The Implications of a Graying Japan for Government Policy.*

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Abstract

Japan is in the midst of a demographic transition that is both rapid and large by international standards. As recently as 1990 Japan had the youngest population among the Group of 6 large, developed countries. However, the combined effects of aging of the baby-boomer generation and low fertility rates have produced very rapid aging. Japan now finds itself with the oldest population among the Group of 6 and its population will continue to age at a rapid pace in future years. Aging is already placing a burden on government finances and Japan's ability to confront the negative fiscal implications of future aging is constrained by its very high debt-GDP ratio. We find that Japan faces a severe fiscal crisis if remedial action is not undertaken soon and analyze alternative strategies for correcting Japan's fiscal imbalances.

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1 Introduction

Japan is in the midst of a demographic transition that is both rapid and large by international standards. In 1990 the share of the population aged 65 and older was 12 percent. According to this metric Japan had the youngest population in the Group of 6 large industrialized economies. By 2005, the elderly share of the population had risen to 20 percent and Japan had the highest fraction of elderly people in the Group of 6. Government projections by the National Institute of Population and Social Security (IPSS) indicate that this figure will reach 40 percent by 2060.

The graying of Japan to date, in conjunction with sluggish growth since 1990, has been associated with a large increase in the stock of government debt. Net government debt in Japan has risen from 8 percent of GDP in 1990 to 150 percent of GDP in 2012.[1] Expenditures on social insurance have risen sharply over this period, from 16.6 percent of total government general account expenditures in fiscal year 1990 to 31.4 percent in fiscal year 2013. Interest payments on government debt have risen from 20.7 percent to 24.0 percent of total government expenditures over the same period despite a substantial decline in the interest rate on government debt.

Japan's high debt-GDP ratio is worrisome because government outlays for public pensions and medical expenses will rise further as the population continues to age. One way to assess the capacity of a country to support pay-as-you-go programs for the elderly is to consider the old-age dependency ratio, which we define as the ratio of the population aged 65 and above to that aged 18-64. According to IPSS projections Japan's old-age dependency ratio will peak at levels that exceed 87 percent.

In this paper we use a general equilibrium model with a rich demographic structure to analyze the fiscal implications of the graying of Japan. We find that even if one factors in legislated increases in the value added tax to 10 percent in 2015 and changes in public pension contribution and benefit rates, current fiscal policies are not sustainable. We project a fiscal crisis by 2039 that will most likely involve at least a partial default on the public debt if no additional actions are taken to correct the fiscal imbalances. We then examine alternative

[1] Our calculations; see the appendix for details. For purposes of comparison the Japanese Ministry of Finance reports a net debt-GDP ratio of 134 percent in 2012.

ways to avoid this outcome that vary in terms of their reliance on tax changes and expenditure cuts, and we analyze how these alternatives affect the lifetime net tax liabilities and utility of different cohorts.

Our model projections posit time-varying fertility rates and cohort-specific mortality rates that are derived from long-term population projections produced by the IPSS. Their medium scenario projections imply that the population will decline from 127.2 million in 2013 to 45.9 million in 2110. These dramatic changes are driven by the current age structure of the population. In particular, the number of females of child-bearing age is low and will decline for decades to come, even with plausible assumptions about an increase in the fertility rate.[2] The population will not stabilize until the next century and possibly late in the next century depending on how rapidly the fertility rate increases. These facts imply that Japan's demographic transition and the consequent economic effects will play out over the course of a couple of centuries rather than decades. Our simulations deal with this entire transition path, and it is important to do so. Individuals in our model are forward-looking, and future events recursively affect decisions made today.

Public pensions and government medical expenditures in our model capture key institutional features of these programs in Japan. In particular, we model the public pension reforms legislated in 2004 that call for a gradual rise in contributions, partial indexation of benefits to inflation, demographic adjustments to benefits, and a commitment to maintain a floor of 50 percent on future public pension replacement rates. Japan offers public insurance for medical expenses and long-term care insurance. Our model features age-dependent medical and long-term care expenses and copayments. This feature of the model, combined with time-varying demographics, generates variation in aggregate government healthcare expenditures. The model incorporates other legislated changes in fiscal policy such as the plan to increase the consumption tax to 10 percent in October 2015 and makes optimistic assumptions about the effects of the Abe administration's fiscal and monetary stimulus programs on inflation and economic activity.

We use a steady-state analysis to document a long-run sustainability problem. A population with an older age distribution requires higher revenue to

[2] We extrapolate the IPSS projections beyond 2110 under the assumption that the fertility rate eventually increases to a value that is consistent with a stable population.

maintain current promises to the old. Our steady-state analysis finds that current levels of taxes on capital in Japan are so high that further increases are not an effective way to increase government revenue. Labor income taxes entail very large steady-state output losses as compared to consumption tax increases. For these reasons we focus on the consumption tax in our dynamic simulations.

The steady-state analysis is informative but it is silent about how urgent the need is to act soon. We next use dynamic simulations to answer this question by considering how long the can can be kicked down the road. This analysis indicates that if no further actions are taken, a fiscal crisis will occur by 2039. The cost of a fiscal consolidation at that point would require increasing the consumption tax rate to over 50 percent. Because the costs of such a sudden increase in the consumption tax are large, particularly to the aged, we conjecture that some form of sovereign default would have to be part of any solution.

Another way to get a handle on the size of Japan's fiscal imbalances is to consider how much the consumption tax rate would have to increase to achieve solvency immediately. Our projections indicate that solvency could be restored if the consumption tax rate were increased to 36 percent in 2019 and kept at this level forever.

Both of these scenarios place a particularly heavy burden on today's elderly who in many cases are not able to re-enter the labor market and thus have no recourse but to sharply reduce their consumption expenditures. This leads us to consider a scenario where the consumption tax rate increases gradually in tandem with pension and healthcare outlays to the elderly. In this scenario the consumption tax rate gradually rises to 30 percent in 2037, but then must increase further to a peak level of 46 percent before falling back to a terminal value of 26 percent.

We also consider a range of measures for reducing government expenditures. Perhaps that most successful among these policies is to gradually increase healthcare copayments for the elderly to the level of working-age individuals (30 percent). This policy places a significant dent in the funding needs of the government and stimulates economic activity. This is the only simple policy we have found in which the peak consumption tax rate is under 25 percent, a level comparable to those in Denmark and Finland.

A number of other researchers have investigated Japan's fiscal fiscal problems. Imrohoroglu and Sudou (2010) consider the implications of an increase in the consumption tax on fiscal balance in Japan using a representative agent model. Their findings suggest that an increase in the consumption tax from 5 percent to 15 percent is not sufficient to restore fiscal balance unless expenditures are also contained. Using a similar model, Hansen and Imrohoroglu (2014) find that a fiscal adjustment on the order of 30-40 percent of consumption would be required to stabilize the debt-GDP ratio. These papers assume that the Japanese population stabilizes by the year 2060. Hoshi and Ito (2013) do not employ an equilibrium model but simulate Japanese fiscal policy to 2055. They also find that the 10 percent consumption tax rate scheduled to take effect in 2015 will not be sufficient to stabilize the Japanese debt-GDP ratio, but they find that a rate of 20 percent would be sufficient, given healthy economic growth and higher inflation. Our model differs from these papers by incorporating an explicit demographic structure that, combined with age-dependent healthcare costs, generates considerable variation in government outlays. Imrohoroglu, Kitao, and Yamada (2013) use a non-behavioral overlapping generations model and report simulations out to the year 2100. They consider public pension reform but do not explicitly model healthcare spending, and they find that a combination of spending cuts and consumption tax increases is necessary to stabilize the debt-GDP ratio. We are the first paper to investigate these issues using an overlapping generations model where agents optimize and adjust their optimal strategies in response to changes in government policy. Our paper differs from all of the above also in that we measure and highlight the important funding problems associated with Japan's public medical care and long-term care insurance programs. Finally, we report simulation results over a longer horizon. Except for Imrohoroglu, Kitao, and Yamada (2013), none of these papers reports results much beyond the middle of this century. We find that most of the "action" generated by Japan's demographic transition occurs late in this century and well into the next, and that these future developments have implications for behavior in earlier years.

The remainder of the paper is organized as follows. Section 2 documents the graying of Japan and describes our demographic projections. The model is presented in Section 3. Section 4 reports how we parameterize the model. Section 5 introduces the fiscal experiments we consider and discusses their steady-state effects, while Section 6 characterizes the transition to a new steady state under alternative policies. Section 7 contains our concluding remarks.

2 Demographics

Because demographic considerations are of central importance to our analysis, we begin by presenting the basic concepts and data on Japanese demographics and explaining how we combine these elements to generate the demographic projections used in the remainder of the paper.

2.1 Demographic Structure

Let $N_{j,t}$ denote the number of people of age j in period t and J denote the maximum possible age. Then the dynamics of the population are governed by the first-order Markov process:

$$\mathbf{N}_{t+1} = \begin{bmatrix} f_{1,t} & f_{2,t} & f_{3,t} & \dots & f_{J,t} \\ \psi_{1,t} & 0 & 0 & \dots & 0 \\ 0 & \psi_{2,t} & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \psi_{J-1,t} & 0 \end{bmatrix} \mathbf{N}_t \equiv \mathbf{\Gamma}_t \mathbf{N}_t, \tag{1}$$

where $\mathbf{N}_t$ is a $J \times 1$ vector that describes the population of each cohort in period t, $\psi_{j,t}$ is the conditional probability that a household of age j in period t survives to period $t+1$ and $\psi_{J,t}$ is assumed to be zero. The quantities $f_{j,t}$ are age-specific fertility rates, and the sum $\sum_{j=1}^{J} f_{j,t}$ is the total fertility rate in period t. The aggregate population in period t, denoted by N_t, is

$$N_t = \sum_{j=1}^{J} N_{j,t}. \tag{2}$$

It follows that the population growth rate is $n_t = N_{t+1}/N_t$ and the age distribution of the population in period t is given by $n_{j,t} = N_{j,t}/N_t$.

A newborn individual's unconditional probability of surviving from birth in period $t-j+1$ to age $j > 1$ in period t is:

$$\pi_{j,t} = \psi_{j-1,t-1}\pi_{j-1,t-1} \tag{3}$$

where $\pi_{1,t} = 1$ for all t.

Suppose that the age-specific fertility and mortality rates are time invariant at values f_j and ψ_j, respectively. This situation leads to a time-invariant age distribution n_j and population growth rate n. Whether the population growth rate is positive or negative depends on the magnitudes of the fertility and mortality rates in the Markov matrix above.[3]

2.2 Demographic Data and Projections for Japan

Japan has been experiencing declining fertility and increasing longevity since the 1950s. Japan's total fertility rate declined from 3.65 in 1950 to 2.14 in 1970, a value roughly consistent with a stable or slowly growing population. The rate declined further to 1.54 in 1990 and to 1.26 in 2005. In 1947, life expectancy at birth was 50.06 years for Japanese males and 53.96 for females. While these figures are higher than before World War II, they are well below the corresponding values of 64.4 and 69.7 for the United States. Today Japan has the longest life expectancy in the world.

These changes in fertility and mortality have greatly affected both the growth rate and the age structure of the Japanese population. The average annual growth rate was more than 1 percent between 1950 and 1980 but is now negative. And as mentioned earlier, Japan went from having the youngest to the oldest population among the Group of 6 large, developed economies in a span of only 15 years.

Official IPSS projections call for these trends to continue or even accelerate over their forecast horizon which ends in 2110. According to their medium projection, population will decline by two-thirds, with the annual growth rate remaining below -1 percent from 2046 on. The old-age dependency ratio is projected to exceed 0.8 from 2053 on.

We compute competitive equilibrium paths that converge to stationary competitive equilibria as defined in Section 3 below. A stationary competitive equilibrium requires a stationary age distribution of the population, which is never reached in the time span covered by the IPSS forecasts. We are thus forced to construct population projections that eventually lead to a stationary age dis-

[3] A more detailed description would distinguish between males and females, but we ignore this distinction. This simplification implies that the fertility rates in our model are roughly half as large as those commonly reported for females. For simplicity, we multiply our model fertility rates by two when discussing them in the remainder of the paper.

tribution. Because we have no basis on which to forecast time variation in the age-specific fertility and survival rates in the far distant future, we assume that these rates eventually become constant. The age distribution of the population stabilizes several generations after the fertility and the survival rates become constant. The total size of the population may be either constant, increasing, or decreasing, depending on the magnitude of the fertility rates relative to the survival rates.

We assume that the total fertility rate eventually increases to a value consistent with a constant population. Population dynamics during the transition to a terminal stationary equilibrium are driven largely by the time required for the total fertility rate to recover to its replacement value. Under any plausible set of assumptions about fertility and survival rates, the age structure of the Japanese population will not stabilize for another 150-250 years. During that time the population will decline substantially. Furthermore, the share of retirees in the population will rise dramatically above its current level and then decline to a new steady-state value that is somewhat higher than today's. The magnitude and timing of these changes depend on the specific assumptions about future fertility and survival rates.

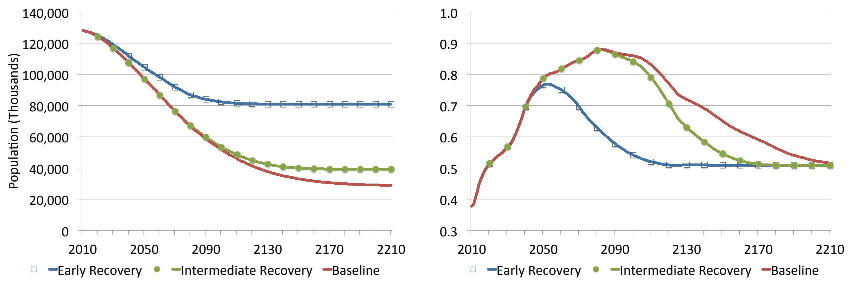
Our demographic projections start from the January 2012 IPSS medium forecasts of population and fertility and survival rates to 2060. In all of our projections we assume that age-specific survival rates remain constant from 2060 onward.[4] In our benchmark projection, we assume that the total fertility rate increases linearly from 1.34000 in 2060 to 2.01125 in 2160.[5] These fertility and survival rates imply a stationary population in the terminal steady state.[6]

[4]The maximum age in the IPSS forecasts is 105. We extrapolate survival probabilities beyond age 105 and assume that the size of a given birth cohort declines with age according to these extrapolated survival rates. We also assume that the maximum attainable age is that at which the probability of surviving an additional year falls below one half. We have found that extending the maximum lifespan to ages with lower conditional survival probabilities sometimes leads to problems in solving the Euler equations for an agent's lifetime consumption and labor supply plan. Truncating the permissible lifespan when the conditional survival probability falls below one half implies a maximum age of 112 in 2060.

[5]Our value of the long-run fertility rate consistent with a stable population is lower than commonly discussed values for two reasons. First, survival probabilities are higher in Japan than in most other countries. Second, females constitute somewhat less than one half of new births. The number of females is less than the number of males in a cohort until about age forty. Our model does not differentiate between males and females and thus requires a lower fertility rate to achieve a stable population.

[6]To eliminate small oscillations in annual births, we fix the number of births in our benchmark projection at 328,600 from the year 2138 onward. With this assumption, the population and its age structure stabilize in the year 2246.

Figure 1: benchmark Demographic Projections and Two Alternative Scenarios



(a) Population

(b) Old-age Dependency Ratio

Figure 1a illustrates some important features of our demographic projections. In our benchmark projection, population falls to 28.8 million before stabilizing, a decline of almost 80 percent from its peak. The old-age dependency ratio (the ratio of the population aged 65 and over to that aged 18-64) stabilizes at 0.509 compared with 0.402 in 2012. This ratio peaks at 0.880 in 2082 and remains above 0.7 for almost a century from 2041 to 2136. This transitory though long-lasting decline in the number of workers relative to population is the mirror image of the“demographic dividend” seen in developing economies in the wake of declines in fertility (Bloom, Canning, and Sevilla 2003).

The Japanese total fertility rate increased from 1.26 in 2005 to 1.39 in 2011, and both the IPSS forecasts and our benchmark projection incorporate this increase. We consider two alternative projections that incorporate a more rapid increase in the fertility rate in future years. In the first of these alternatives, which we call “intermediate recovery,” the fertility rate follows the IPSS forecast until 2060 and then increases linearly to 2.01125 in 2110, rather than 2160. In the second alternative projection, which we call “early recovery,” we abandon the IPSS forecasts and assume that the total fertility rate increases linearly to 2.01125 in 2060. Each of these alternatives results in a larger stationary population for Japan, 39.2 million in the intermediate recovery case and 81.0 million in the early recovery case. Because they are based on the same stationary fertility and survival rates, however, all three sets of projections yield the same stationary age distribution. The old-age dependency ratio in the intermediate recovery case is quite close to that in the benchmark case throughout this century and remains above 0.7 until 2120. The early recovery case implies an old-age dependency ratio that drops below the benchmark projection after mid-century and below 0.7 by 2069. We report this projection not because we think it very likely, but simply to illustrate how rapidly the fertility rate would have to rise to prevent Japan from becoming a substantially older society than it is now and from remaining quite old well into the next century. Even in the early recovery case, the Japanese population will never again be as young as it is today.

3 The model

We consider an overlapping-generations economy that evolves in discrete time with a model period of one year. Time is indexed by t where $t \in \{..., -2, -1, 0, +1, +2, ...\}$.

3.1 Household's problem

Households have one adult member and a fractional number of dependent children that varies with the age of the adult. A household is formed and is of model age 1 when an individual reaches maturity. Cohorts are indexed by the year of household formation. Households enter retirement at age j_r and live at most J periods, and J cohorts of households are alive in any period t. They experience mortality risk in each period of their lifetime, as described in equation 1 above.[7]

The utility function for a household formed in period s is given by

$$U_s = \sum_{j=1}^{J} \beta^{j-1} \pi_{j,t} \frac{(c_{j,t}^{\theta}, \ell_{j,t}^{1-\theta})^{1-\gamma}}{1-\gamma}, \tag{4}$$

where β is the preference discount rate, $c_{j,t}$ is consumption and $\ell_{j,t}$ is leisure for a household of age j in period $t = s + j - 1$.

Households are born with zero assets and are not allowed to borrow against their future income. Labor supply of a household of age j in period t is $1 - \ell_{j,t}$. Labor income is determined by an efficiency-weighted wage rate $w_t \varepsilon_j$ per unit of labor supplied, where w_t denotes the market wage rate per unit of effective labor in period t and ε_j denotes the time-invariant efficiency of an age-j worker.

[7] When we simulate the model we will assume that households are formed when individuals reach a calendar age of 21, that they retire at a calendar age of 65 and live until at most age 112. These assumptions imply the model ages $j_r = 45$ and $J = 92$.

The efficiency index ε_j is assumed to drop to zero for all $j \geq J_r$, where J_r is the retirement age.

Households are subject to exogenously given medical expenses, $c^m_{j,t}$, that vary with the age of the household. We assume that $c^m_{j,t}$ is given by

$$c^m_{j,t} = \zeta_t \varphi_j \tag{5}$$

where φ_j, assumed to be time-invariant, measures relative medical expenditures at each age and ζ_t measures variation in medical costs over time that is common to individuals of all ages.[8] Japan has a socialized medical system that covers a fraction κ_{jt} of these expenditures. Thus, a household's out-of-pocket medical expenditures are given by $(1 - \kappa_{jt})c^m_{j,t}$.

In our setting with no uncertainty, government debt and private capital are perfect substitutes. We nevertheless allow the interest rate on government debt to be lower than the return on capital. This permits us to correctly measure the size of government interest payments and thus the evolution of government debt. The following restriction on asset holdings ensures that individuals hold government debt

$$\phi_t a_{j,t} \leq d_{j,t}, \tag{6}$$

where $d_{j,t}$ denotes government debt owned by a member of cohort j. Given that we limit attention to situations where government debt is dominated in rate of return, equation (6) holds with equality. We assume that in each period the government sets ϕ_t equal to the ratio of aggregate government debt to aggregate assets held by individuals of all ages in that period.

The budget constraint for a household of age j in period t is:

$$(1 - \kappa_{jt})c^m_{j,t} + c_{j,t} + a_{j,t} \leq (1 + R_t)a_{j-1,t-1} + w_t \varepsilon_j (1 - \ell_{j,t}) + b_{j,t} + \xi_t - \theta_{j,t} \tag{7}$$

where $a_{j,t}$ denotes assets held at the end of period t (with $a_{0,t} = 0$ for all t), $\theta_{j,t}$,are taxes imposed by the government, $b_{j,t}$ denotes public pension benefits, and ξ_t is a uniform, lump-sum government transfer to all individuals alive in period t. The pension benefit $b_{j,t}$ is assumed to be zero before age J_r and a lump-sum payment thereafter. Define the interest rate on one-period government debt to be r^g_t. Then the return on assets is $R_t = \phi_t r^g_t + (1 - \phi_t)r^k_t$ where r^k_t is the return on capital.

[8] Medical expenditures for a household consist of medical expenditures of the adult and those of the dependent children.

Taxes imposed by the government on households are given by

$$\theta_{j,t} = \tau_t^a R_t a_{j-1,t-1} + \tau_t^\ell w_t \varepsilon_j (1 - \ell_{j,t}) + \tau_t^c c_{j,t} \tag{8}$$

where τ_t^a, τ_t^ℓ, and τ_t^c are the tax rates on asset income, labor income, and consumption respectively. Observe that capital is taxed twice, once at the firm level and again at the household level, whereas interest on government debt is only taxed at the household level.

3.2 Firm's Problem

There is single good that is produced by firms in a perfectly competitive market. Firms combine capital and labor to produce output using a Cobb-Douglas constant returns to scale production function

$$Y_t = A_t K_t^\alpha H_t^{1-\alpha}, \tag{9}$$

where Y_t is the output which can be used for either consumption or investment, K_t is the capital stock, H_t is effective aggregate labor input and A_t is total factor productivity.[9]

Factor markets are perfectly competitive

$$r_t = \alpha A_t K_t^{\alpha-1} H_t^{1-\alpha} \tag{10}$$

$$w_t = (1-\alpha) A_t K_t^\alpha H_t^{-\alpha}, \tag{11}$$

where r_t is the rental rate on capital and w_t is the wage rate per effective unit of labor. We assume that the real return on physical capital, $r_t - \delta$, is subject to a tax of τ_t^k that is paid by the firm. Thus the return to shareholders net of taxes paid at the firm level is $r_t^k \equiv (1 - \tau_t^k)(r_t - \delta)$.

The good is either consumed or used to produce capital, K_t, according to:

$$K_{t+1} = (1 - \delta_t) K_t + I_t \tag{12}$$

where, I_t, denotes investment and δ is the depreciation rate.

[9] As described below, labor efficiency is assumed to vary with age, so that changes in the age distribution of the population alter the average efficiency of the labor force. This effect is measured by H_t, while changes in efficiency due to technical progress are captured by A_t.

3.3 Government

The government raises tax revenue to finance an exogenously given sequence of government purchases, to fund a public pension program and to finance the government's share of medical expenses. Government tax revenue consists of revenue from a 100-percent tax on accidental bequests, Z_t, and revenue from the taxes on assets, labor and consumption

$$T_t = Z_t + \tau_t^k (r_t - \delta) K_t + \sum_{j=1}^{J} \left[\tau_t^a R_t a_{j-1,t-1} + \tau_t^\ell w_t \varepsilon_j (1 - \ell_{j,t}) + \tau_t^c c_{j,t} \right] N_{j,t} \quad (13)$$

where the tax on bequests is given by:

$$Z_t = \sum_{j=2}^{J+1} (1 - \psi_{j-1,t-1}) (1 + R_t) \, a_{j-1,t-1} N_{j-1,t-1}. \quad (14)$$

Government purchases are divided into purchases of medical goods and services, $G_t^m = \sum_{j=1}^{J} \kappa_{jt} c_{jt}^m N_{jt}$, and government purchases of other goods and services G_t^o. We denote total government purchases by $G_t \equiv G_t^m + G_t^o$.

The government also runs a public pension system. We model the public pension to reflect the key elements of Japan's employees public pension program (Kosei-Nenkin-Hoken) including the provisions of the 2004 pension reform act. This reform act calls for a gradual increase in pension contributions and adjustments to benefits that depend on the evolution of macroeconomic and demographic conditions in future years.

A household born in period $t - j_r + 1$ and retiring at age j_r in period t receives an initial pension benefit $b_{j_r,t}$ that is proportional to its average indexed earnings before retirement. The initial benefit is given by

$$b_{j_r,t} = \max \left[b_t^{min}, \; \lambda_{t-j_r+1} \frac{x_t^w}{j_r - 1} \sum_{i=1}^{j_r-1} \frac{w_{t+i-j_r} \epsilon_i (1 - l_{j,t+i-j_r})}{x_{t+i-j_r}^w} \right] \quad (15)$$

$$b_t^{min} = \frac{\underline{b}}{\sum_{j=1}^{j_r-1} N_{j,t}} \sum_{j=1}^{j_{r-1}} N_{j,t} w_t \epsilon_j (1 - l_{j,t})$$

where λ_{t-j_r+1} is the replacement ratio for households born in period $t - j_r + 1$, $\underline{b}$ determines the minimum initial pension, and x_t^w is the indexing factor for real wages in period t which evolves according to

$$x_t^w = x_{t-1}^w \max\left[1,\ 0.997 \min\left(1,\ \frac{N_t^w}{N_{t-1}^w}\right) \frac{w_t P_t}{w_{t-1} P_{t-1}}\right] \frac{P_{t-1}}{P_t}. \quad (16)$$

In the above expression P_t is the price level in period t and N_t^w is the size of the working-age population in period t.[10] The retiree's pension benefit in subsequent periods $\{b_{j,t}\colon j > j_r\}$ evolves according to:

$$b_{j,t} = b_{j-1,t-1} \frac{x_t^r}{x_{t-1}^r} \quad (17)$$

where x_t^r is the indexing factor for real benefits in period t, which evolves according to

$$x_t^r = x_{t-1}^r \max\left[1,\ 0.997 \min\left(1,\ \frac{N_t^w}{N_{t-1}^w}\right) \frac{P_t}{P_{t-1}}\right] \frac{P_{t-1}}{P_t}. \quad (18)$$

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These formulas have several important elements. The max operator in equation (15) reflects a commitment by the Japanese government that the initial pension benefit be at least half as large as the economy's cross-sectional average earnings at the time of retirement for qualifying beneficiaries. The number 0.997 enters these formulas to adjust for future increases in life expectancy and tends to lower both the initial benefit and its subsequent evolution as the retiree ages. Because nominal benefits are not permitted to fall as the retiree ages, deflation in isolation acts to boost real benefits. Positive inflation, on the other hand, causes a retiree's pension benefit to decline with age.[11] Equations (15) and (16) express the initial pension benefit as a function of the retiree's real earnings history. Real earnings at each age are indexed upward to account for cumulative productivity growth up to the retirement date. Both the life-expectancy adjustment and a declining working-age population work to reduce the indexing and hold down the initial pension benefit.

[10] The actual benefit formula depends on the three-year average growth rate of the number of insured workers contributing to the pension system. For simplicity, we use the projected one-year growth rate of the working-age population. In addition, the actual benefit formula depends on the three-year average growth rate of nominal take-home pay. We use the one-year growth rate of the nominal wage instead.

[11] This can be seen by considering equation (18). Suppose, for simplicity, that there is no growth in the working-age population and that the life-expectancy adjustment (0.997) is set instead to 1.0. If prices are declining, then $x_t^r > x_{t-1}^r$ and an individual's real benefits grow with age. If prices are rising, then $x_t^r = x_{t-1}^r$ and real benefits are constant during retirement. With a life-expectancy adjustment of 0.997 and a declining working-age population, positive inflation implies that $x_t^r < x_{t-1}^r$ and a retiree's benefits shrink with age.

Aggregate pension benefits in period t are

$$B_t = \sum_{j=j_r}^{J} b_{j,t} N_{j,t}. \tag{19}$$

We allow the government to run a deficit. The public debt evolves according to

$$D_{t+1} = (1 + r_t^g) D_t + G_t + B_t + \Xi_t - T_t \tag{20}$$

where $\Xi_t = \sum_{j=1}^{J} \xi_t N_{j,t}$ are lump-sum transfers.

Definition 1 *Feasible period-t government policy*

A feasible period-t government policy is a set of taxes and transfers: $\Psi_t \equiv \{\{b_{j,t}, \kappa_{j,t}\}_{j=1}^{J}, \tau_t^a, \tau_t^k, \tau_t^c, \tau_t^l, G_t, D_{t+1}, \Xi\}$ that satisfies (20).

This leads us to the following definition.

Definition 2 *A sustainable government policy*

A sustainable government policy is a sequence of government policies $\{\Psi_t\}_{t=0}^{\infty}$ that are feasible for all t and satisfy

$$\lim_{T\to\infty} \frac{D_T}{\prod_{t=1}^{T}(1 + r_t^g)}. \tag{21}$$

3.4 Competitive Equilibrium

We are now in a position to define a competitive equilibrium.

Definition 3 *Competitive Equilibrium*

Given an initial age-wealth distribution, a set of government policies, $\{\Psi_t\}_{t=0}^{\infty}$, a sequence of technologies, birth rates and survival probabilities, $\{A_t, n_{1t}, \Gamma_t\}_{t=0}^{\infty}$, a competitive equilibrium is a set of allocations and prices that satisfies the following restrictions:

1. Households are on their demand functions for consumption, leisure and assets at the given prices.

2. Firms are on their demand functions for labor and capital at the given factor prices.

3. The government policies are sustainable.

We are interested in computing competitive equilibria that evolve to a balanced growth path starting from an initial condition that is calibrated to data from a particular year. This equilibrium transition path depends on the initial condition, the terminal balanced growth path, and the particular sustainable policy chosen by the government. It is thus important to be precise about the terminal balanced growth path that we consider.

Definition 4 *Stationary Competitive Equilibrium*

Let, g_A, denote the growth rate of technology; g_n, the population growth rate; g_w, the growth rate of both per capita output and the wage rate, and g_y, the growth rate of aggregate output. Then a stationary competitive equilibrium is a competitive equilibrium in which (1) each of these growth rates is constant over time, (2) government policies satisfy the time invariance properties $\{b_{j,t+1} = (1+g_w)b_{j,t},\}_{j=1}^{J}$, $\{\kappa_{jt} = \kappa_j\}_{j=1}^{J}$, $\tau_t^k = \tau^k$, $\tau_t^a = \tau^a$, $\tau_t^c = \tau^c$, $\tau_t^l = \tau^l$, $G_{t+1} = (1+g_y)G_t$, $D_{t+1} = (1+g_y)D_t$, $\lambda_t = \lambda$, $A_t = (1+g_A)A_t$, $n_{1t} = (1+g_n)n_{1t}$, $\Gamma_t = \Gamma$, and the set of allocations and prices satisfies the time invariance properties $\{\ell_{j,t} = \ell_j\}_{t=1}^{J}, \{c_{j,t+1} = c_{j,t}(1+g_y)\}_{j=1}^{J}$, $K_{t+1} = (1+g_y)K_t$, $r_t = r$, $w_{t+1} = (1+g_w)w_t$.

In a stationary competitive equilibrium the growth rates of aggregate output and the wage rate are related to the growth rates of technology and population in the following way: $1+g_y = (1+g_n)(1+g_A)^{1/(1-\alpha)}$ and $1+g_w = (1+g_A)^{1/(1-\alpha)}$.

3.5 Policy Experiments

Policy experiments are comparisons of alternative sequences of government policies $\{\Psi_t\}_{t=0}^{\infty}$. In making these comparisons, we are interested in three issues:

- **Sustainability.** Which policy sequences are sustainable, in the sense of Definition 2 above, and which are not? Separating sustainable from unsustainable policies amounts to describing the feasible set from which the government must choose.

- **Macroeconomic effects.** How do alternative policy choices affect the behavior of major macroeconomic variables such as per capita output, the capital stock, and government debt?

- **Welfare effects.** How do alternative policies affect the well-being of different cohorts? We use two approaches in evaluating cohort-specific effects. First, we compute a set of generational accounts (net taxes) along the lines of Auerbach, Gokhale and Kotlikoff (1991). Second, we compute the compensating variation required to make members of a cohort indifferent between two alternative policy choices.

Because $\{\Psi_t\}_{t=0}^{\infty}$ is of infinite dimensionality, we must adopt some assumptions to limit the number of cases we consider. The first assumption is that the policy vector eventually becomes constant, i.e., $\Psi_t = \Psi_T$ for $t \geq T$, so that we need to consider only the sequence $\{\Psi_t\}_{t=0}^{T}$. This assumption is required by our earlier assumption that the economy eventually converges to a stationary competitive equilibrium. We take time 0 to be the year 2007 and time T to be 2307, a transition path of 300 years. This transition period is long enough so as not to impose artificial constraints on the short-run behavior of policy variables while still ensuring that policy sequences that we identify as "sustainable" really are sustainable and are not mere snapshots of shorter, ultimately unsustainable sequences.

The elements of the policy vector Ψ_t that we consider varying are:[12]

- the tax rates $\tau_t^a, \tau_t^k, \tau_t^c$, and τ_t^l,
- tax provisions (deductions, exemptions, and credits), modeled as changes in the lump-sum transfer $\widehat{\xi}_t$, that affect the amount of revenue generated at given tax rates,
- government purchases, $\widehat{G_t}$,
- the public pension system, including the size of the benefit, $\widehat{b}_{j,t}$
- the medical care system, including the age-specific copayment rates, $\kappa_{j,t}$, and the time-series index of medical costs, $\widehat{\zeta}_t$, and
- the government debt, $\widehat{D}_t$.

While the medical cost index, $\widehat{\zeta}_t$, is not an explicit policy variable, we assume that the government can affect it indirectly using regulatory tools, possibly including price controls and rationing.

[12]The productivity-deflated value of a variable X_t is denoted $\widehat{X_t}$, defined as $X_t/A_t^{1-\alpha}$.

It is impossible to vary all of these elements independently and still satisfy the government budget constraint. Except where noted, we assume that the government debt, $\widehat{D}_t$, eventually stabilizes at a level equal to annual GDP. $\widehat{D}_t$ fluctuates endogenously for $0 \leq t \leq T$, and one or more of the tax rates fluctuates endogenously in the years leading up to T in order to ensure that $\widehat{D}_t = 1.0$ for $t \geq T$. There is a tradeoff between stability of $\widehat{D}_t$ and stability of the tax rates over the transition path leading up to time T. In general, greater stability of the tax rates leads to higher variability of $\widehat{D}_t$, and vice versa.

4 Calibration

Performing dynamic simulations of the model requires a large amount of information. One must specify numerical values of structural parameters and the exogenous sequences that govern the evolution of the size and age distribution of the population, government policy, medical expenditures and technology. We detailed our demographic projections in Section 2.2 above and discuss the remaining calibration issues here.

4.1 Structural Parameters

Table 1 reports the parameterization of the structural parameters. Some of these structural parameters have been calibrated to directly to match sample averages of Japanese data. The values of other parameters were chosen so that sample averages of data objects match the values of endogenous variables generated by a stationary competitive equilibrium (initial steady state) of the model. Complete details are reported in the Appendix.

4.2 Pensions, Medical Outlays, and Other Sequences

Changes in the age structure of the Japanese population will cause substantial variation in per capita expenditures on pension benefits and medical care. Medical expenditures are exogenous in our model, as shown in equation (5). Medical expenditures for each household are the product of a time-invariant, age-specific quantity, φ_j, and a time-series index of medical costs, ζ_t. Because φ_j increases with age, population aging will result in an increase in per capita

Table 1: Model Parameterization

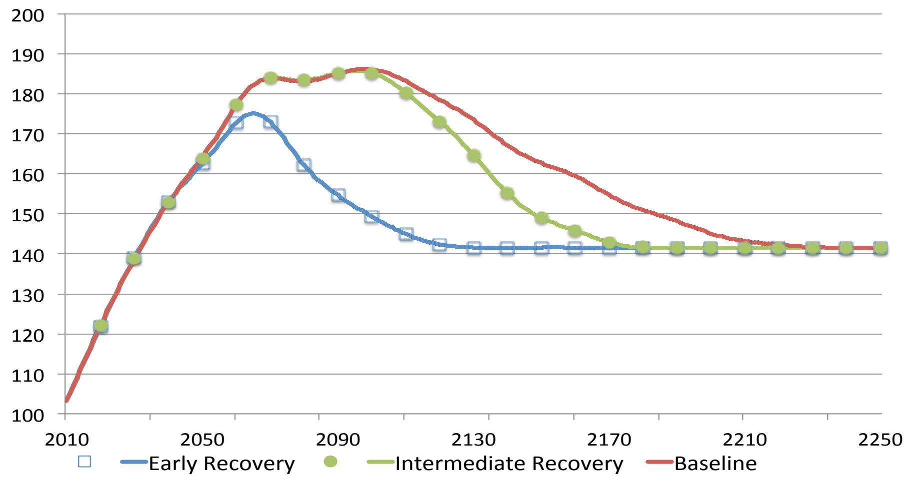
Parameter	**Description**	**Value**
α	capital share parameter	0.409
δ	depreciation rate	0.102
γ	utility curvature parameter	5
θ	preference consumption share	0.198
β	preference discount factor	1.041
τ^a	initial tax rate on asset income	0.100
τ^k	initial tax rate on firm income from capital	0.428
τ^c	initial tax rate on consumption	0.050
τ^w	initial tax on labor income	0.232
G/Y	government purchases-output ratio	0.158
D/Y	government debt-output ratio	0.843
r^g	interest rate on government debt	0.027
g_y	growth rate of per capita output (initial and terminal)	0.02
g_n	population growth rate (initial)	0.01
g_n	population growth rate (terminal)	0.0

medical expenditures.[13] The government's share of each household's medical costs depends on a set of age-specific copayment rates. Our default assumption is that these copayment rates remain at values fixed under current law. By default, we also assume that the time-series index ζ_t grows at the same rate as per capita output, $g_w = (1 + g_A)^{1/(1-\alpha)} - 1$, and we detrend medical expenditures using that growth rate.[14] Under these assumptions, the only source of variation in total and per capita productivity-detrended government medical

[13]The specific details of how we calibrate φ_j are contained in the Appendix.

[14]In the remainder of the paper we will report technology-deflated quantities on either an aggregate or a per capita basis. Per capita quantities are equal to aggregate quantities divided by the number of single-adult households.

Figure 2: Index of Aggregate Healthcare Expenditures Under the Three Population Scenarios (2008 = 100)



outlays is changes in the age structure of the population. As alternatives to these default assumptions, we consider policies that would increase copayment rates or restrain the growth of ζ_t.

Figure 2 shows the evolution of detrended per capita government medical outlays for each of our three demographic projections. In each case, the permanent aging of the population causes these expenditures eventually to stabilize 40 percent above the 2010 level, and the three series are almost identical to each other into the second half of this century. Expenditures in the benchmark and intermediate cases do not differ from each other until early in the next century and remain 80 percent or more above the 2010 level from 2063 to 2110.[15]

These increases in medical expenditures will place a large burden on the government budget in future years. This is because under current law the Japanese government is responsible for more than 80 percent of total medical expenditures.[16]

[15] Although they are endogenous in our model, the government's public pension outlays will exhibit similar fluctuations if current public pension benefit formulas remain in place. For example, pension outlays will increase from 9.1 percent of GDP in 2007 to 14.6 percent of GDP in a new stationary equilibrium in which government spending rules remain unchanged and the debt-GDP ratio is stabilized by increasing the consumption tax rate.

[16] To be more specific, our model implies that the government share of medical expenditures is 81.5 percent in 2009. This is close to the value of 80.5 percent reported by the OECD for

In 2004 Japan passed legislation to reform the public pension system. This law has the following features which we model. Contribution rates are scheduled to gradually increase from 13.4 percent in 2004 to 18.3 percent in 2017 after which point they will remain constant at that level. We adjust the labor tax rate to capture these changes in statutory public pension contribution rates. The government has committed to maintaining benefits for newly retired qualifying beneficiaries above a replacement rate of 50 percent of cross-sectional average wages at the time of retirement. Government projections imply that this floor will be reached in 2038. Some self-employed workers do not contribute to the public pension program. Other workers do not contribute enough years to become vested.[17] Those who do not contribute or are not vested receive no pension benefits. We scale down the floor by 5 percent to reflect these facts and set the parameter $\underline{b}$ to 0.45 unless stated otherwise. Benefits are subject to macroeconomic adjustments that were described in Section 3 above.

The other the sequences of fiscal policy instruments vary across simulations and are discussed when we present results below.

4.3 Initial age-wealth distribution

When computing dynamic simulations of the model we also need to specify an initial age-wealth distribution, the paths of exogenous variables and a terminal condition. The initial wealth distribution is taken from the initial steady state mentioned above. This steady state is computed using initial values of the exogenous variables taken from Japanese data (see the Appendix for details). We make alternative assumptions about the subsequent evolution of these variables, and these assumptions form the basis for the alternative dynamic simulations reported below. The terminal condition is a steady state in which the exogenous variables have settled down to constant values or growth rates.

5 Comparative Steady-State Results

Before considering the entire government policy sequence $\{\Psi_t\}_{t=0}^{T}$, we begin by comparing fiscal policies as of 2007 (Ψ_{2007}) with the policy vector Ψ_T that holds in the ultimate stationary competitive equilibrium, or terminal steady state.

the same year.

[17] In our sample the vesting period is 25 years.

This comparative steady-state analysis is sufficient to identify some nontrivial restrictions on the set of sustainable policy sequences.

To see why this is the case, observe that the steady-state government budget constraint is

$$\widehat{T} = \left(\frac{r^g - g_y}{1 - g_y}\right)\widehat{D} + \widehat{G} + \widehat{B} + \widehat{\Xi}, \tag{22}$$

where the productivity-deflated value of a variable X_t is denoted $\widehat{X_t}$, defined as $X_t/A_t^{1-\alpha}$ and the lack of subscripts indicates that the variables are time-invariant. For given terminal steady-state government purchases and outlays on healthcare and pensions, this equation links tax revenues required to fund these expenditures to the ratio of public debt to output chosen by the government.

If we also fix all tax rates but one at their 2007 levels, then long-run sustainable policies are alternative values of the free terminal tax rate and associated debt-GDP ratios that can be supported as terminal steady states.

We will next show that either taxes must rise from their 2007 levels or expenditures must fall from their current levels if we are to support any positive debt-GDP ratio in the terminal steady state. In this sense current fiscal policy in Japan is not sustainable.

One way to get a handle on the size of the long-run revenue gap is to assume that the government bridges any future funding gaps by levying a uniform lump-sum tax on all individuals of real-time age 21 or greater (model age 1 or greater).[18]

The bottom curve in Figure 3 shows lump-sum tax revenue (as a percent of GDP) needed to satisfy the government budget constraint in the terminal steady state at alternative terminal debt-GDP ratios.[19] In the baseline transitional

[18]Our model includes a lump-sum transfer, ξ_t, that, among other functions, serves to distribute accidental bequests collected by the government uniformly to all surviving individuals. The lump-sum tax takes the form of a reduction in ξ_t, which is not constrained to be positive. Apart from the experiment discussed here, we keep ξ_t constant at its initial steady-state value, reflecting the assumption that the government does not have access to lump-sum taxes.

[19]The reference point for these adjustments to the lump-sum tax is an initial steady state with government purchases, outlays, and public debt set to their average values as a fraction of output in Japanese data between 2000 and 2006. The consumption and income tax rates are set to their average values over this same period. In this initial steady state, the population growth rate is set to 1 percent and the growth rate of per capita output is 2 percent. This hypothetical initial steady state is calibrated so as to closely match the values of labor input, the capital-output ratio, the consumption-output ratio, and other relevant macroeconomic variables in the years leading up to 2007. We refer to these values as 2007 values and use them as points of comparison in describing the behavior of the economy under alternative

analysis that follows we assume a terminal (net) debt-GDP ratio of 1.0. From Figure 3 we see that stabilizing the terminal debt-GDP ratio at this value would require additional lump-sum taxes amounting to 5.9 percent of output in the terminal steady state. Higher lump-sum taxes induce workers to increase their work effort. Hours per worker increase by 16.2 percent, but because the fraction of the adult population that is of working age is lower than in 2007, hours per adult are down by 1.4 percent. Capital per adult is 9.5 percent higher and detrended output per adult increases by 3.5 percent. Additional revenue is also required at much lower terminal values of the debt-GDP ratio. For instance, a terminal debt-GDP ratio of zero would require additional lump-sum taxes equal to 6 percent of GDP in the terminal steady-state.[20]

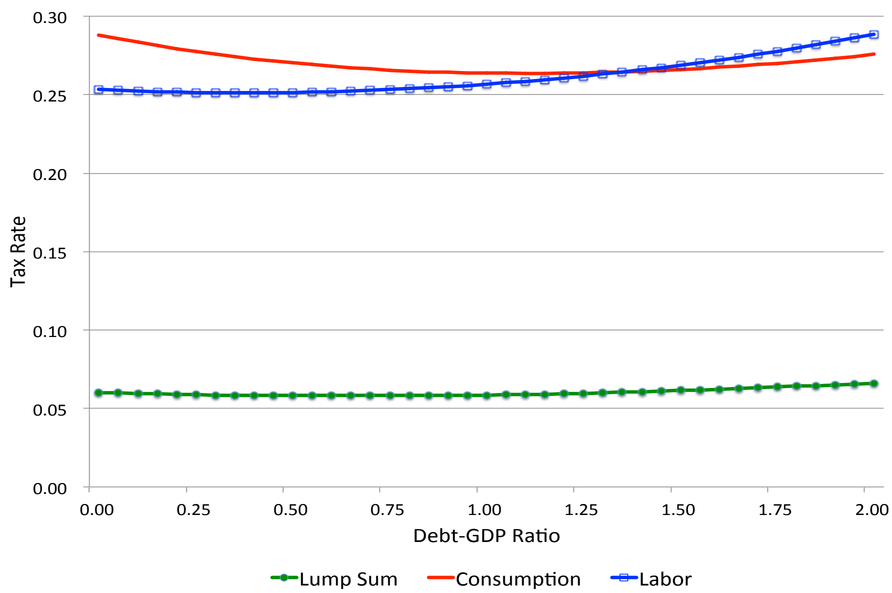
The main reason why revenue must rise is that the old-age dependency ratio is higher in the ultimate steady state as compared to 2007. A smaller fraction of working-age individuals implies that revenue from labor income taxes (per adult) is lower in the terminal steady state. At the same time, a higher fraction of retirees means that public healthcare and pension costs are higher in the terminal steady state.

The lump-sum tax is a useful way to characterize the magnitude of the long-term fiscal funding gap but it is not realistic to expect that the gap will be bridged in this way. Figure 3 also shows terminal values of the tax rates on consumption and labor income that are consistent with fiscal sustainability. Supporting terminal government expenditures at a debt-GDP ratio of 1.0 would require a consumption tax rate of 26.4 percent, more than three times as high as the rate of 8 percent in effect from April 2014. If the labor income tax is adjusted instead, its terminal steady-state value is 25.5 percent at a debt-GDP ratio of 1.0. This measure of the labor income tax does not include the social insurance payroll tax, which is set to 16.8 percent in the terminal steady state, based on current law. Thus, the overall tax rate on labor income is 42.3 percent

fiscal policies. The 2007 level of output is normalized to 1.0.

[20]Figure 3 shows that, starting from a low debt-GDP ratio, a higher debt-GDP ratio corresponds to a smaller lump-sum tax. From equation 22, this fact might suggest that the economy is dynamically inefficient at low debt-GDP ratios. Such is not the case with our calibration, however, for two reasons. First, the interest rate in the first term of equation 22 is the before-tax rate on government debt, which we have calibrated to be lower than the marginal product of capital. Second, a change in the debt-GDP ratio affects components of tax revenue other than the lump-sum tax. For instance, part of the higher government interest expense resulting from higher debt flows back to the government in the form of higher taxes on interest income, thus mitigating any required increase in lump-sum taxes.

Figure 3: Sustainable Long-Run Combinations of Tax Rates and Government Debt



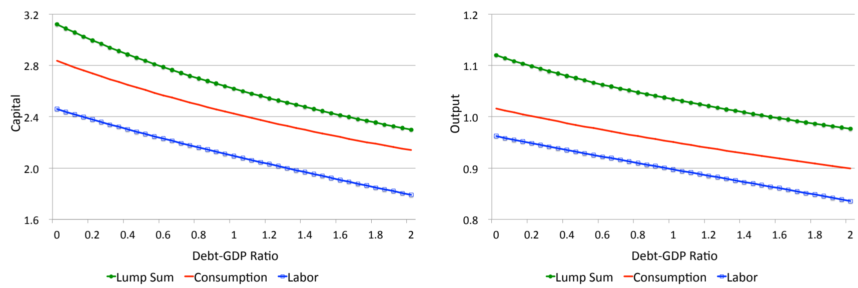
The terminal steady-state government budget constraint is balanced by adjusting either the lump-sum tax, the consumption tax rate, or the labor income tax rate.

at a debt-GDP ratio of 1.0.

Our results indicate that it is not possible to sustain a debt-GDP ratio much above 3.0 by adjusting the labor income tax rate alone. Because our model is non-Ricardian, an increase in the public debt reduces the capital stock. And a debt-GDP ratio of 3.0 or more requires a labor income tax rate in excess of 35 percent, which depresses work effort. These factor supply responses begin to cause substantial reductions in output at debt-GDP ratios much above 3.0, making such high levels of debt and tax rates infeasible.

Similar experiments indicate that we can support a debt-GDP ratio of roughly 3.8 using the consumption tax. However, it is impossible to raise revenue sufficient to satisfy the terminal steady-state government budget constraint using the capital income tax if the terminal debt-GDP ratio is 1.0. Even if the entire public debt could be retired during the transition, a capital income tax rate of 98 percent would be required to finance higher pension and healthcare costs in the terminal steady state.

Figure 4: Terminal Steady-State Per Capita Capital and Output



(a) Capital Stock (b) Output

Terminal steady-state per capita capital and output associated with alternative sustainable fiscal policies, with per capita output in 2007 normalized to 1.0. The terminal steady-state government budget constraint is balanced by adjusting either the lump-sum tax, the consumption tax rate, or the labor income tax rate.

Figures 4a and 4b show how the capital stock and output would vary as functions of the terminal debt-output ratio in each of these three experiments. The figures show that use of either the consumption tax or the labor income tax entails a significant distortion of economic activity compared with the case in which lump-sum taxes are assumed to be available. At a debt-GDP ratio of 1.0, use of the consumption tax results in a capital stock and output that are 7.5 percent and 8.1 percent lower than with lump-sum taxes, respectively. Use of the labor income tax results in a capital stock and output that are 20.0 percent and 13.2 percent lower than with lump-sum taxes.

Our comparative steady-state analysis indicates that substantial fiscal adjustments will be required for Japan to achieve long-run fiscal sustainability. These adjustments may well include tax increases as well as spending cuts. Henceforth, we assume that lump-sum taxes are not available. Because increases in the consumption tax rate entail smaller output costs than do income tax increases, we assume that any increases in taxes are effected by raising the consumption tax.

Given the magnitude of the tax rate increases required to achieve long-run fiscal sustainability, it is likely that the Japanese government will resort to spending cuts as well as tax increases. The results up to now have assumed no reduction in spending, but it is possible to produce analogous results for any specified set of spending cuts. Such spending cuts shift all of the curves in Figure 3 downward, implying lower steady-state tax rates at any debt-output ratio. Table 2 illustrates the magnitude of these shifts. It shows how much particular spending reductions would reduce the consumption tax rate required to achieve fiscal stability in a terminal steady state with a debt-output ratio of 1.0.

A 10 percent reduction in government purchases and a 10 percent reduction in public pension benefits, with no change in contribution rates, each reduce the consumption tax rate by roughly five percentage points compared with the case in which spending is not reduced. The reduction in pensions causes households to save more for retirement, and the resulting increase in the capital stock means that output is somewhat higher with a 10 percent pension cut than with a 10 percent reduction in government purchases. A 10 percent reduction in medical costs (public and private) results in a slightly higher tax rate and lower output than the 10 percent reduction in government purchases.

Table 2 also reports the effects of another change in healthcare policy, i.e., an increase in the copayment rates applied to the elderly. Working-age individuals are currently responsible for 30 percent of their medical expenditures, but this copayment rate drops to 20 percent for individuals aged 70-74 and to 10 percent for individuals aged 75 and above. Raising the copayment rate to 20 percent for those aged 75 and above results in a tax rate of 20.7 percent, while raising the copayment rate to 30 percent for those aged 70 and above requires a tax rate of only 14.6 percent in the terminal steady state. Alternatively stated, this policy requires an increase in the tax rate of only 4.6 percentage points above the 10 percent rate scheduled to go into effect in 2015, while a policy without spending cuts requires an increase of 16.4 percentage points above the rate planned for 2015.

An increase in copayment rates also results in higher output than any of the other policies. One reason why the output effects of higher copayments are so large is that medical expenditures are exogenous in our model. Individuals cannot reduce their consumption of medical care in response to changes in copayment rates. Increasing copayments for the elderly causes individuals to work and save more to finance higher medical outlays in old age. The associated increases in labor input and the capital stock boost output in our model. These

Table 2: Effects of Lower Government Expenditures on Consumption Tax Rate and Output in the Terminal Steady State

Spending Change	Phase-in Period	Consumption Tax Rate	Output
none	NA	26.4	88.8
10 percent reduction in purchases	2018-2027	21.1	88.8
10 percent reduction in pensions	1960-1969	21.6	90.7
10 percent reduction in medical costs	2018-2027	22.9	88.4
copayments of 0.3 for elderly aged 70+	2021-2078	14.6	98.1
copayments of 0.2 for elderly aged 75+	2021-2048	20.7	93.1

* These results assume a debt-GDP ratio of 1.0 in the terminal steady state. The phase-in period has no effect on the steady-state consumption tax rate and debt-GDP ratio but does affect the transition paths reported in section 6 below. The phase-in period for Policy 3 refers to the birth year of cohorts subject to the pension reduction.

output effects would be attenuated if individuals were allowed to reduce their consumption of medical care because of higher copayments. Such a reduction in medical care by the elderly would also lower the government's healthcare costs, and the required consumption tax rate would be even lower than shown in Table 2. In that sense, the tax rate effects of higher copayments reported in Table 2 are probably conservative estimates.[21]

The size of taxes in the long run depends on a range of other conditioning assumptions. Some of the current proposals for structural reforms in Japan could affect these assumptions. One proposal calls for increasing immigration flows of workers into Japan to a level of 200,000 per year, which is roughly 0.16 percent of the current Japanese population. If net immigration is permanently

[21]For example, if individuals have a unit price elasticity of demand for medical care, doubling the copayment rate from 10 percent to 20 percent for individuals aged 75 and above would cause them to cut their consumption of medical care in half. The required consumption tax rate would be 18.1 percent, as compared with 20.7 percent reported in Table 2 for the case of a zero elasticity. Output would be 96.2, as opposed to the 99.7 reported in Table 2. Most estimates of the price elasticity of demand for medical care are substantially below unity.

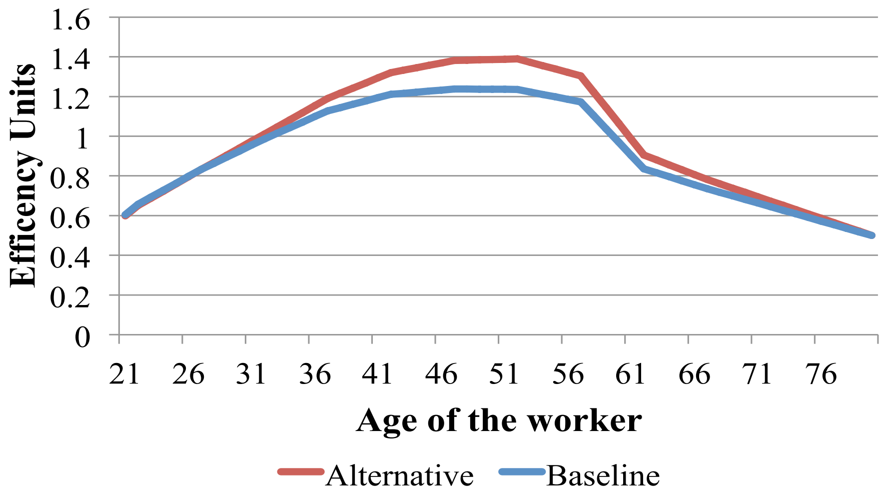
held at the same fraction of population, it will increase the ratio of workers to retires and the population growth rate in a way similar to an exogenous increase in new births (of 21 year olds) from the perspective of our model. The results we have reported up to this point assume that the fertility rate eventually rises to a level that is consistent with a constant population. To investigate the effects of permanently higher immigration flows we conducted a simulation in which the population growth rate in the terminal steady steady was increased from zero to 0.16 percent per year. This scenario has about the same impact on public finances as a 10 percent reduction in public pensions, with the consumption tax in the terminal steady state falling from 26.4 percent to 21.9 percent. A higher population growth rate also has a small positive effect on the steady-state level of per capita output, which rises from 95.1 to 96.5.

A second structural reform proposal is to reduce gender barriers in the workplace. Wage gaps between male and female workers are increasing in the age of the worker. For instance, the gap for full-time male and female workers aged 20-24 is about 10 percent. It grows to 23 percent for those aged 30-34 and reaches a peak of 43 percent for those aged 50-54. Associated with the widening in the wage gap is a sharp decline in the fraction of employed women who work full-time. The wage gap reflects a variety of barriers faced by married women with children. Married women who stay in the labor force often make occupation choices that involve shorter work weeks and/or are more flexible in terms of taking leaves to bear and care for children (see e.g. Goldin (2014)). This preference for more flexible work arrangements is very clear in Japanese data. Over 70 percent of working women aged 20-24 work full time, but only 51 percent of women aged 50-54 work full time.

Some of the proposed reforms in Japan are aimed at reducing these implicit barriers. If they are successful we could see a reallocation of women from less productive part-time jobs to more productive full-time jobs. Our model is not rich enough to analyze the full impact on labor productivity of efforts to shift females into more productive occupations or to measure the fiscal costs of proposals that call for expanding government-provided day-care services. Our model has no explicit occupation choice or participation decisions.

The best we can do is to conjecture how efforts to increase female labor productivity would alter the average age-efficiency profile. In particular, we

Figure 5: Benchmark and Alternative Average Worker Efficiency Units by Age with a Posited Increase in Female Efficiency Units Due to Structural Reforms



suppose that the productivity differential between full-time male and female workers, and thus the gender wage gap, remains constant in future years at the level for 20-24 year olds (10 percent). We assume further that the fraction of women in full- and part-time jobs remains fixed at 70 percent. These assumptions produce the alternative average age-efficiency profile shown in Figure 5. Observe that the peak in average efficiencies rises by 11 percent as compared to the benchmark.

This increase in productivity due to a more efficient allocation of female workers increases steady-state output by 5 percent as compared to the benchmark. However, the effect on public finances is relatively small. If we hold the terminal debt-GDP ratio fixed at 1.0, a consumption tax rate of 24.7 percent is required to satisfy the government's budget contraint. This compares to a tax rate of 26.4 percent for the specification with no expenditure cuts reported in Table 2. Thus, the fiscal benefits of higher average labor efficiency are lower than those associated with any of the expenditure reductions considered in Table 2 and also lower than those associated with a higher population growth rate of 0.16 percent. One reason why the fiscal benefits of higher labor efficiency are relatively low is that individuals in the economy with high labor efficiency have higher lifetime earnings and thus receive higher public pension benefits. Unfunded public pension obligations increase by 6 percent. Funding these benefits requires more consumption tax revenue, which partly offsets the fiscal benefits of a higher average labor efficiency profile.

6 Transitions

Our steady-state analysis illustrated that Japan's fiscal policy is not sustainable in the long run. However, that analysis is silent about the urgency of Japan's fiscal problems. We now use dynamic transitions to show that these are urgent and pressing problems. If further adjustments are not made soon, the fiscal imbalances will become so severe that Japan will face a severe fiscal crisis. We then discuss strategies for correcting Japan's fiscal imbalances.

The Japanese government has been cognizant for some time of the fiscal implications of aging and plans have already been legislated to confront this difficult issue. Under current law public pension contributions are scheduled to increase in future years and public pension benefits are only partially indexed to inflation. These measures along with the other macro adjustments we described above imply that the administrative initial pension benefit will gradually decline to 50 percent of average indexed earnings. Two increases in the consumption tax have also been legislated. The tax rate was increased from 5 percent to 8 percent in 2014 and it is scheduled to increase to 10 percent in October of 2015. In the simulations that follow we assume that these reforms are implemented except where noted.

Our simulations also reflect the first two arrows of the Abe plan, which call for moderate inflation and short-term fiscal stimulus. First, we assume that the Bank of Japan is successful in producing a 1 percent inflation rate in 2013 and a 2 percent inflation rate from 2014 on. Second, we assume that the combined effects of fiscal policy and monetary policy produce real aggregate GDP growth of 2.5 percent in 2013 and 2 percent in 2014 and 2015. We believe these are optimistic scenarios given the scheduled increases in the consumption tax in 2014 and 2015.

6.1 Kick the Can Down the Road Scenarios

One way to measure the urgency of undertaking fiscal reforms is to consider how long current tax and expenditure policies can be maintained. From the steady-state analysis we know that it is not possible to kick the can down the road forever. Either higher taxes and/or lower expenditures will be required in the long run. By conducting a sequence of dynamic simulations we can find the most distant date, t', that a fiscal consolidation can occur. When determining t' we assume that expenditures do not change and that a fiscal consolidation is effected by allowing the consumption tax to jump in period t'. We also impose the restriction that the debt-GDP ratio not exceed 3.5 in all periods of the transition.

This final restriction is motivated by the following considerations. In Section 5 above we were able to compute steady states with debt-GDP ratios somewhat above 3.8. And in the transitions we have been able to temporarily support debt-GDP ratios that are as high as 4. However, these figures are very high compared to other thresholds that have been discussed in the literature. For instance, many of the episodes of sovereign default listed by Reinhart and Rogoff (2010) occur at substantially lower levels of debt. The debt-GDP ratios we have derived are also much larger than thresholds derived by Conesa and Kehoe (2013). They compute regions where countries are at a high risk of a sovereign default crisis and find that the crisis zone ranges from debt-GDP levels of 1.38 to 2.25.

The reason that extraordinarily high debt-GDP ratios are sustainable in the long run in our model has to do with the fact that the government can credibly commit to a unique sequence of future actions. Sustainable debt levels are lower in settings such as Conesa-Kehoe (2013) where self-fulfilling sovereign-debt crises can occur if the debt-GDP ratio exceeds a threshold. Sustainable debt-GDP ratios are also much lower when the government cannot commit to a path for fiscal policy. In Aguiar and Amador (2014), for instance, the optimal fiscal policy calls for high taxes in early periods and no outstanding public debt in the long run when the government cannot credibly commit to future tax plans. Thus, our assumption of an upper limit of 3.5 on the debt-GDP ratio does not seem unduly restrictive, and we view it as providing an upper bound on the amount of time the Japanese government has left to correct its fiscal

Table 3: Kick the Can Down the Road Scenarios

Result	8 Percent Consumption Tax Rate	10 percent Consumption Tax Rate
Date of Fiscal Consolidation	2036	2039
Maximum Consumption Tax Rate	55.4%	57.0%

imbalances.

We first consider a scenario in which the increase in the consumption tax rate from 5 percent to 8 percent is implemented but not the subsequent increase to 10 percent. This policy requires a fiscal consolidation in 2036 as reported in Table 3. The debt-GDP ratio continues to rise for two years before hitting a peak value of 3.4 in 2038. Implementing the second increase in the consumption tax rate to 10 percent in October 2015 postpones the fiscal consolidation by only three years, to 2039.[22] A sudden jump in the consumption tax rate from a level of 8 percent or 10 percent to levels in excess of 50 percent would be unprecedented and places a particularly severe burden on older cohorts. It is our view that the tax rate increase implied by these fiscal consolidations is so costly that the government would opt to default on at least part of its debt instead. One way this could occur would be by engineering significantly higher inflation, which erodes the real value of nominal debt obligations.[23] Thus, one way to interpret these dates and associated debt-GDP levels is that they provide an upper bound on the timing and size of government debt that would result in a sovereign default. We now consider transition paths in which fiscal policy is adjusted so as to avoid a default.

[22] These particular results are based on a run in which the consumption tax peaks in the year it jumps and then gradually drops towards its terminal steady-state value. The debt-GDP ratio follows a similar trajectory. We have experimented with alternative paths of the consumption tax after the jump date and found that the jump date is reasonably robust to how this is modeled. The jump dates do not change, for instance, if we hold fixed the consumption tax rate at a constant value from the jump date until 2050 and then let it adjust to the terminal steady-state instead. Moreover, the resulting value of the consumption tax at the jump date continues to exceed 50% in both scenarios.

[23] This implicit default channel plays a significant role in the analysis of Hoshi and Ito (2013).

6.2 Transitions without Spending Cuts

The first issue to be addressed is whether projected spending in and of itself implies unsustainability. To answer this question, we explore whether it is possible to vary the consumption tax rate over time in such a way as to make the spending levels embodied in current policy sustainable. We find that such paths for the consumption tax rate exist, and we report two such paths.

One solution to Japan's fiscal problems would be to impose a one-time, permanent increase in the consumption tax rate sufficient to fund all future spending implied by current policy. Barro (1979) presents a model in which it is optimal for the government to set tax rates so that they are expected to remain constant in the future. Under such a policy, the public debt evolves endogenously to satisfy the government budget constraint. Is such a policy feasible for Japan? If so, how high would the tax rate (call it τ^c_*) need to be, and how would the public debt behave over time?

According to our model, the Japanese government could satisfy its intertemporal budget constraint without enacting spending cuts by permanently increasing the consumption tax rate to a little above 36 percent in 2018.[24] We refer to this policy as the Constant Tax equilibrium. Taking immediate and decisive action to enhance revenues means that the peak value of the consumption tax rate is about 20 percentage points lower than in our kick the can down the road scenarios, but it produces wide fluctuations in the debt-GDP ratio and is still very painful for older cohorts. The debt-GDP declines during 2017-2055, is negative during 2043-2067, and reaches a minimum of -0.192. The ratio in the new steady state is 3.83, which is substantially higher than both the current value in Japan, values historically observed elsewhere and our sustainability threshold of 3.5.[25] The immediate jump in the tax rate results in higher lifetime tax payments by individuals born before 1960, who are retired or close to retirement and thus have little scope to alter their labor supply or retirement saving in response to the higher tax rates. Thus, while a permanent, one-time increase in the consumption tax rate is helpful in quantifying the overall magnitude of Japan's fiscal imbalances, it is not a plausible solution to Japan's fiscal

[24] Our solution algorithm requires that the consumption tax rate fluctuate endogenously over part of the transition path in order to hit a target debt-GDP ratio. In this experiment, the tax rate remains between 36.02 percent and 36.20 percent before stabilizing at 36.04 percent.

[25] The debt-GDP ratio rises above 3.5 in the year 2180.

problems.

We next consider a more gradual increase in government revenue. We have seen in Figure 1b that the old-age dependency ratio is hump-shaped. It continues to rise until the end of the century and gradually declines thereafter. In our Baseline scenario, the consumption tax rate is set to roughly mimic this hump-shaped path. This transition path keeps spending at levels implied by current policy and has a terminal debt-GDP ratio of 1.0, implying a terminal consumption tax rate of 26.37 percent. We vary the consumption tax rate so that $0.9 \leq D_t/Y_t \leq 1.1$ for $t > t^*$.[26] Figures 6 and 7 show the paths of the tax rate and debt-GDP ratio for Policy 0. The tax rate steadily increases from 10 percent in 2017 to 30 percent in 2037 in increments of one percentage point per year. After pausing at 30 percent until 2050, the tax rate increases by one percentage point per year until it reaches 42 percent in 2062. It increases slowly to 46 percent in 2102 and remains there for ten years before gradually declining to its long-run value of 26.37 percent.

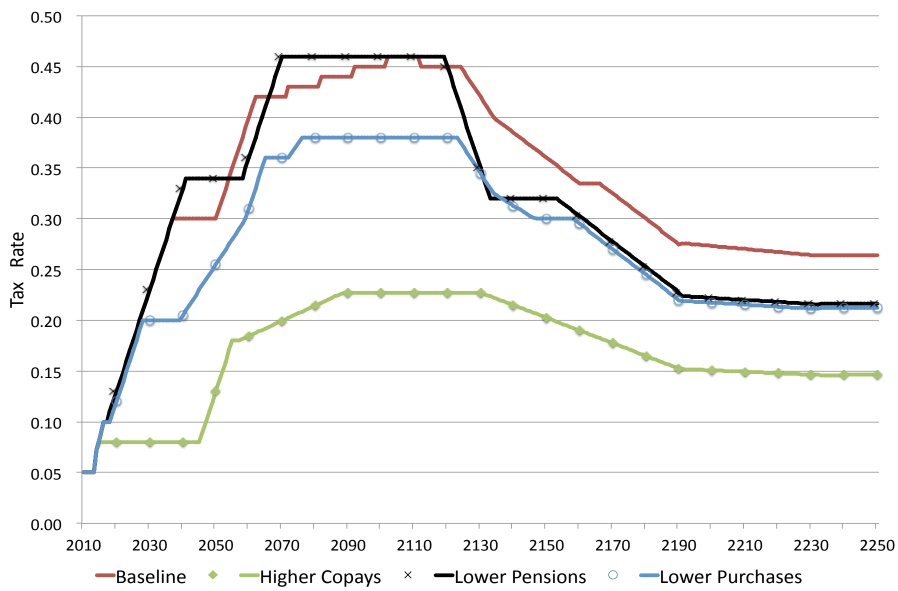
Nordic countries currently have some of the world's highest value-added tax rates. For example the rate is currently 25 percent in Denmark and 24 percent in Finland. If public pension and medical benefits are kept at their current levels in Japan, our simulation results imply that the consumption tax rate will need to rise temporarily to a level that is almost double the current rate in Finland before eventually falling to a rate only slightly above those in Nordic countries today.

Adjusting the consumption tax in this fashion results in a more stable path for the debt-GDP ratio than in the tax-smoothing transition because revenue is more closely linked to the time profile of pension and healthcare outlays (see Figure 7). The increase in the consumption tax rate to 10 percent scheduled for 2015 is insufficient to stabilize the debt-GDP ratio in the near term. This ratio continues increasing to a value of 1.61 in 2022, by which time the consumption tax rate has reached 15 percent. The debt-GDP ratio permanently falls below 1.1 in 2055, and remains between 0.9 and 1.1 thereafter.

These high tax rates, combined with a permanently older population, impose large costs in terms of output and consumption. Detrended per capita output falls below 90 percent of its 2007 level by 2055, continues falling until reaching a

[26]We do not fix an exact target for t^*, but it generally falls in the middle third of the present century in transitions of the sort just described.

Figure 6: Consumption Tax Rate under Alternative Spending Policies

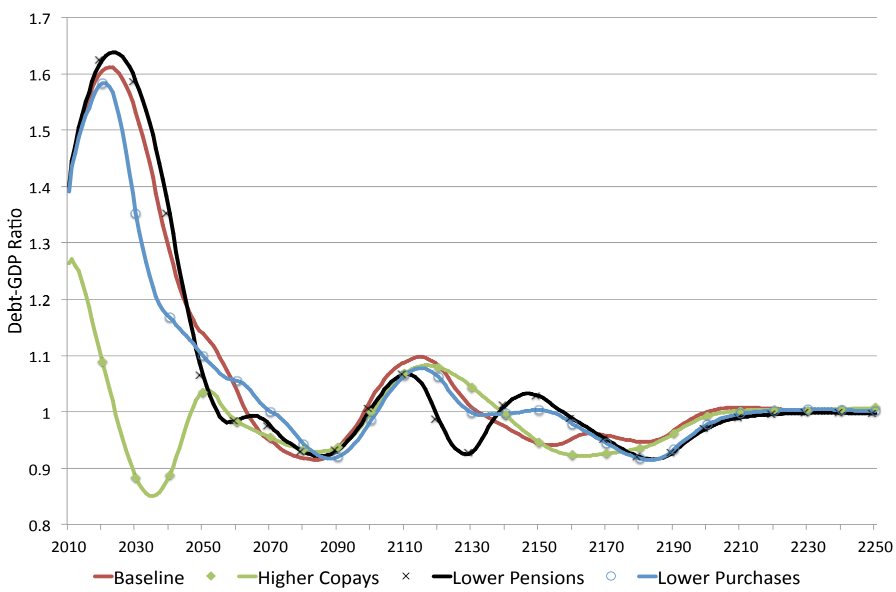


The Baseline run assumes no expenditure cuts. The High Copays run assumes that health care copayments for retires aged 70+ gradually rise to 30 percent. The Lower Pensions scenario assumes that public pension payments are gradually reduced by 10 percent and the Lower Purchases scenario assumes that general government purchases are gradually reduced by 10 percent.

minimum equal to 85.7 percent of its 2007 level in 2106, and eventually stabilizes at a long-run value equal to 88.8 percent of its 2007 level. Detrended per capita consumption takes an even larger hit. It remains between 63 percent and 65 percent of its 2007 value during 2092-2127 before eventually stabilizing at 76.1 percent of its 2007 value.

The high consumption tax rates and large output and consumption losses implied by our baseline transition suggest that at least some reliance on reductions in government spending will be required to correct Japan's fiscal imbalances. We now explore some of these options.

Figure 7: Debt-GDP Ratio under Alternative Spending Policies



See the note to Figure 6 for a description of each scenario.

6.3 Transitions with Spending Cuts

We focus in turn on policies that reduce either the government's portion of healthcare spending, its pension outlays, or its purchases of goods and services. In addition, we consider the possibility of reducing the growth rate of total healthcare costs.

Medical care expenditures and in particular public expenditures for long-term care expenses are already large and are projected to grow in future years. Total expenditures on long-term care were about 1.9 percent of GDP in Fiscal Year 2011 and are expected to grow to as high as 4.1 percent of GDP by Fiscal Year 2025 (see Shimizutani (2013)). Currently, administrative copayments for long-term care are set at 10 percent. Those over 75 also pay a 10 percent copayment for other medical expenses.[27] Copayments have caps that reduce the actual size of out-of-pocket payments (see Ihori, Kato, Kawade and Bessho (2010) for details). We scale the administrative copayments to match aggregate out-of-pocket expenditures and find that this results in effective copayments

[27]Individuals with high income pay a 30 percent copayment.

that are 83 percent of the administrative levels.

One way to reduce the size of future public expenditures is to increase the size of copayments. The largest medical expenditures are concentrated at the end of life, and administrative copayments for retirees are currently lower than for working-age individuals (30 percent for working-age individuals, 20 percent for retirees less than 75 as of April 2014 and 10 percent for retirees 75 and older). We consider a reform that raises copayments for retirees to the level faced by working-age individuals (the Higher Copays policy). Imposing such a reform immediately would place a heavy burden on the current elderly. So we instead assume a pre-announced increase in the administrative copayment for retirees to 30 percent phased in gradually beginning in 2021.[28] Given our scaling of copayments, this corresponds to an effective copayment of 22 percent for retirees.[29]

Announcing this policy change now gives individuals time to adjust their work and saving plans so that they can cover the higher copayments in retirement. As with the Baseline policy, we compute a path for the consumption tax rate that brings the debt-GDP ratio into the range of 0.9-1.1 in the near future and keeps it there forever. The tax rate path, shown in Figure 6, is substantially lower than the one associated with no spending cuts. The maximum tax rate is 22.75 percent, eventually falling to 14.63 percent. The corresponding figures without spending cuts are 46 percent and 26.37 percent. Equally noteworthy is the fact that the consumption tax rate does not rise above its current level of 8 percent until 2046. Despite this delay in raising the tax rate, the debt-GDP ratio begins to decline almost immediately. The rapid stabilization of the debt, despite a delay in raising the consumption tax rate, is the result of an immediate increase in labor supply in anticipation of higher out-of-pocket healthcare costs in old age. Saving also increases, resulting in a larger capital stock and higher output in future years. Relative to a normalized value of 100.0 in the year 2007, detrended per capita output peaks in 2030 at 115.4 and remains above 100.0

[28]In our simulation, the announcement of the policy change is assumed to have occurred in 2008. The copayment rate increases by one percentage point in 2021 and by an additional percentage point every third year until reaching 30 percent. This phase-in is complete by 2048 for individuals aged 70-74 and by 2078 for individuals aged 75 and above.

[29]Empirical research by Shigeoka (2014) using Japanese data finds little evidence that variation in the size of the copayment within the range we consider has any substantial effect on mortality or other physical health outcomes, although the data used in this research do not permit measuring long-term effects.

until 2112 before settling at 98.1, which is 9.6 percent above the Baseline.

In addition to putting upward pressure on government healthcare payments, an aging population increases pension outlays. As noted above, the Japanese government has already taken steps to limit the growth of pensions and our Baseline transition incorporates these policy changes. Further restraints on the growth of pension outlays might be a plausible alternative or a complement to the higher medical copayments just analyzed. We next examine the effects of reducing pension payments by 10 percent compared with those implied by current law. As in many other countries, a retiree's pension in Japan depends on lifetime earnings. We assume that the replacement rate (the ratio of the pension to average annual earnings) is reduced by one percentage point for individuals born in 1960, by an additional percentage point for the 1961 birth cohort, and so on until the reduction reaches 10 percent for individuals born in 1969 and later. The replacement rate is unchanged for those already retired or near retirement. The rationale for this phase-in is similar to that for the delayed increase in copayments, and the "grandfathering" of current retirees and older workers has precedent in pension reforms enacted in other countries.

This phased reduction in the generosity of the pension system (the Lower Pensions policy) has surprisingly different effects on the government fiscal situation as compared to the Higher Copay policy. The debt-GDP ratio falls significantly when copayments are increased, while reducing pension benefits puts upward pressure on the deficit. Higher copays also result in lower consumption taxes. However, the tax rate implied by the pension-reduction policy is generally even higher than that under the Baseline policy of no spending cuts until early in the next century.

The main reason for this discrepancy is that increases in copayments encourage work effort while pension cuts discourage it. The Lower Pensions policy does not alter the labor income tax rate, including the social insurance payroll tax, but lowers the incremental pension benefits accrued from an additional hour of work. The resulting fall in labor supply leads to less saving and capital in the intermediate term and less output than either the Higher Copay or the Baseline policies for most of this century. Reducing public pension benefits eventually leads to more saving, capital, and output, but the increases are small. For instance, terminal steady-state output in the Lower Pensions scenario is only 2.1

percent higher than the Baseline.

So far we have concentrated on public policies that reduce resources to the elderly. Reducing general government expenditures is another way to proceed. We simulate a policy (Lower Purchases) that eventually reduces government purchases 10 percent below the trend incorporated in our baseline policy. This reduction is phased in, one percentage point per year, between 2018 and 2027. The tax rate path implied by this policy is almost the same (within one percentage point) as the Baseline policy until 2028 but is noticeably lower beyond that point. The maximum tax rate of 38 percent is in effect for almost 50 years, from 2076 to 2123, after which the rate declines gradually to its long-run value of 21.11 percent.

Finally, we have also considered the possibility that, through price controls, rationing, or other policies, the government might restrain the growth of aggregate healthcare spending, both public and private.[30] A 10 percent reduction in the time-series index of healthcare costs, ζ_t, below the trend value in our baseline case that is phased in, by a one percentage point reduction per year between 2018 and 2027, has similar effects to a 10 percent reduction in government purchases The maximum tax rate is 40 percent between 2076 to 2123, after which the rate declines gradually to its long-run value of 22.92 percent.

6.4 Net Lifetime Taxes and Welfare

We now turn to consider how the policy mix and the timing of policy changes affects net lifetime taxes and welfare of members of each cohort. Net lifetime taxes are calculated using the generational accounting methodology of Auerbach, Gokhale and Kotlikoff (1992). This methodology computes the expected present value of taxes paid over the remaining lifetime of each cohort net of the value of benefits received from the government. Our model starts in 2008. Thus, for cohorts born in 1988 and later the generational accounts capture expected taxes paid and benefits received from birth. For older cohorts, however, the generational accounts only measure expected net lifetime taxes from 2008 on. Net taxes are discounted using the prevailing sequence of after-tax interest rates that prevail during each cohort's life. To facilitate comparisons among current

[30] Japan currently regulates the price of medical services fairly stringently, and it is unclear how feasible a further 10 percent reduction would be.

and future cohorts, lifetime net taxes are detrended for productivity growth between 2007 and the cohort's birth year.

We also measure welfare effects of various fiscal policy scenarios by computing compensating variations. The Baseline policy is used as the reference point. For each alternative policy, we compute the proportional increase in consumption in each remaining period of life that would make an individual indifferent between the alternative policy and the Baseline. Thus, a positive compensating variation implies that the Baseline Policy is preferred, while a negative compensating variation implies that the alternative policy is preferred.

Figure 8 shows the expected present value of lifetime net taxes for cohorts born in 1900 or later. Results are reported for the Baseline, Higher Copay and Constant Tax policies. The Lower Purchase and the Lower Pension policies are omitted because their pattern of net lifetime taxes is very close to the Baseline policy.

The figure exhibits a general shape that is qualitatively robust across all of the transition paths we have computed. First, lifetime net taxes are negative for cohorts born before the mid-1950s to mid-1960s. This result is to be expected given that benefits tend to be concentrated late in life whereas taxes are paid earlier in life. For these older cohorts the generational accounts capture most of lifetime pension and medical benefits but omit the bulk of lifetime taxes.

The second general pattern apparent in Figure 8 is that net lifetime taxes are positive for all cohorts born after 1988 and reach a maximum around 1990. The height of this peak varies across the runs. Those born around 1990 experience the lowest net lifetime taxes under the Higher Copay policy. This is to due to the fact that increases in consumption taxes and copayments are phased in gradually. Those born around 1990 experience the highest lifetime net taxes under the Baseline scenario. Benefits in this scenario and the Constant Tax scenario are the same, whereas the consumption tax increase occurs sooner under the Constant Tax policy. From the perspective of these cohorts, the effects of a gradual but steady increase in tax rates from 10 percent to levels in excess of 45 percent are more costly than a one-time increase in the consumption tax to a level of about 36 percent. The magnitude of the difference across fiscal policy scenarios is very large for cohorts born around 1990. For instance, the Higher Copay scenario reduces lifetime net taxes of individuals born in 1989 by

Figure 8: Expected Present Value of Lifetime Net Taxes under Alternative Spending Policies, by Birth Cohort

The Baseline run assumes no expenditure cuts and a gradual increase in the consumption tax. The Higher Copay scenario assumes that health care copayments for retires rise to 30 percent. The Constant Tax run assumes no expenditure cuts and a one time increase in the consumption tax in 2018. Present values are computed as of either 2007 or the year of birth, whichever is later, and productivity growth after 2007 is then removed from the present values for cohorts born after 2007. These detrended present values are expressed in units of 2007 per capita income, which is normalized to 1.0.

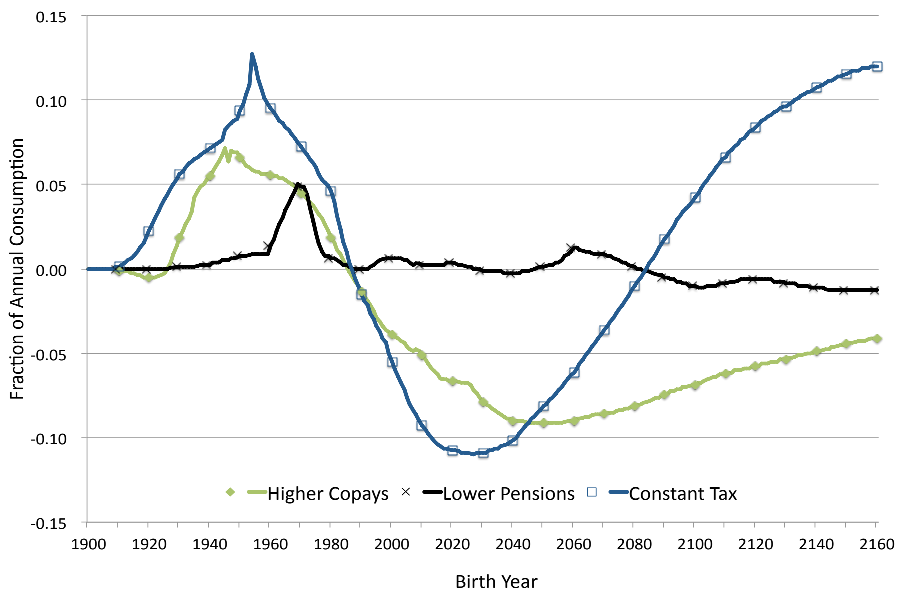
more than three years of per capita GDP.

More generally, net lifetime taxes are lowest under the Higher Copay policy for all cohorts born between 1930 and 2030. Subsequent cohorts experience the lowest net lifetime taxes under the Baseline policy. The former result would seem to suggest, for instance, that cohorts born in between 1930 and 2030 would prefer lower copays over higher taxes. The story is not that simple, however. Figure 9 shows compensating variations by cohort for the Higher Copay, the Constant Tax and the Lower Pensions policies.[31] Interestingly, cohorts born between 2000 and 2045 actually prefer the Constant Tax policy.

Why do these cohorts prefer the Constant Tax policy? We have seen that

[31] Lower government purchases are omitted because welfare unambiguously increases.

Figure 9: Compensating Variation Resulting from Alternative Spending Policies, by Birth Cohort



The compensating variation for each cohort is calculated relative to our Baseline policy with no spending cuts. Negative numbers indicate that the alternative policy is preferred.

higher medical copayments have powerful positive effects on saving, work effort and output in periods leading up to the year 2030. Underlying these macroeconomic responses are adjustments by individuals to self-insure against high medical expense risks that are concentrated at the end of life. Take for instance the 2020 cohort. This cohort experiences a 4 percent compensated consumption benefit under the Constant Tax policy as compared to the Higher Copay policy even though net life-time taxes are lower by two years of per-capita GDP under the Higher Copay policy. In the Higher Copay scenario copayments are already at the 30 percent level when the 2020 cohort retires. To provision for higher out-of-pocket medical expenses these individuals save more while working as compared to the Constant Tax scenario and also retain their wealth much later in life. The end result is that this cohort dies with significantly larger unused asset balances in the Higher Copay scenario. The expected value of these accidental bequests is 3.25 times larger than with the Constant Tax policy. Our finding that individuals value social insurance for end-of-life risks echoes previous findings of Braun, Kopecky and Koreshkova (2014) and De Nardi, French and Jones (2014). These papers have found that social insurance for end-of-life medical risks is highly valued by both rich and poor households/individuals. Individuals in our economy also value this form of social insurance.

Cohorts born after 2050 strongly prefer the Higher Copay policy to the Constant Tax policy. An important factor underlying this reversal in rankings is that the terminal steady state in the Constant Tax scenario has a much higher debt-GDP ratio, which reduces the capital stock and lifetime earnings. In addition, terminal taxes must be higher to cover interest payments on government debt.

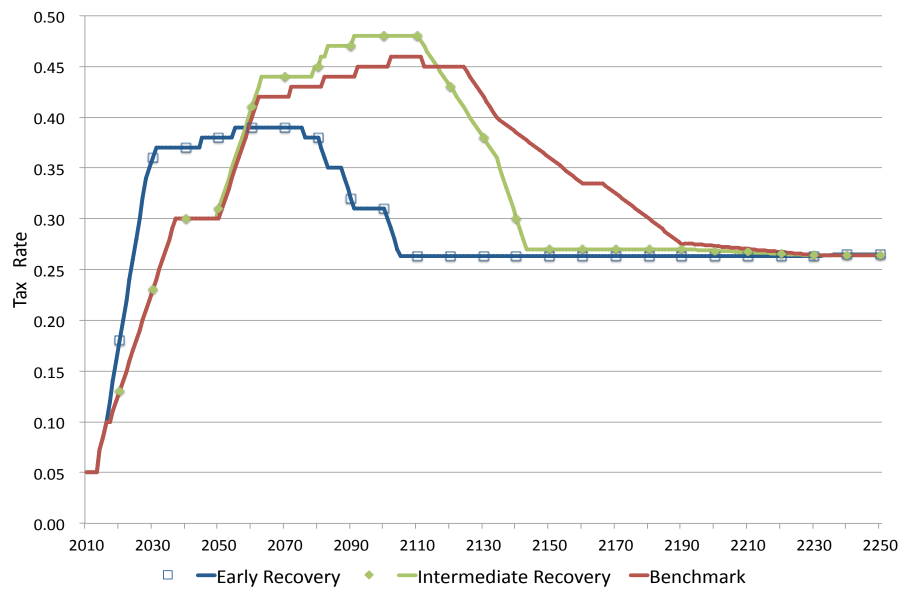
Finally, observe that cohorts born before 1990 prefer the Baseline policy. In other words, they prefer no cuts in government expenditures, high government borrowing and a gradual but steady increase in the consumption tax rate.

6.5 Robustness

Alternative Demographic Assumptions. The transition results reported above are based on the assumption that Japan's total fertility rate does not reach the replacement level until the year 2160. Section 2 also presents two alternative demographic projections with faster recoveries in the fertility rate. In the Intermediate Recovery projection the fertility rate reaches its replacement value in the year 2110. This projection results in an old-age dependency ratio and healthcare expenditures that are nearly identical to those under the Benchmark demographic projection until early in the next century, after which they begin to diverge (see Figures 1b and 2). The Early Recovery projection abandons the IPSS forecasts and assumes that the fertility rate recovers by 2060. This results in a lower peak old-age dependency ratio of 0.77 as compared to 0.88 in the benchmark projection and an earlier peak. In the Early Recovery projection the old-age dependency ratio peaks in the year 2050, which is thirty years earlier than the Benchmark projection.

We now use these two alternative scenarios to analyze how Japan's fiscal situation changes if fertility rates recover faster. Because all of our demographic projections assume a constant population in the long run, the resulting terminal steady states differ only in the absolute size of the population. However, readily discernible differences can be found in consumption tax rates and debt-GDP

Figure 10: Consumption Tax Rate under Benchmark and Alternative Demographic Projections



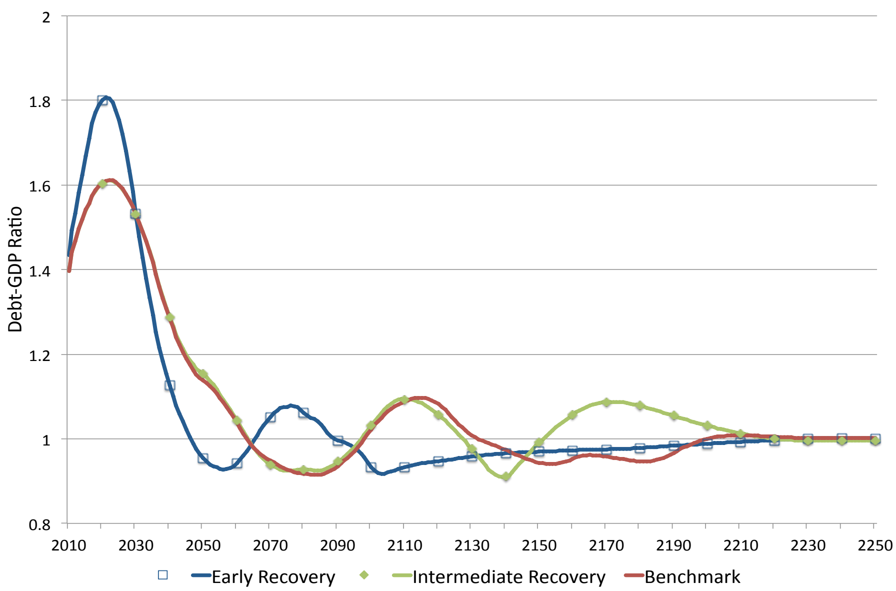
Benchmark scenario: benchmark demographic projections. Intermediate scenario: intermediate demographic projections Early scenario: Early Recovery demographic projections. All scenarios use the Baseline fiscal policy with no expenditure cuts.

along the transition path, as is shown in Figures 10 and 11.[32] Perhaps the most noteworthy distinction is that the financing needs of the government actually increase in the intermediate term if the fertility rate recovers faster. The consumption tax rate in our Intermediate Fertility projection exceeds the tax rate in the Benchmark projection between 2060 and 2130 and the consumption tax using the Early Recovery projection is higher than the Benchmark between 2018 and 2060.

The reason that a faster increase in fertility leads to a higher consumption tax rate lies in the general equilibrium effects incorporated in our perfect-foresight model. In particular, factor prices in the future affect the behavior of forward-looking agents today. A more rapid increase in the fertility rate leads to more new workers entering the market beginning in the last quarter of this century. The direct effect of this increase in the workforce is to increase output and

[32]These simulations are based on the Baseline fiscal policy scenario.

Figure 11: Debt-GDP Ratio under Benchmark and Alternative Demographic Projections



See the notes to Figure 10.

tax revenue and to lower the deficit and ultimately the consumption tax rate in the medium term. But a larger workforce also depresses the capital-labor ratio and the wage rate. In our model this decline in future lifetime wages is anticipated and affects the behavior of workers immediately. In particular, they save less because of their anticipated reduction in permanent income. The capital-labor ratio and the wage rate thus begin to decline even before the influx of new workers, causing a reduction in the supply of hours per worker before the number of workers begins to increase. Lower capital and labor lead to lower output and revenue, thus requiring higher tax rates to stabilize the public debt. These effects are particularly, pronounced in the Early Recovery scenario. Eventually, of course, the increase in the workforce comes to dominate these anticipatory responses, permitting a lower tax rate than under the Benchmark demographic projection. But this payoff in terms of lower tax rates does not occur for decades into the future.

Our model incorporates another effect that causes higher fertility to lead to higher tax rates in the intermediate term. Higher fertility implies a larger population of dependent children, leading to higher government healthcare spending. Our model does not include government spending on education and other services for minor children, which could affect the size of the fiscal imbalances associated with a more rapid recovery in fertility rates.[33] Still, our results suggest that a more rapid recovery in the fertility rate could actually compound Japan's fiscal imblances in the short to intermediate term.

A Final Caveat. All of our transition simulations assume full commitment on the part of the government. In particular, all simulations but one call for a sequence of tax increases spread out over many years. This assumption may appear to be particularly troubling for the Higher Copay policy. The behavioral responses to this policy change stimulate economic activity and increase government revenue immediately. Although an increase in the consumption tax rate to as high as 22.8 percent is a crucial element of this policy, the additional short-run revenue permits deferring any increase in the tax rate above the current 8 percent level until 2046. This delay in increasing taxes raises the possibility that individuals will not find the policy credible and thus will not increase their saving and work effort, causing the policy to break down.

Although it is beyond the scope of our analysis to directly take on the issue of credibility, we can control for these expectation effects by considering a variant of the higher copay policy in which the consumption tax is increased in 2019 and held fixed for 150 years before gradually declining to the same terminal value as in the Higher Copay scenario. The resulting value of the consumption tax rate is 19.2 percent, which is lower than the peak tax rate with the Higher Copay policy. From this we see that even if we rule out long-deferred increases in the consumption tax, higher copayments continue to have a big positive effect on the government's fiscal situation.

[33]Because of positive medical copayments, working-age parents must pick up a portion of the healthcare costs of minor children, leading parents to work somewhat harder. But this effect is too small in our model to offset the decline in hours per worker resulting from the general equilibrium effects described above. The increase in other child-rearing costs might lead parents to work even more, as in the model of Braun, Ikeda, and Joines (2009). Greater parental labor supply would generate more government revenue, tending to reduce the deficit and the consumption tax rate needed to stabilize the debt-GDP ratio in the intermediate term.

7 Conclusion

This paper has analyzed the effects of a graying Japan against the background of a high and rapidly growing debt-GDP ratio. Our projections indicate that Japan faces severe fiscal imbalances and that there is an urgent need to address them. We have explored alternative policies that do so, and it is likely that any solution will entail some combination of these and possibly other policies that we have not considered. In particular, correcting Japan's fiscal imbalances will require both higher taxes and reductions in government outlays. Perhaps surprisingly, measures that would produce a more rapid increase in fertility may exacerbate Japan's fiscal problems in the short to intermediate run.

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8 The Appendix

This Appendix describes how we assign numerical values to: the structural parameters of the model; the exogenous variables used for computing the initial and terminal steady-states; and the benchmark sequences of exogenous variables.

We start by describing some of the basic demographic features of the model that pertain to the calibration. A model period is taken to be one year and the model is calibrated using annual data. Households are formed at real-time age 21, retire at age 65 and survive to a maximum age of 112. Each household consists of one adult member and a fractional number of children that varies with the age of the adult.

Table 1 reports the principal structural parameters of the model and the settings of exogenous variables used in the initial and terminal steady states. Missing from Table 1 are parameters related to the public pension programa and medical expenditures which we discuss separately below.

Most of the structural parameters are calibrated using an updated version of the adjusted NIPA data-set constructed by Hayashi and Prescott (2002) and a sample period of 2000 to 2006.

The capital share parameter α and the depreciation rate δ are calibrated directly from Japanese data. The targets for these parameters are respectively capital's share of income and depreciation as a fraction of output,

Other structural parameters are calibrated by matching specific moments from the initial steady state of the model with corresponding moments in the data. The exponent on consumption in the utility function θ is calibrated to reproduce a share of working time of 28 percent of an assumed weekly time endowment of 112 hours. And β and γ are calibrated to reproduce the capital output ratio and the ratio of hours worked by 24-34 year olds to hours worked by 55-64 year olds.

We now describe how we set tax rates and government purchases. In principal, we need to specify the following objects: an initial value for each of these variables that is used to compute the initial steady state, a terminal value and sequences that describe the evolution of these variables during the transition. Some of these variables such as e.g. τ_t^c vary depending on the simulation as described in Section 6. Other taxes such as τ_t^k are generally the same across simulations. In principal, unless stated otherwise, we will specify an initial value which is used for computing the initial steady state and keep the fiscal variable fixed at that initial value throughout the transition and in the terminal steady state.

The tax rates are set in the following way. The value of the personal tax rate on dividend and interest income, τ^a, is set at its statutory rate based on reports to the OECD. This rate was 10 percent between 2003 and 2011 and increased to 20 percent in 2012. We thus set τ^a to 10 percent when computing the initial steady state. When computing dynamic simulations we increase τ^a_t to 20 percent in 2012 and keep it fixed is this value thereafter. The initial firm level tax rate on income from physical capital, τ^k is constructed using the same methodology as Hayashi and Prescott (2002) using data from 1990-2006. This results in a value of 0.428. The initial value of the consumption tax is set to the statutory tax rate of 5 percent . The initial tax rate on labor income, τ^w, is taken from data from OECD on the overall tax wedge on labor income. This object is a comprehensive measure of the labor wedge that includes employer and employee public pension contributions, contributions for medical insurance, and labor income taxes used to finance other government expenditures. The average value of the labor wedge from 2003-2006 is 0.232.[34] When computing dynamic simulations this tax rate varies by year due to changes in social security contribution rates. We describe this below.

The initial ratio of total government purchases to output net of health expenditures is set to 0.15 which is its average value over the 2005-2007 sample period.[35]

The initial government debt-output ratio is chosen to be 1.2, which is the value of the net government debt-GDP ratio for the year 2007 in our data set. Care must be taken to choose a measure of the government debt that is consistent with the measures of receipts and outlays on the right-hand-side of equation 20. A very expansive measure of debt that includes, e.g., the unfunded liabilities of the public pension system, is inappropriate as the receipts and outlays of the pension system are already included on the right-hand-side of 20. All of the transactions on the right-hand-side of 20 are between the government and the

[34] No data is available for 2001 and 2002.

[35] Our measure of government purchases is the sum of government consumption and gross investment.

private sector. Thus, the appropriate measure of the debt is the government's net liabilities to the private sector, with all intra-governmental holdings netted out. Our measure of government debt is based on flow of funds data and consists of gross debt and net loan liabilities of the general government (including the fiscal loan fund (FILP)) less holdings of government debt by the general government, the Bank of Japan and the Social Security Trust Fund. The initial real interest rate on government debt is set to 2.7 percent. This interest rate is an average rate across all maturities of government debt that is computed by taking the ratio of interest payments to the stock of debt. We convert this into a real interest rate using core CPI inflation. The value we use is the average interest rate from 2000-2006.

Our model assumes that the government can borrow at a lower rate than the rate of return on capital. When we do dynamic simulations we hold the spread between the rate of return on capital and government debt fixed at 1.24 percent. This value is an average using data from 2000-2006. The return on capital is the return after corporate profits taxes are paid but before personal asset taxes are paid and the return on government debt is a before tax rate of return. This value is the average difference between the return on government debt and the return on capital between 2000 and 2006.

We set the initial growth rate of technology to 2 percent rate of per capita output. Since 2006 Japan has experienced large variations economic activity. We capture this variation by adjusting A_t in 2008-2011 to reproduce variations in real per capita GDP growth in these years. After 2011 we set the growth rate of technology to 2 percent in all periods.

We assume an initial population growth rate of 1 percent and use the 2007 age distribution from Japanese data when computing the initial steady state. The remainder of our calibration of demographics is described in Section 4.

We now turn to discuss how we set parameters and exogenous variables that pertain to the public pension program and medical expenditures. We scale λ, which determines a retiree's initial pension benefit as a function of average indexed earnings, to reproduce a ratio of aggregate expenditures on pension benefits to GDP of 0.091. This is the value of this ratio in Japanese data for the 2007 fiscal year.[36]

[36]This ratio is changing rapidly as the population ages so rather than take an average we use the value for 2007.

We allow health care expenditures to vary with the age of the head of the household. Our measure of age specific health expenditures is based on data from Fukui and Iwamoto (2006) who report medical expenditures by age. They report total expenditures (public and private) for two categories of health expenditures: medical expenses and long-term care expenses. We use their estimates to construct a profile of total age-specific medical care expenditures, φ_j. The time-specific medical cost intensity, ζ_t, in the initial steady-state is set to 9.2 percent of output which is the average share of Japanese aggregate healthcare expenditures in GDP between 2005 and 2007. In our benchmark experiment, we assume that the productivity-deflated value of ζ_t is constant over time, i.e., that $\zeta_t / A_t^{1-\alpha} = \overline{\zeta}$, a constant. In words, we are assuming that health expenses grow at the rate of output.

We start with statutory copayment rates $1 - \kappa_j, j = 1, ...J$, rates by age (see e.g. Ihori, Kato, Kawade, Bessho (2010)). For children below age 14 the copayment rate is 20 percent. It rises to 30 percent between for those aged 14-69. Copayment rates for those of age 70 to 74 are 10 percent between 2007 and 2008 and then increase to 20 percent in 2009. For those 75 and older the copayment rate is 10 percent. We then scale the statutory copayments to reproduce the average share of out of pocket payments in total medical expenditures between 2005 and 2007. Copayments constructed in this way amount to 1.3 percent of GDP.

Transitional population dynamics generate transitional dynamics in the economy, which also can result from other sources. We assume that these other sources of variation settle down to constant values by the time population stabilizes. In addition to the assumptions described above relating to technology and population, we also assume that the government eventually adopts a stationary fiscal policy characterized by constant values of all tax rates, public pension benefit formulas, and government purchases (relative to output), and we restrict consideration to fiscal policies that lead to a non-explosive (and constant) ratio of government debt to output. These assumptions imply that the economy attains a steady state in the very long run. We assume this steady state is attained by the year 2308, although in practice each of our simulated economies settles down to a balanced growth path long before that.