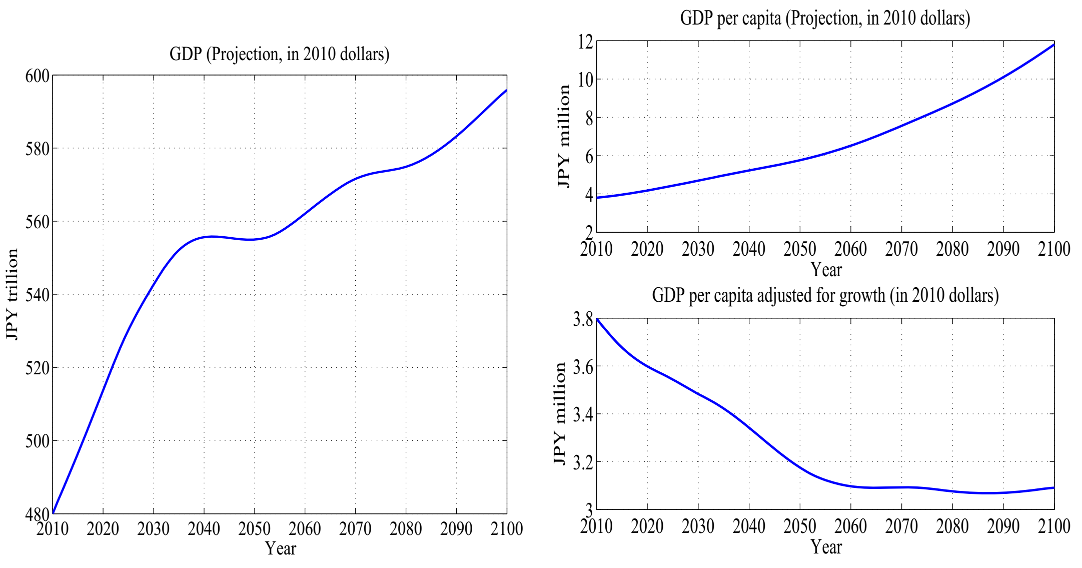
where g_t^n is the working population growth rate, and the initial GDP in 2010, GDP_{2010}, is set at 480 trillion yen. We abstract from inflation everywhere in the model except where we assume the inflation rate of 1% in computing the macroeconomic slide of the public pension system and adjusting the benefits in real values. All the yen values presented are in terms of 2010 yen.

GDP per worker grows at 1.5% annually, consistent with our "balanced growth" assumption of $g_t^w = 1.5\%$ growth in the average real wage. Total GDP, on the other hand, is the product of GDP per worker and total working population whose growth rate is negative and changes over time and makes the growth rate of GDP always positive but lower than 1.5% per year. Figure 8 shows the path of GDP and GDP per capita. Since the growth rate of total population is higher (less negative) than that of the working age population, GDP per capita grows at less than 1.5%. If we eliminate the effect of the TFP growth, GDP per capita will decline sharply, as shown in the bottom right panel of the figure due to the decline in the size of the labor force.

We now display our model's forecasts of debt-to-GDP ratio. Figure 9 depicts the net debt-to-GDP ratio, which represents publicly held net debt excluding the pension fund. This construct is directly comparable to the publicly held net debt in United States and other OECD countries.

According to Figure 9, the ratio of net debt to GDP, $(B_t - F_t)/Y_t$, will reach 162% in 2020, 207% in 2030, 270% in 2040, 367% in 2050, and 477% in 2060 when demographic projections end.

It is difficult to evaluate these numbers in the absence of a theory of debt that would have provided some insight. However, such a theory does not exist yet, and we can only compare these enormous debt levels to recent experiences of debt-ridden economies. When international bond markets started to aggressively unload Greek bonds, their debt-to-GDP ratio was around



(a) GDP (b) GDP Per Capita

FIGURE 8

PROJECTED GDP AND GDP PER CAPITA (IN 2010 YEN): 2010–2100

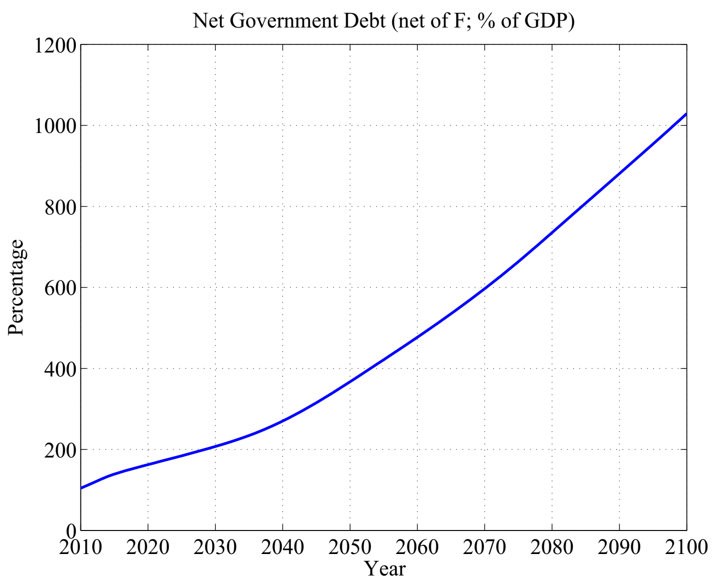


FIGURE 9

NET GOVERNMENT DEBT-TO-GDP RATIO

150%. The ratio rose further afterward even though there were substantial haircuts and outright default.

Of course, Japan is very different from Greece; it is a very large advanced economy. Most of the Japanese debt is held by Japanese individuals and institutions (more than 92%), and they seem to continue to demand JGBs despite very low yields. Our model, like others in the literature, is silent on what a dangerous threshold is for the debt-to-GDP ratio. Our simulations

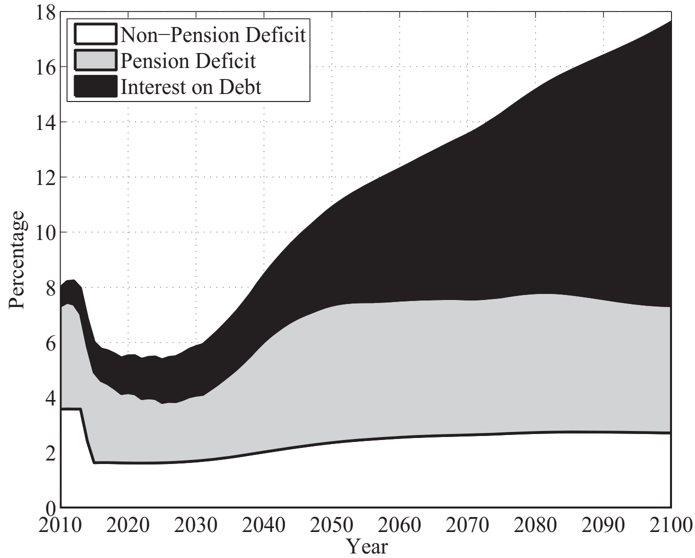


FIGURE 10

SOURCES OF NET BORROWING (% OF GDP)

indicate that the ratio can go near 300% in the 2040s if there is no change in current policy and demographic projections. Below, we will examine the main contributors to the explosion in the debt-to-GDP ratio.

Consider net new borrowing (as a ratio to GDP) given by

$$\frac{(B_{t+1}-F_{t+1})-(B_t-F_t)}{Y_t}=\frac{(G_t+TR_t-T_t)}{Y_t}+\frac{(P_t-PR_t)}{Y_t}+\frac{(r_{b,t}B_t-r_{f,t}F_t)}{Y_t}.$$

Here, we express the net borrowing requirement (as a percentage of GDP) as coming from three distinct sources: (1) government purchases and transfer payments other than pensions, (2) burden on the budget from the pension deficit, and (3) net interest paid on net government bonds (net of the pension fund returns).

Figure 10 shows this first decomposition of net borrowing.

From Figure 10, we can highlight several key findings:

- Pension and nonpension deficits contribute about the same, about 4% of GDP each, to new borrowing requirements over the next few years, with net interest on debt playing a much smaller role, thanks to the low real interest rate on JGBs in the current economic environment.
- With the consumption tax rate expected to rise from 5% to 10% in 2014–2015, there is a significant improvement in the nonpension deficit and then a gradual rise over time as nonpension transfers and health expenditures relative to GDP start to rise.
- There is an initial, significant decline and, later, a smooth decline in the pension deficit due to the reduction in replacement rates through the macroeconomic slide, the ongoing increase in the retirement age, and a rise in the pension premium. However, in about 25 years the pension deficit starts to rise again, eventually stabilizing at about 5% of GDP annually.
- Net interest payments on JGBs eventually dominate net borrowing requirements despite the low 1% interest rate; the stock of debt is just too large and has to keep on rising to finance the increasing interest payment.

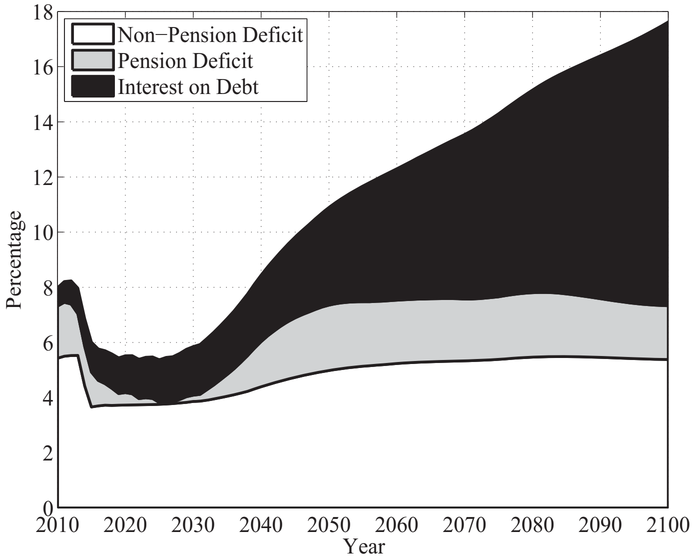


FIGURE 11

SOURCES OF NET BORROWING (% OF GDP): ALTERNATIVE DEFINITION OF PENSION DEFICIT INCLUDING THE CONTRIBUTION FROM THE GENERAL TAX REVENUES TO COVER 50% OF BASIC PENSION BENEFITS

The government uses general tax revenues to finance 50% of the total basic pension benefits. Below, we will provide an accounting of the net borrowing requirement with this alternative classification of government accounts:

$$\frac{(B_{t+1} - B_t)}{Y_t} = \frac{(G_t + TR_t + X_t - T_t)}{Y_t} + \frac{(P_t - PR_t - X_t)}{Y_t} + \frac{(r_{b,t}B_t - r_{f,t}F_t)}{Y_t}.$$

Figure 11 shows this decomposition of net borrowing.

Note that the above decomposition simply shifts the burden of pension payments onto the nonpension side of the government primary deficit. In other words, Figure 11 portrays a rosy picture of public pensions and a more depressing picture of nonpension budgetary items.

Now that we have presented some basic accounting, we can dig deeper into the components and explore the factors behind the rise in the debt-to-GDP ratio.

Figure 12 shows the time path of major government accounts all expressed as a ratio to GDP: (i) purchases of goods and services, (ii) nonpension transfer payments, (iii) total pension payments, (iv) government's 50% contribution toward basic pension payments, (v) tax revenues, and (vi) total pension premiums.

In the first frame of Figure 12, we observe a nearly 4-percentage-point increase in the ratio of government purchases to GDP. The reason for this increase is our assumption that GDP rises at the TFP growth rate of 1.5% plus the growth rate of the working population, which is lower than the growth rate of total government expenditures, which stands at 1.5% plus the growth rate of the entire population. Once population dynamics stabilize around 2060, this ratio also stabilizes. However, until then, government purchases impose an increasing burden on government finances. Any reform that would reduce the projected growth of government purchases, for example, in public health expenditures, would reduce the fiscal pressures to raise taxes and slow down the growing need to borrow from the public.

The upper right frame of Figure 12 shows the ratio of (nonpension) transfer payments to GDP. Once again, GDP rises more slowly than nonpension transfers, and the additional burden introduced by this increase is about an annual 1% of GDP in terms of new borrowing.

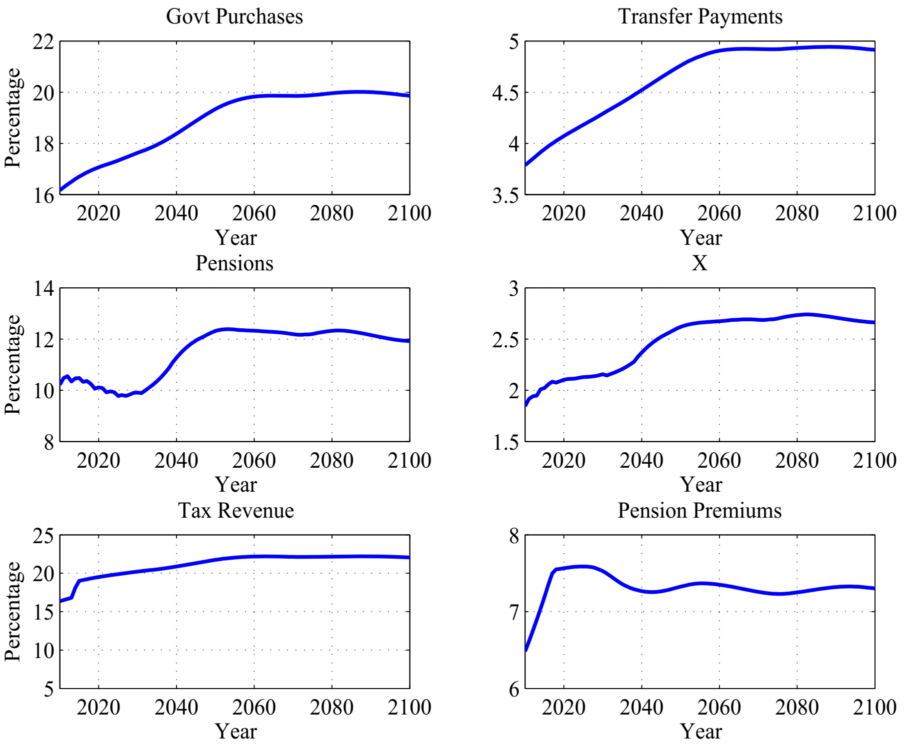


FIGURE 12

DECOMPOSITION OF GOVERNMENT ACCOUNTS (% OF GDP)

Pension payments, on the other hand, create a significant burden on the budget despite the macroeconomic slide. In the middle left frame of Figure 12, the ratio of total pensions to GDP falls by about 0.7 percentage points due to the macroeconomic slide, but once the macroeconomic slide ends, it rises quickly to reach above 12% of GDP in the mid 2040s. Clearly, pension reform would have to be a part of any fiscal policy package that deals with bringing about fiscal sustainability. A related figure is depicted in the middle right frame as the payment out of general tax revenues made by the government. This payment amounts to half of total basic pension payments. Despite the macroeconomic slide, the Japanese government has to use a significant fraction of resources to finance total pension payments over what the pension premiums can finance.

How are the tax revenues projected to deal with these large expected government expenditures? In the lower left frame of Figure 12, the ratio of tax revenues (excluding pension premiums) to GDP is projected to rise significantly due to the expected rise in the consumption tax in 2014–2015. After then, tax revenues (that include capital income tax revenues and lump sum taxes that represent import taxes and duties) are assumed to rise at the same rate as the tax base of consumption, labor, and capital income, whereas GDP rises more slowly as the size of the working population shrinks quickly. Once again, as demographic transition converges by 2060, so does this ratio.

Finally, the last frame in Figure 12 displays the ratio of total pension premiums collected to GDP. As the contribution rate for employees' pension insurance is scheduled to rise from 16.058% in 2010 by 0.354% every year to 18.3% in 2017 and the lump-sum premium for the basic pension rises, this ratio reaches a peak of above 7.5% of GDP and eventually settles around 7% of GDP.

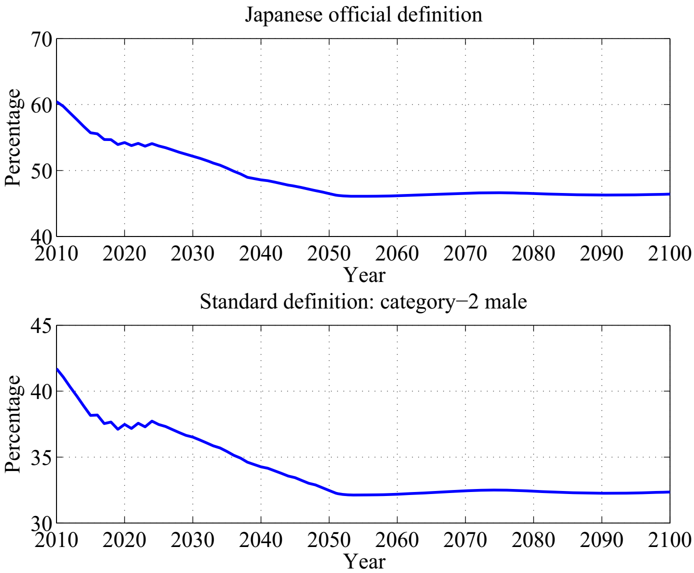


FIGURE 13

PENSION REPLACEMENT RATE

Figure 12 suggests that taking a closer look at reforms in the government expenditures could yield significant relief to the projected budget deficits. As total GDP grows at a rate less than the growth of real wages and productivity ($g_t^w = 1.5\%$), due to the decline in the size of the working population, government purchases will become a larger burden on the budget over time. Our model predicts an eventual 4% increase in the ratio of government purchases to GDP. If taxes are not raised to finance this increase, a new burden of about 4% would add to the government debt every year.

The detailed government accounts displayed in Figure 12 suggest that there are three avenues to achieve fiscal balance: (i) G_t must be contained and the near-4% of GDP increase minimized, (ii) T_t must be raised further, perhaps by enlarging the tax base and the number of taxpayers, and (iii) the pension deficit must be reduced.

We now look more closely at the Japanese pension program. As the population ages, there are increasing numbers of retirees receiving pensions. At the same time, the macroeconomic slide helps reduce the replacement rate of the pension benefits.

Figure 13 shows the projected pension replacement rates using two definitions. The first frame shows the replacement rate according to the Japanese official definition. It is the total pension benefit for a "typical" household at the age of 65 that consists of a husband who is category 2 insured and a housewife who receives the basic pension only, expressed as a ratio to the cross-sectional average disposable earnings of category 2 insured male workers. With the macroeconomic slide in effect, this replacement rate falls from 60% to about 46%. Using a different definition, where the replacement rate is taken as the ratio of category 2 insured male to the cross-sectional average earnings of category 2 male, we again see a significant reduction from above 42% to about 32%. Although there is a significant increase in the number of retirees after 2010, the macroeconomic slide reduces the average pension per retiree, and therefore there is not much change in the ratio of total pensions to GDP as we saw in Figure 12. Appendix A.3 presents the replacement rates for different types of individuals.

The impact of these projections on the pension fund can be seen in Figure 14.

Since the pension balance is negative and significant at about 4% of GDP in 2011, the pension fund begins its steep decline fueled by increased retirement in the 2010s, from about 37% of

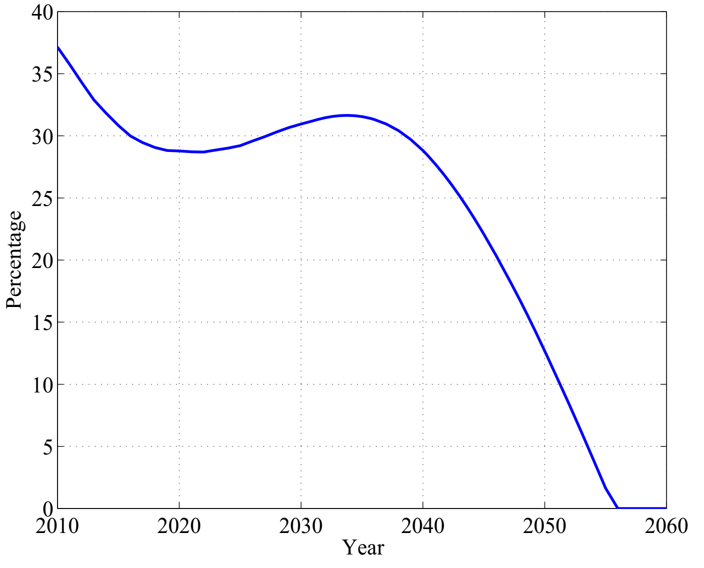


FIGURE 14

PENSION FUND (% OF GDP)

GDP to about 28% of GDP. This occurs despite the ongoing macroeconomic slide that reduces the benefit paid to each retiree. Thereafter the pension deficit declines as higher premiums are collected and lower per capita benefits are distributed to pensioners. As a result, the pension deficit falls to 2.5% in 2020s. This reduction in the pension deficit gives a pause in the fall of the fund and increases the fund balance by a few percentage points of GDP until the mid-2030s. The pension deficit rises back to its older and higher levels and settles around 5% of GDP, and this restarts the decumulation of the fund and an eventual exhaustion in 2056.

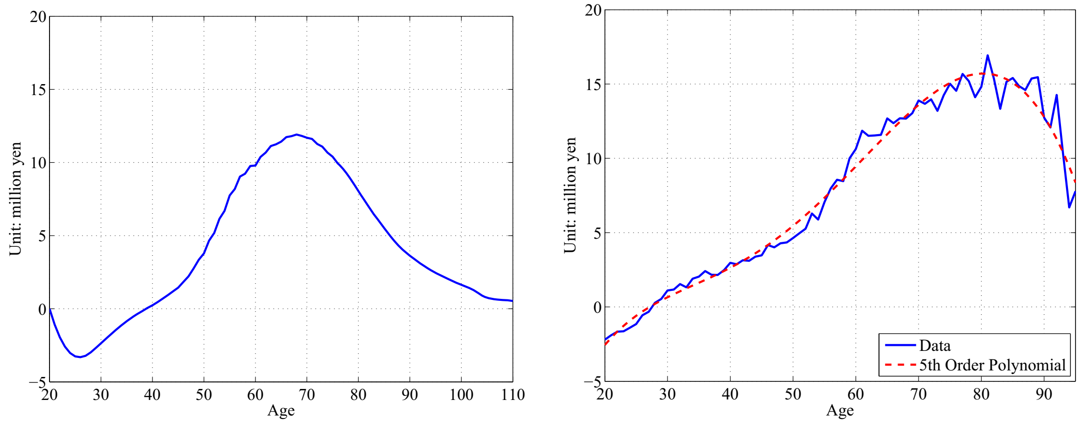
The official projection of the pension fund follows a different trajectory, which shows a rise in the fund for a few decades, followed by a steady decline. The projection, however, of the MHLW shows the funds will not be depleted even at the end of the century. Appendix A.4 compares the projection with the baseline model and discusses the difference in the underlying assumptions that can explain the variation in the results.

Figure 15(a) shows the life-cycle asset profile of individuals of the model in 2010. In the model, where we assume complete markets and allow for borrowing and lending at the same interest rate, young individuals with low income borrow against future resources. The assets are negative initially, turn positive as individuals start accumulating wealth for retirement, and peak at around 70. After that, individuals decumulate wealth to supplement pension benefits for retirement consumption.

Figure 15(b) displays the profile we have computed based on the NSFIE data, where net assets are defined as the sum of a household's financial assets net of debt. We compute a profile for individuals using an equivalence scale.

The data show a similar hump-shaped pattern, though the accumulation continues until around 80, about a decade later than in the model. Features such as bequest motives or precautionary savings against health expenditure shocks, which the model does not explicitly incorporate, may contribute to the difference in the peak. The ratio of average wealth held by retirees to that of all individuals is 0.56 in the model compared to 0.63 in the data.[21]

[21] The aggregate consumption is approximately 180 trillion yen in 2010, which is lower than 220 trillion yen, the final consumption expenditure of households from the SNA data in 2010. The ratio, however, of the aggregate consumption to total earnings of households is 0.84, which is in line with that in the data at 0.83.



(a) Model (b) Data

FIGURE 15

ASSET PROFILE

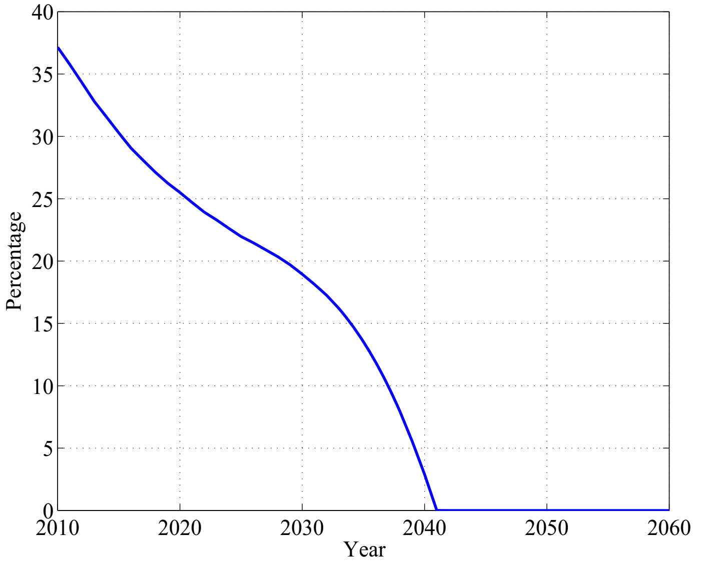


FIGURE 16

PENSION FUND (% OF GDP): WITHOUT MACROECONOMIC SLIDE

6. SENSITIVITY ANALYSIS

6.1. *No Macroeconomic Slide.* How important is the macroeconomic slide introduced in 2004 and amended since then? Figure 16 shows the pension fund under the counterfactual assumption that the pension rules follow pre-2004 arrangements and ignore the reforms of the macroeconomic slide.

Without any significant reductions in pension benefits or increases in premiums, the pension fund is very quickly depleted and disappears in 2041. This counterfactual simulation highlights the quantitative significance of the macroeconomic slide in containing the burden of pensions on the government budget.

TABLE 2
EFFECTS OF DIFFERENT WAGE GROWTH RATES ON FISCAL SUSTAINABILITY

	$\frac{(B_t - F_t)}{Y_t}$		
g_t^w	0.5%	Baseline (1.5%)	2.5%
2010	1.042	1.042	1.042
2020	1.862	1.625	1.411
2030	2.712	2.074	1.562
2040	3.935	2.701	1.811
2050	5.778	3.670	2.280
2060	8.026	4.771	2.777

If the macroeconomic slide were not implemented, Japan would have experienced additional increases in the debt-to-GDP ratio. By 2020, this would add 6.2% to the ratio of JGBs to GDP, but by 2030 it would amount to an extra 20.6% and by 2050 an extra 77.2%, including the added burden of higher interest payments due to a larger stock of debt. Clearly, the macroeconomic slide helps reduce the pension deficit and the overall fiscal burden during the transition period due to the retirement of an increasing number of individuals.

6.2. *Productivity Growth.* In our baseline simulation, we assume a real wage growth rate of 1.5%, in part to be consistent with official forecasting in calculating future pension benefits and premiums. Below, we present alternative results that assume growth rates of 0.5% and 2.5% instead.

In Table 2, a higher real wage growth of 2.5% allows for a longer period of time until debt-to-GDP ratio goes above 200%, as tax revenues grow faster than the benchmark case. Still, the fiscal balance is not achieved with debt-to-GDP ratio at historically unprecedented highs.

On the other hand, slower growth, such as a 0.5% real wage growth, brings the fiscal day of reckoning much faster and makes the case for fiscal reform urgent. The ratio of debt to GDP goes over 200% soon after 2020. The growth rate of real GDP in Japan has been below 2.5% over the last two decades, and this table suggests that unless a growth miracle occurs, policymakers should not count on significant increases in tax revenues coming from faster economic growth.

In order to see how growth affects the decomposition of the budget deficit into components, consider Table 3.

Table 3 presents a detailed accounting of the reasons for the debt-to-GDP ratio to increase. In 2010, the nonpension budget deficit contributes 44.9% of the net borrowing requirements, which amounts to 3.58% of GDP. The pension deficit creates a fiscal burden of a similar magnitude, 46.7% of the total for 2010, which is 3.73% of GDP. The burden of net interest on government's net debt is only 0.67% of GDP. The total net borrowing requirement in 2010 is 7.98% of GDP.

According to Table 3, slower real wage growth mostly affects the pension budget deficit. When the labor income tax base grows slower than in the benchmark simulation, total pension premiums and taxes collected grow more slowly, creating a larger deficit and a much larger net borrowing requirement. The opposite is true with a higher real wage growth rate.

Slower or faster real wage growth has an indirect impact on the contribution of net interest payments on government debt to the net increase in debt. As the tax base grows slower than in the benchmark case, there is a larger debt arising from higher pension and nonpension deficits. In addition, the reduction in the pension fund reduces the return that the government makes on the fund. As a result, net interest paid on the government's net debt eventually becomes the largest component in net borrowing by 2060.

6.3. *Returns on the Pension Fund.* Table 4 shows the debt-to-GDP ratios for selected years for different assumptions on the return to the pension fund assets. Clearly, the return on the

TABLE 3
EFFECTS OF DIFFERENT WAGE GROWTH RATES ON SOURCES OF BORROWING

g_t^w	0.5%	Baseline (1.5%)	2.5%
		$\frac{(G_t + TR_t - T_t)}{Y_t}$	
2010	0.0395	0.0358	0.0315
2020	0.0202	0.0163	0.0127
2030	0.0212	0.0170	0.0135
2040	0.0247	0.0202	0.0167
2050	0.0284	0.0236	0.0200
2060	0.0304	0.0256	0.0220
		$\frac{(P_t - PR_t)}{Y_t}$	
2010	0.0383	0.0373	0.0364
2020	0.0344	0.0255	0.0175
2030	0.0371	0.0238	0.0127
2040	0.0553	0.0400	0.0276
2050	0.0673	0.0499	0.0357
2060	0.0687	0.0498	0.0346
		$\frac{(r_{b,t}B_t - r_{f,t}F_t)}{Y_t}$	
2010	0.0067	0.0067	0.0067
2020	0.0158	0.0134	0.0118
2030	0.0248	0.0176	0.0120
2040	0.0384	0.0241	0.0140
2050	0.0578	0.0354	0.0193
2060	0.0803	0.0477	0.0252

TABLE 4
EFFECTS OF DIFFERENT RETURNS ON THE PENSION FUND ON FISCAL SUSTAINABILITY

		$\frac{(B_t - F_t)}{Y_t}$	
$r_{f,t}$	1%	Baseline (2%)	3%
2010	1.042	1.042	1.042
2020	1.657	1.625	1.589
2030	2.138	2.074	1.996
2040	2.802	2.701	2.564
2050	3.805	3.670	3.459
2060	4.923	4.771	4.489

fund has a very small impact on the overall debt, as the ratio of the pension fund to GDP is relatively small and projected to decline in the future.

6.4. *Returns on the Government Debt.* However, if the interest rate on government debt is higher than the 1% assumed for the benchmark case, the resulting impact on fiscal balance can be disastrous. For example, if the real interest rate on government debt is 3%, then the debt-to-GDP ratio will reach 200% in 2020 and 300% in 2030, as shown in Table 5.

On the other hand, a lower real interest rate on government bonds significantly reduces the fiscal burden. For example, if the interest rate is zero, then the 200% debt-to-GDP threshold is postponed for another decade. In addition, if Japan experiences inflation, and, in particular, inflation in excess of the nominal interest rate of government bonds, then the decline in the real

TABLE 5
EFFECTS OF DIFFERENT RETURNS ON GOVERNMENT DEBT ON FISCAL SUSTAINABILITY

			$\frac{(B_t - F_t)}{Y_t}$		
$r_{b,t}$	−1%	0%	Baseline (1%)	2%	3%
2010	1.042	1.042	1.042	1.042	1.042
2020	1.318	1.465	1.625	1.799	1.988
2030	1.416	1.716	2.074	2.500	3.006
2040	1.619	2.090	2.701	3.493	4.520
2050	2.049	2.724	3.670	5.001	6.880
2060	2.525	3.420	4.771	6.828	9.981

TABLE 6
EFFECTS OF DIFFERENT FERTILITY PROJECTIONS ON FISCAL SUSTAINABILITY

		$\frac{(B_t - F_t)}{Y_t}$	
	Low Fertility	Baseline	High Fertility
2010	1.042	1.042	1.042
2020	1.621	1.625	1.628
2030	2.050	2.074	2.099
2040	2.667	2.701	2.740
2050	3.712	3.670	3.631
2060	5.008	4.771	4.560

value of the stock of government bonds helps contain the fiscal problem for several decades. In this case, more moderate reform in expenditures or small increases in tax revenues may bring about fiscal sustainability. However, this case assumes a negative 1% real interest rate on JGBs for nearly a century, and it is difficult to expect that Japanese bondholders would not demand better terms to hold this asset voluntarily.

6.5. *Different Fertility Projections.* There are three versions of the fertility projections produced by the IPSS: low, medium, and high variants. Table 6 shows the debt-to-GDP ratios for selected years for the three variants of fertility projections. Higher fertility raises the relative share of working cohorts in the population and tends to improve fiscal balance. However, whichever variant happens to be realized, there is very little difference on the fiscal position of Japan. This may come as a surprise at first glance. However, an improvement in tax revenues as the tax base increases is nearly completely offset by similar increases in per capita expenditures, both during working years and also in retirement. As a result, higher or lower fertility has only a small impact on the debt-to-GDP ratio, even in the long run.

6.6. *Different Survival Projections.* Table 7 displays the debt-to-GDP ratios for selected years for low, medium, and high survival rate projections made by the IPSS. Here, the impact on fiscal sustainability is even smaller. Longer lives raise the fiscal burden as the share of elderly in the society increases. However, the quantitative impact seems to be very small.

7. POLICY EXPERIMENTS

7.1. *Pension Rules.* The population is aging very rapidly in Japan, and this is putting significant pressure on the pension system. If the government undertook additional pension reform, how much would this impact the debt-to-GDP ratio in the future?

TABLE 7
EFFECTS OF DIFFERENT SURVIVAL PROJECTIONS ON FISCAL SUSTAINABILITY

$$\frac{(B_t - F_t)}{Y_t}$$

	Low Survival	Baseline Survival	High Survival
2010	1.042	1.042	1.042
2020	1.625	1.625	1.626
2030	2.061	2.074	2.078
2040	2.664	2.701	2.723
2050	3.594	3.670	3.724
2060	4.645	4.771	4.868

TABLE 8
EFFECTS OF DIFFERENT PENSION RULES ON FISCAL SUSTAINABILITY

$$\frac{(B_t - F_t)}{Y_t}$$

	Baseline	$i_R = 70$	Benefit Cut by 10%	$i_R = 70$ and Benefit Cut by 10%	Earnings Tax Rate Up by 5%
2010	1.042	1.042	1.042	1.042	1.042
2020	1.625	1.608	1.502	1.487	1.622
2030	2.074	1.992	1.818	1.744	1.942
2040	2.701	2.417	2.277	2.022	2.347
2050	3.670	3.058	3.021	2.470	3.046
2060	4.771	3.830	3.861	3.013	3.834

Table 8 summarizes the impact on Japan's net government debt-to-GDP ratio under alternative pension reforms. Raising the retirement age to 70 has a small effect in the short run, a larger effect in the long run, but still does not bring about a sizable reduction in debt to GDP over the next 30+ years compared to the baseline case.[22] Just by itself, raising the retirement age from the current 65 to 70 is insufficient in achieving fiscal balance in Japan.

Cutting pension benefits by 10% reduces debt to GDP (by reducing the pension deficit) more significantly in the short run. Similarly, raising the earnings tax rate on employers' pension part by 5 percentage points slows down the increase in debt-to-GDP ratio.

What helps the most is a combination of raising the retirement age to 70 and reducing benefits by 10%. The debt-to-GDP ratio is still below 200% until 2040 under this combination of new pension rules. The findings in Table 8 highlight the need to consider bolder reforms in the pension system, but at the same time, point to other policies in conjunction with pension reform in order to establish fiscal sustainability.

Table 9 presents the net borrowing requirements in selected years when the retirement age is raised to 70 and there is a 10% cut in pensions.

The decrease in the share of retirees in the population has a positive impact on the nonpension deficit. The biggest impact, however, is naturally on the pension deficit. It drops below 1% for two decades and then hovers about 2 percentage points for a long time. With significant improvement in the pension and nonpension budget balances, the debt-to-GDP ratio increases much more slowly, and the interest burden is much smaller than in the benchmark case. Still, if the goal is to restore fiscal balance and bring the debt-to-GDP ratios to levels in the last two decades, then additional policies must be put on the table.

7.2. *Consumption Tax.* Table 10 displays the net debt-to-GDP ratio when the consumption tax is raised beyond 10%, which is the current law and expectation. We assume that the

[22] Raising the retirement age to 67 has very little impact in the short run and only a minor effect by 2060.

TABLE 9
RETIREMENT AT AGE 70 AND 10% BENEFIT CUT

	$\frac{(B_t - F_t)}{Y_t}$	$\frac{(G_t + TR_t - T_t)}{Y_t}$	$\frac{(P_t - PR_t)}{Y_t}$	$\frac{(r_{b,t}B_t - r_{f,t}F_t)}{Y_t}$
2010	1.042	0.034	0.024	0.007
2020	1.487	0.014	0.014	0.011
2030	1.744	0.014	0.005	0.012
2040	2.022	0.017	0.005	0.013
2050	2.470	0.021	0.018	0.015
2060	3.013	0.024	0.019	0.018

TABLE 10
EFFECTS OF HIGHER CONSUMPTION TAX RATES ON FISCAL SUSTAINABILITY

		$\frac{(B_t - F_t)}{Y_t}$	
$\tau_{c,t}$	10%	15%	20%
2010	1.042	1.042	1.042
2020	1.625	1.573	1.564
2030	2.074	1.814	1.662
2040	2.701	2.218	1.856
2050	3.670	2.932	2.336
2060	4.771	3.765	2.925

consumption tax rate increases 1% per year from 2016 and reaches 20% in 2025. According to our simulations, we can expect a sizable reduction in the debt-to-GDP ratio when the consumption tax rate is raised to 20%.

A higher consumption tax reduces the nonpension deficit significantly. In fact, when it is raised to 20%, the nonpension budget balance becomes positive and helps in reducing the overall net borrowing requirements. However, the pension deficit remains unchanged, and these findings highlight the importance of pension reform or much higher levels of taxation or a combination of these policies in order to bring about fiscal sustainability to Japan.

In order to highlight the factors that cause the depletion of the pension fund and the continued increase in the debt-to-GDP ratio in the long run, consider Figure 17, which shows the decomposition of net borrowing requirements into pension, nonpension, and interest payment sources.

Figure 17 indicates that the nonpension deficit is eliminated through 2100 and turned into a surplus. The pension deficit is unaltered, and, together with the increasing burden of interest payments, the ratio of net debt to GDP continues to rise out of control.[23]

7.3. *Female Labor Force Participation.* The level of the female labor force participation rate in Japan is comparable to other OECD countries, and it is in fact slightly above the average. The gap, however, between male and female participation rates stood at 25% in 2009, although it was much lower in other countries, for example, at 14% in the United States, 13% in the United Kingdom, and 12% in Germany, according to the IMF Report by Steinberg and Nakane (2012).

[23] In an unreported experiment, we calculated the consumption tax that would be sufficient to finance the fiscal burden related to aging and stabilize the debt-to-GDP ratio at around 80%. We found that a 35% consumption tax is needed. Note, however, that this is likely to be a lower bound for a consumption tax rate that will restore fiscal balance because we abstract from the negative effects of a higher consumption tax on the private sector behavior. Indeed, when Hansen and İmrohoroğlu (2013) take the distorting effects of a higher consumption tax into account, they find that a consumption tax higher than 45% is needed to achieve fiscal sustainability.

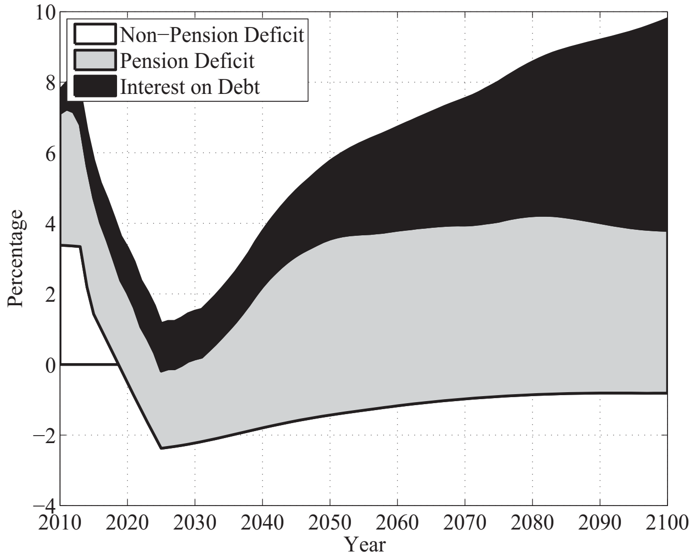


FIGURE 17

SOURCES OF NET BORROWING REQUIREMENTS (% OF GDP): CONSUMPTION TAX AT 20%

TABLE 11
EFFECTS OF FEMALE LABOR FORCE PARTICIPATION ON FISCAL SUSTAINABILITY

	$\frac{(B_t - F_t)}{Y_t}$			
	Baseline	FLFP (A)	FLFP (B)	FLFP (C)
2010	1.042	1.042	1.042	1.042
2020	1.625	1.496	1.593	1.457
2030	2.074	1.724	1.932	1.555
2040	2.701	2.148	2.389	1.779
2050	3.670	2.845	3.163	2.247
2060	4.771	3.654	4.061	2.812

Below, scenario (A) assumes a rise in the average FLFP rates to those of males at each age holding unchanged the relative shares of three employment types as regular, contingent job, and self-employed, conditional on participation. Scenario (B) assumes a rise in the share of regular employment for females and convergence of employment type distribution to the level of males at each age, with no change in the average FLFP rate at each age. Finally, scenario (C) assumes that (A) and (B) occur simultaneously.

Table 11 shows that a significant increase in the FLFP, especially under scenario (C), provides medium term relief to the fiscal burden. Indeed, the improvement in the debt-to-GDP ratio under scenario (C) is greater than that under a consumption tax rate of 20%, as the last columns of Tables 10 and 11 indicate.

Figure 18 reveals how higher FLFP under scenario (C) improves fiscal projections.

First, the pension tax base is greatly (and immediately) increased, and the pension balance improves significantly. Although females now receive larger total pensions that result from higher labor market earnings, they also contribute larger pension premiums on their employers' pension. Since the latter starts immediately, there is a significant relief to the pension budget. Eventually, the pension deficit grows to an annual rate of about 4% of GDP, somewhat smaller than that in the benchmark case.

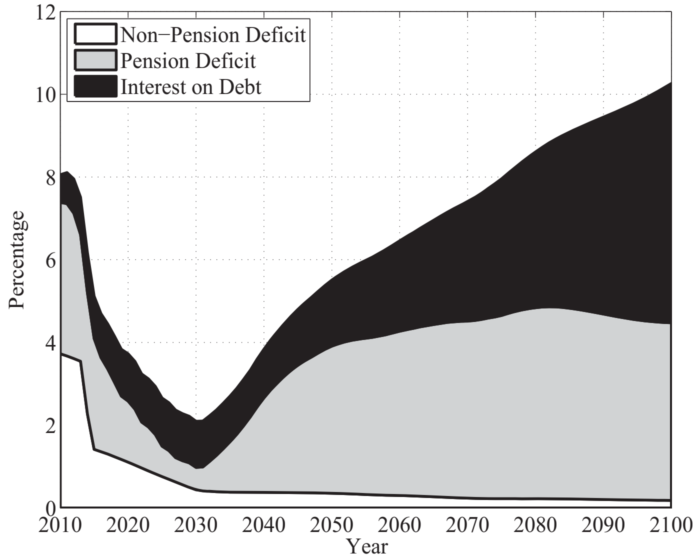


FIGURE 18

SOURCES OF NET BORROWING REQUIREMENTS (% OF GDP): FLFP SCENARIO (C)

Second, when females participate in labor market activities at rates comparable to their male counterparts, the nonpension part of the budget is almost permanently brought to balance.

These results emphasize the quantitative importance of raising the female labor force participation rates in Japan. With positive effects in both the pension and the nonpension (and therefore in the interest burden as well), designing policies that incentivize higher labor market activities among females seems very promising.

7.4. *Additional Earnings Heterogeneity.* In this section, we assume that female earnings are determined as a function of not only age, gender, and employment but also the number of dependent children in a household. As discussed in Section 4, we use the BSWS data for the calibration of earnings, but since we are not able to access individual data, we use the NSFIE data to estimate the impact of dependent children on earnings of female workers. We assume that the effects of children are represented by a second-order polynomial and estimate coefficients of the following regression model:

$$\ln Y_{i,e} = \ln \bar{Y}_{i,e} + \alpha_{1,e}\#Kids_t + \alpha_{2,e}\#Kids_t^2,$$

where $\bar{Y}_{i,e}$ is the base earnings of a female worker of age i and employment type e without a dependent child.

In defining a dependent child in each household, we assume that the relationship to head of household is "children" in the database and the age has to be below 16. The estimated coefficients are summarized in Table 12. The presence of children in a household is associated with lower earnings across female workers of different types. There are some economies of scale, and each additional child has less negative impact, as can be seen in the small, but positive coefficient on the square terms.

We have simulated the benchmark model as well as other policy experiments and sensitivity analysis under the assumption that earnings depend on the number of dependent children. The main results as well as the experiment results, are not different from those in the baseline model both qualitatively and quantitatively.

TABLE 12
EFFECT OF CHILDREN ON FEMALE EARNINGS

	$\alpha_{1,e}$	$\alpha_{2,e}$
Full-time worker	−0.26684	0.04036
	(0.0109)	(0.0037)
Contingent job worker	−0.11173	0.00967
	(0.0223)	(0.0068)
Self-employed	−0.22847	0.03374
	(0.0480)	(0.0151)

NOTES: Standard errors in parentheses.

As shown in Figure 2, the fertility rates are projected to decline slightly over the next decades. Fewer dependents will have positive effects on the average earnings through the negative relationship between female earnings and the number of dependent children. The higher earnings will raise the revenues for the pension budget as the tax base increases, but at the same time increase the benefits when the individuals reach the retirement age. The pension fund will decline at a slower pace, but the difference is small. The fund will reach zero in 2057, one year later than in the baseline model with no earnings dependence on children.

7.5. *Immigration Policy.* In this section, we present the results that assume that the government implements a new guest worker program in Japan.

In the past, Japan has not been very active in allowing foreign workers to reside in Japan, and immigration policies have not been given serious consideration as a major solution to deal with fiscal problems. In February 2014, however, the government started to take the issue more seriously and published a preliminary report that studies the fiscal impact of allowing more immigrants.[24]

We represent the government's newly proposed guest worker program by allowing a fixed number of foreign workers to work in Japan for a limited number of years. This is done in a similar way as the U.S. government allows temporary foreign workers with a nonimmigrant visa and has them return to their home country once the visa expires.

More precisely, we assume that 200,000 foreign workers will come to Japan every year starting in 2015 and that every worker arrives at age 25 and stays for the maximum period of 20 years. Every year 10% of existing foreign workers return to their own country, implying an average duration of 10 years. The total number of guest workers amounts to 1,780,000 eventually.

For simplicity, we assume that 50% of the foreigners are male and the other 50% are female and that they will all work as employees and earn the wages that are the same as those of irregular workers in Japan. The wage assumption is based on Hashimoto (2009) that documents that the wage profile of foreign workers in Japan is similar to that for irregular Japanese workers. Note that we have already estimated an earnings profile for these irregular workers that we will now also use for the guest workers. Concerning the consumption pattern of guest workers, there are no data available, and we simply assume that guest workers and immigrants consume 80% of their earnings, a similar percentage to the Japanese, and send the remainder to their home countries as remittances. In terms of the pension subscription categories, we assume that 50% are of category 1, enrolled in the basic pension (*Kiso Nenkin*) program only, and the other 50% are covered by an employer-based pension (*Kosei Nenkin Hoken*) program and contribute to the system accordingly.[25]

The path of the pension fund under the guest worker program is displayed in Figure 19 and

[24] "*Sentaku-suru Mirai*," Cabinet Office, Government of Japan (2014).

[25] Foreign workers are allowed to submit a claim for a partial refund of the contribution they have made to the public pension programs after they return to their home country, but we abstract from this payment since the scope of the repayment is limited. In our model, the guest workers pay the consumption tax, labor income tax, and the lump-sum tax, but they do not pay capital income tax since their financial assets are assumed to be sent to their home

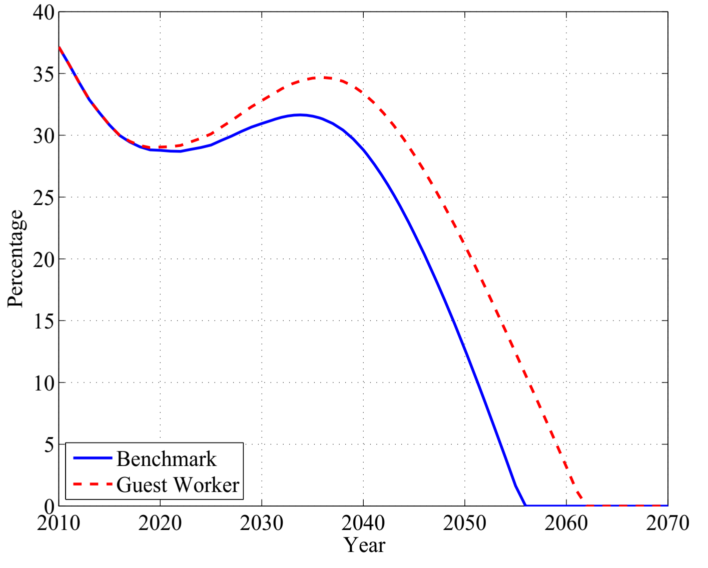


FIGURE 19

PENSION FUND (% OF GDP)

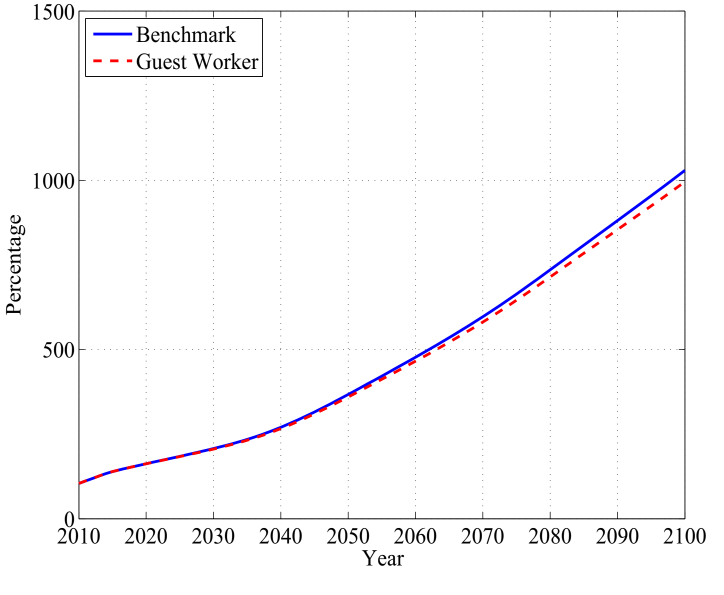


FIGURE 20

NET GOVERNMENT DEBT-TO-GDP RATIO

compared to the profile in the benchmark model. This immigration policy will increase the revenues through the taxation on foreigners' earnings and delays the timing of the pension fund exhaustion, although the change is relatively small, by about 6 years.

The path of the debt-to-GDP ratio is displayed in Figure 20. The guest worker program will reduce the level of the debt as foreign workers contribute to tax revenues and the social security

countries. In addition, they receive the nonpension transfer payments tr_t, and the government incurs per-capita expenditures g_t as for each Japanese individual.

budget, but the program will not dramatically affect the overall picture of the mounting debt or resolve the imbalance in the social security program.

8. CONCLUSION

Most advanced economies are currently facing significant demographic and fiscal problems. Among them, Japan leads the world in the speed of aging and the level of the public debt. In this article, we build a detailed overlapping generations model and use estimates from Japanese micro data to simulate future paths of fiscal quantities. Our findings suggest that absent any change in current policies, Japan will continue to run large pension and nonpension deficits, and the debt-to-GDP ratio will continue to reach unprecedented highs, with interest payments on the debt becoming the biggest and growing burden.

We find that no single policy or economic outcome considered can restore fiscal balance in Japan by itself. Among the alternative scenarios analyzed, pension reform that extends the retirement age to 70 and cuts benefits by 10% reduces the pension deficit significantly and helps to slow down the growth of government indebtedness. An increase in the consumption tax from the scheduled 10% to 20% turns the nonpension deficit into a surplus immediately and for several decades. However, the unchanged pension deficit results in large new borrowing, and the ratio of debt to GDP resumes its rise. An increase in the female labor force participation rate that makes both the participation rates and employment types and earnings of females similar to those of males has a larger impact. This outcome improves both the pension and the nonpension balance, but large deficits still persist into following decades. Only a combination of these and other outcomes may accomplish the task of achieving fiscal balance in Japan.

Of course, there are other policies that can make a large impact. In particular, a comprehensive immigration policy or fundamental tax reform could reduce distortions and increase the tax base. These policies and other reforms are left for future research.

APPENDIX

A.1. *More Details on the Calibration of the Pension System.* This section provides more details of the Japanese pension system and how it is calibrated in the article.

As discussed in Section 4.3, individuals in each type of employment are assigned to the three categories of pension subscription to match the distribution across categories by gender as reported in the Subscription Survey conducted by the MHLW.[26]

For males, we assume that all regular workers are category 2 subscribers and that all contingent job and self-employed workers as well as those not working are category 1 subscribers. For females, we assume that all regular workers are category 2 subscribers. Contingent job workers constitute the largest fraction of female workers above age 35. We allocate female contingent job workers of each 5-year age group to the three categories of pension subscription so that we match the age-category distribution as reported in the survey.[27] Self-employed workers belong to category 1. For nonemployed individuals, we assume that about 40% belong to category 1 and 60% to category 3, except for younger age groups in their 20s, where a larger fraction of nonworking females are of category 1 rather than 3, accounting for a larger number of unmarried females in this age group.

As discussed in Section 3.1, the two main pillars of the public pension schemes in Japan are the basic pension (*Kiso Nenkin*) and the employees' pension insurance (*Kosei Nenkin Hoken*). All citizens in Japan between ages 20 and 59 are covered under the basic pension, which constitutes the first tier of the public pension system. The employees' pension insurance is available only

[26] http://www.mhlw.go.jp/toukei/list/141-1.html (in Japanese). See the appendix for more details of the pension subscription categories.

[27] The fraction of female contingent job workers that are category 1 subscribers falls from 62.5% at age 20–24 to 40% at 25–29, 22.5% at 30–34, and 20% at 35–54. The fraction of category 3 subscribers rises from 7.5% at 20–24 to 30% at 25–29, 47.5% at 30–34, and 50% at 35–54. The category 2 subscribers constitute about 30% across all age groups.

for category 2 workers.[28] Although some companies provide schemes such as private defined contribution pension plans as a third tier, we do not consider them explicitly in the model.

Macroeconomic slide. As discussed in Section 4.3, the Japanese government automatically adjusts pension benefits according to the "macroeconomic slide." $x_{t,t-i}$ in Equation (4) is the slide factor that represents the adjustment through the macroeconomic slide, and it is determined as follows.

First, denote by s_t the "slide adjustment factor," which consists of two parts: one that reflects the change in the number of the insured and the second that is associated with a rise in life expectancy (or expected duration of pension receipt). The slide adjustment rate is approximately estimated at 0.9% (0.6% and 0.3% for these two factors, respectively) on average. In the official projections by the government, they assume that the slide adjustment occurs from 2012 to 2038 for the basic pension and to 2019 for the employees' pension insurance.[29]

The reduction, however, may not happen every year, since the adjustment is capped by inflation rates as explained below. In the benchmark case, we assume an inflation rate of 1% to make the macroeconomic slide work although it is slightly higher than the realized inflation rates in recent years.[30] Denote the inflation rate as π_t and growth rate of real wage as g_t^w. The slide factor $x_{t,t-i}$ is given as

$$x_{t,t-i} = (1 + g_t^x) x_{t-1,t-i-1},$$
$$g_t^x = \begin{cases} \max\{g_t^* - s_t, 0\} & \text{if} \quad g_t^* \geq 0, \\ g_t^* & \text{if} \quad g_t^* < 0. \end{cases} \tag{A.1}$$

For new recipients (*Shinki-saitei*), who have just reached the retirement age, g_t^* in (A.1) is defined as $g_t^* = g_t^w + \pi_t$. For existing recipients (*Ki-saitei*), $g_{t,t-i}^* = \pi_t$. Therefore, if the sum of the wage growth rate and the inflation rate is strictly larger than the slide adjustment rate, the actual replacement rate gradually declines as time goes by.

For example, if the inflation rate is 1.0% and the wage growth rate is 2.0%, the benefits of retiring cohorts would increase by 3.0% normally. With the macroeconomic slide, however, if the slide adjustment factor s_t is 0.9%, the actual change will be only 2.1%. In the same year, the benefits of existing retirees will increase by $1.0 - 0.9 = 0.1\%$. Note that for given wage growth and inflation rates, the adjustment differs by cohort $t - i$, because the slide adjustment rate s_t varies over time.

A.2. *Notes on the Database Used in the Calibration.* This section describes more details about different data sets we use in the article and explains how the selection is made. To calibrate our model, we need data on earnings by age, gender (for females with and without children), and job type. These age-earnings estimates will drive our results, together with our representation of the Japanese pension system and tax policy. What is the best source of data for our purposes? We consider three options; the BSWS, the FIES, and the NSFIE.

[28] More concretely, the second tier consists of the employees' pension insurance and mutual aid pension (*Kyosai Nenkin*). Public officer and teachers are included in the mutual aid pension, not the employees' pension insurance. However, as the insurance payments and benefits of these two are very similar, we combine the two and treat them as the employees' pension insurance in the second-tier.

[29] The final year in which the macroeconomic slide stops is endogenously determined from the official simulation, called the actuarial valuation for public pension system (*Zaisei Kensyo*), by the government. It is determined so as to satisfy the following two criteria: (1) the budget for public pension balances in about 100 years, and, when (2) the government can maintain the balance in the public pension fund, which amounts to one year benefit in 2105. Because the basic pension (*Kiso Nenkin*) fund does not have sufficient balance compared with the employees' pension insurance, the adjustment is expected to last longer for the basic pension.

[30] In fact, the macroeconomic slide did not work as intended after its introduction in 2004 due to deflation.

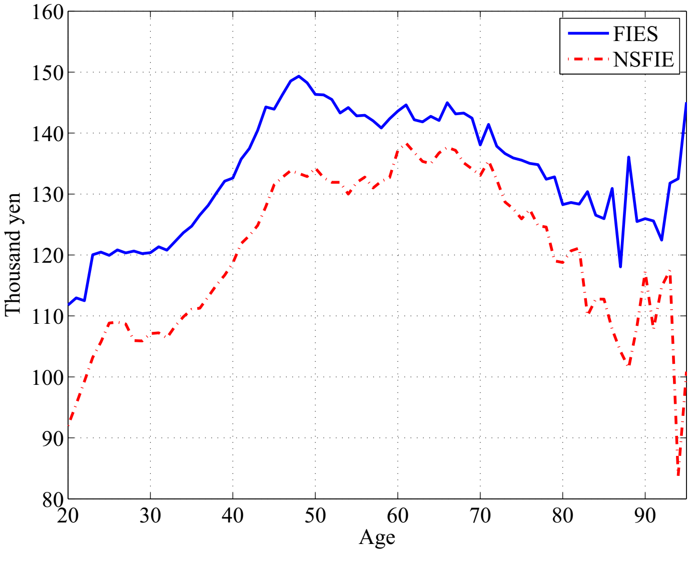


FIGURE A.1

CONSUMPTION PROFILE: FIES VERSUS NSFIE

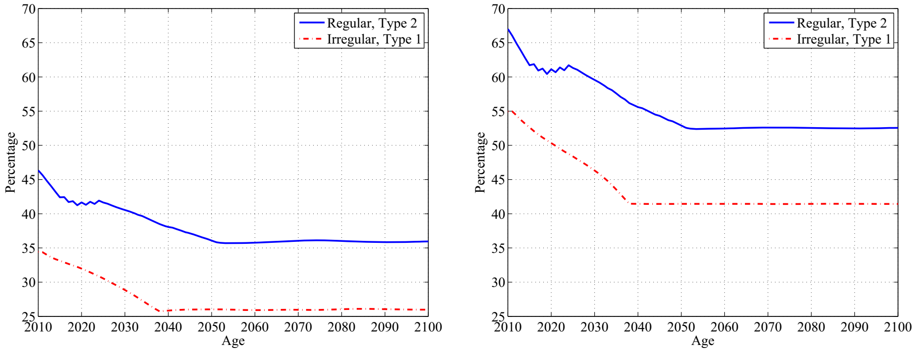
We chose to use the BSWS to estimate and calibrate the baseline earnings profiles since the data are based on a comprehensive national survey of both public and private employees and serve as the most reliable and accurate estimates of the earnings process across heterogeneous agents in our model. The survey is focused on the details of the earnings and characteristics of employees including gender, age, employment type, industry, employee ranking, etc. The survey unit of the BSWS is establishments, instead of individual workers. The sample size of the establishments is about 78,000, and the number of the employees sampled is over 1.5 million.

The sample size of the other data sets, FIES and NSFIE, is not large enough to estimate the earnings of heterogeneous individuals in the model, for example, earnings of full-time females at old ages. Being an establishment survey, the BSWS does not cover self-employed workers. For the calibration of the earnings of self-employed individuals, we use the NSFIE. The FIES also asks their sample subjects about both monthly and annual earnings, but self-employed workers do not necessarily report monthly earnings as salaried workers. In addition, annual self-employed income reported by a household includes asset and other nonlabor income. It is also not separable between husband and wife, and we are not able to estimate earnings profiles of self-employed by gender using the FIES.

For the purpose of estimating the shape of consumption over the life cycle, we use the FIES data. The FIES collects data on monthly expenditures of households throughout the year, and we can derive expenditures of each household for an entire year. The NSFIE reports average consumption expenditures between September and November only, and the estimates are subject to biases associated with seasonality. We pointout, however, that the NSFIE could be a better source without the seasonality issue given that the sample size is much larger than FIES. For the life-cycle asset profile that we have shown in the text, we use the NSFIE for this reason.

To further investigate the advantage of using the FIES in estimating the consumption profile, we have studied the consumption data from the NSFIE and compared them with those from the FIES, as shown in Figure A.1.

The shapes of the two profiles are similar, and both exhibit a hump shape with the peak reached at around 50. The levels, however, differ significantly because the NSFIE fails to capture large seasonal expenditures such as tuition fees and holiday spending at the end and



(a) Male (b) Female

FIGURE A.2

REPLACEMENT RATE FOR REGULAR AND IRREGULAR WORKERS

beginning of the year. It also does not cover the periods when a biannual bonus is typically paid to employees in the summer and winter.

A.3. *Pension Replacement Rates.* This section presents four sets of pension replacement rates in our model in addition to the two that we report in Section 5, one for the replacement rates according to the Japanese government's official definition and the other one for male workers in category 2 subscription.

Figure A.2 shows replacement rates for two types of workers, males and females, respectively, who retire at age 65 in each year, defined as the pension benefits as a fraction of average life-time earnings. The solid line in each plot represents the replacement rate for a hypothetical individual who worked as a regular worker throughout his or her life cycle as a category 2 pension subscriber. The dash-dotted line represents the replacement rate for an individual who worked as an irregular worker and under the pension subscription category 1.

Since male regular workers receive higher wages than irregular workers, the denominator of the replacement rate will be higher, but a higher pension benefit due to the part that is proportional to earnings will dominate, and the replacement rate is higher for regular category 2 workers.

Earnings of female workers are significantly lower than those of males in both regular and irregular jobs, and the replacement rates are higher. The fixed basic pension accounts for a much larger fraction of pension benefits for females.

A.4. *Comparison with the Official Projections.* In this section, we compare our benchmark results to the official projection of the government. The MHLW reports the projections of the pension budget.[31]

The projected path of the pension trust fund according to the MHLW's forecast is displayed in Figure A.3 as "official." Compared to our baseline model, they project higher net revenues, and the program will not go into deficit again until 2040 and the funds will not be exhausted even at the end of the century. Our baseline model predicts the fund will be depleted by 2056.

The official projections make a few key assumptions that produce results that differ from those in our scenario. First, the labor force participation for both male and female workers is assumed to grow by several percentage points, whereas our baseline model assumes that the

[31] The forecast is part of the actuarial valuation for the public pension system (*Zaisei Kensyo*) and includes projections for both the basic pension (*Kiso Nenkin*) and the employees' pension insurance (*Kosei Nenkin Hoken*). http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/nenkin/nenkin/zaisei-kensyo/index.html (in Japanese)

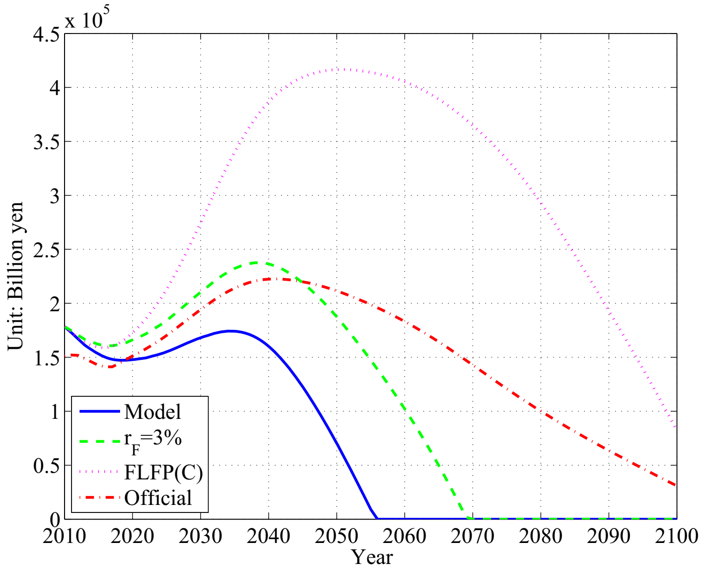


FIGURE A.3

PENSION FUND: COMPARISON WITH OFFICIAL FORECAST

TABLE A.1

PRIMARY BALANCE: MODEL VERSUS GOVERNMENT FORECAST (% OF GDP)

	Government Forecast	Model Baseline
2013	−7.0%	−7.0%
2014	−4.3%	−5.8%
2015	−3.5%	−4.9%
2016	−3.0%	−4.6%
2017	−3.1%	−4.5%
2020	−3.2%	−4.2%
2022	−3.2%	−4.0%
2023	−3.3%	−4.0%

participation rates will remain constant for both genders. The MHLW forecast assumes that the assets in the trust fund earn a return of 3.1%, which is higher than the 2% assumed in our benchmark model based on the historical average.

To demonstrate the effect of different assumptions on labor force participation and a higher return on the trust fund, the figure also includes the path of the trust fund under two scenarios that we had considered in Sections 5, and 7, one with a much more optimistic assumption about the female labor force participation, FLFP(C) case presented in Section 7, and another simulation with a higher trust fund return at 3%.

Next, we study the government's forecast of the primary balance and compare it to what is implied in our model.[32] As shown in Table A.1, the official primary balance starts with a deficit of 7.0% in 2013, which is projected to decline and stay at 3.1%–3.3% of GDP around 2020. Our baseline model starts with the same level of deficit in 2013, which declines thereafter as in the official projections and reaches the annual deficit of 4% in the early 2020s.

[32] The forecast and underlying assumptions are summarized in the report of the Cabinet Office, "Economic and Fiscal Projections for Medium to Long Term Analysis" (2013). We use the projections under "Reference Case." The table includes the years for which official projections are available.

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