The Japanese Economic Review
The Journal of the Japanese Economic Association

The Japanese Economic Review doi: 10.1111/jere.12135
Vol. 68, No. 1, March 2017

WHEN DO WE START? PENSION REFORM IN AGEING JAPAN

By SAGIRI KITAO
Keio University

Japan is faced with rapid demographic ageing and fiscal challenges. This paper simulates pension reform to reduce the replacement rate by 20% and raise the retirement age by 3 years gradually over a 30-year period. We consider three scenarios with different points in time to initiate reform in 2020, 2030 and 2040, respectively. A delay would suppress economic activities, lowering output by up to 4% and raising tax burden by more than 8% of total consumption. Delaying reform implies a transfer of costs of demographic ageing to the young and deteriorates the welfare of future generations by up to 3% in terms of consumption equivalence.
JEL Classification Numbers: E2, E6, H3, J1.

1. Introduction

Japan is experiencing dramatic demographic ageing at an unprecedented speed and it is faced with a significant rise in government expenditure. Sustainability of the social security system is a major concern of the Japanese Government and this paper studies the effects of pension reform, focusing on the timing of a policy change. Total pension expenditures already exceeded 10% of GDP in 2014 and they are expected to rise quickly as the old-age dependency ratio doubles over the next few decades. The Japanese Government implemented major pension reform in 2004 in an effort to keep benefit expenditures under control. The pillar of the 2004 reform was the "macroeconomic slide" mechanism, which would automatically adjust benefits downwards with a rise in average life expectancy and a decline in the number of the insured. The adjustment, however, is subject to enough inflation as downward adjustment is restricted in nominal terms. The slide has been triggered only once in 2015, since the reform was implemented in 2004. Although the macroeconomic slide, if successfully executed, is expected to reduce replacement rates by approximately 20%, how the adjustment will proceed and when and whether it will be completed are unknown.

The average life expectancy of Japanese people is the longest among major developed countries. The normal retirement age, that is, the age at which individuals are entitled to full pension benefits, is 65, which is one of the lowest in the world, implying that Japanese people have a longer expected duration of receiving public pension benefits compared to people in other developed economies. Although raising the normal retirement age beyond 65 had not been very seriously debated in Japan until very recently, it is a policy that Japan should consider immediately, and implement before the old-age dependency ratio reaches an unprecedented level, as we discuss in Section 2. The replacement rate, especially once the macroeconomic slide is complete, is fairly low, and comparable to other developed countries with pay-as-you-go pension systems, and an aggressive adjustment in the replacement rate alone beyond what the 2004 reform would lead us to might be a challenge. Combination of the adjustment in both the extensive margin (normal retirement age and duration) and the intensive margin (replacement rate) of a reasonable magnitude seems to be sensible and it is worth analysing policy options to keep expenditures under control.

We will, therefore, consider reform that will reduce benefits by 20% as embedded in the pension reform of 2004 and raise the normal retirement age by 3 years gradually, increasing by 1 year every decade, from 65 to 68. We will also assume that benefits will decline over a period of 30 years and the change will occur only slowly so that it will not force a sudden and large change in the income and consumption of any generation.

We will focus on the effects of reform timing and compare outcomes of scenarios under which reform begins in different years. We build a quantitative general equilibrium model populated by overlapping generations, calibrated to micro and macro data of the Japanese economy with time-varying demographics as projected over coming decades. We consider three points in time to initiate reform, 2020, 2030 and 2040, respectively. Although the paths under each scenario will converge to a common transition path eventually, economic consequences at both macro and micro levels are very different during the transition.

Compared to the economy with no reform, individuals who see their expected pension benefits decline have stronger saving motives for retirement and aggregate capital will be higher. By 2040, the difference is as much as 8.7% when reform begins in 2020, while it is 6.3% and 3.4% when reform starts in 2030 and 2040, respectively. Labour supply also differs across three scenarios and so does the welfare of different generations. Current retirees and middle-aged individuals would prefer a scenario of delaying reform as long as possible because the direct loss from reduced benefits would outweigh gains from lower taxes and other general equilibrium effects. Younger and future generations would be better off if they started their economic life under scenarios where reform is already in progress for a longer period. For instance, individuals born in 2000, who will become adults in 2020, would be better off by more than 2% in terms of consumption equivalence if reform begins in 2020 rather than 2040. They would enjoy higher wages throughout their careers and lower taxes for the rest of their lives.

In terms of the structure of the model, the present paper builds on a growing literature that studies the effects of ageing demographics on fiscal sustainability in Japan using a dynamic general equilibrium model populated by overlapping generations. Quantitative analyses of social security reform and intergenerational and intragenerational redistributional effects in a full-blown overlapping generation model have developed since the seminal work of Auerbach and Kotlikoff (1987), mostly in the context of the US economy.[1]

Ihori *et al.* (2005) build a life-cycle model with public pension and health insurance programmes in Japan and study the effects of ageing demographics and public debt policy. Braun and Joines (2015) model details of medical expenditures and the health insurance system and study the effects of public pension and health insurance reform in a general equilibrium life-cycle model. Kitao (2015) distinguishes between health and long-term care insurance programmes and quantitatively evaluates the effects of ageing demographics on fiscal sustainability in a model with endogenous participation in the

[1] See, for example, Conesa and Krueger (1999), De Nardi *et al.* (1999), Attanasio *et al.* (2007), İmrohoroğlu and Kitao (2009, 2012) and Kitao (2014).

labour market. Kitao (2015) simulates alternative pension reforms that will reduce pension benefits through a reduction in replacement rates or an increase in the retirement age.[2] Adjustments will be made gradually over a given period but in all experiments reforms are assumed to begin immediately in a given year. In this paper, as mentioned above, we focus on the effects of different timings for initiating reform.

The rest of the paper is organized as follows. Section 2 summarizes the current and projected demographics of Japan, and reviews the main features of the pension system and compares them to those in other developed countries. The theoretical model is presented in Section 3 and Section 4 discusses parametrization. Section 5 presents numerical results and Section 6 concludes.

2. Demographics and pension policy in Japan

In this section we review the current state of demographics in Japan and issues that will arise over the coming decades as we extrapolate the population distribution based on official projections. We will then summarize the pension policy in Japan and compare it to that of other major developed countries. The review will be used as a basis for choosing the particular reform that we simulate in the numerical analysis that follows.

2.1 Demographics in Japan

Figure 1 shows the population data and projections through to the end of the century reported by the National Institute of Population and Social Security Research (IPSS).[3]

The population increased monotonically during the last century, except for a few years during World War II. The trend, however, has reversed since 2008, when the number of deaths started to surpass that of births, and a decline in population is projected to continue throughout the rest of the century. According to the official projection, by 2100 the population will reach 50 million, 40% of the level in 2015, or back to the level of the 1910s.

The ongoing decline in the Japanese population is attributable to low fertility rates. Figure 2 shows historical and projected total fertility rates since 1950. Total fertility rates declined sharply in the 1950s after the first baby boom in the late 1940s following World War II. Fertility rates somewhat recovered in the 1960s and early 1970s, creating the second baby boom generations.[4] Since the mid-1970s, fertility rates have trended down and fallen well below the replacement rate that is needed to prevent the population from declining. They even fell below 1.5 and have not exceeded that level in the two decades since the early 1990s. The IPSS projects that the total fertility rate will stay at around 1.35 through to 2060, the last year of official projections.

While the number of newborns has declined, life expectancy has increased with the continued improvement in health care and advancements in medical technology. Figure 3

2 Other papers in the literature include Doi (2008), Doi *et al.* (2011), Ihori *et al.* (2011), Yamada (2011), Okamoto (2013), Hoshi and Ito (2014), Hsu and Yamada (2015), and Hansen and İmrohoroğlu (2016). Kitao (2016) studies effects of policy uncertainty explicitly in a similar model.

3 The projections are based on IPSS's "medium" assumptions on fertility rates, released in 2012.

4 There is a major drop in the number of births in 1966, the year of "Hinoe-uma" (the fire horse) and associated superstition, which occurs every 60 years.

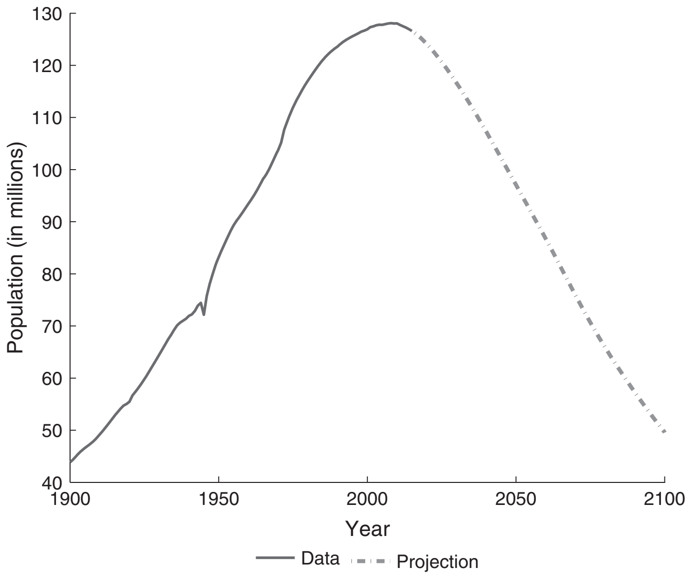

FIGURE 1. Japanese population: Data and projection
Source: IPSS (2012).

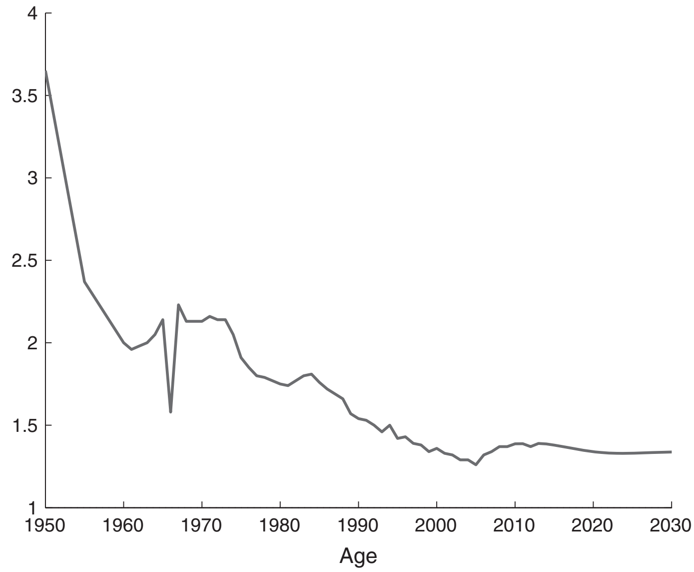

FIGURE 2. Total fertility rate: Data and projection
Source: IPSS (2012).

shows life expectancy at birth, based on the data and projections of the IPSS. Life expectancy has increased by approximately 30 years for both men and women since 1950. It is projected to rise further, reaching almost 85 for men and above 90 for women by 2060.

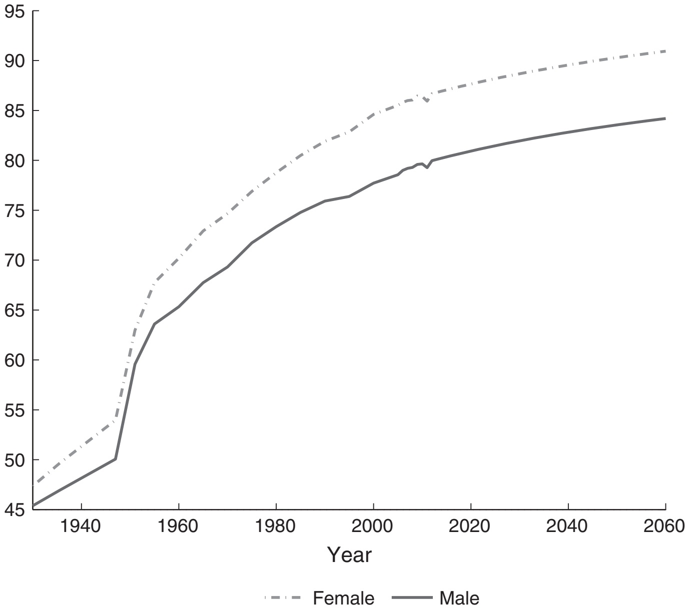

FIGURE 3. Life expectancy at birth. Data and projection
Source: IPSS (2012).

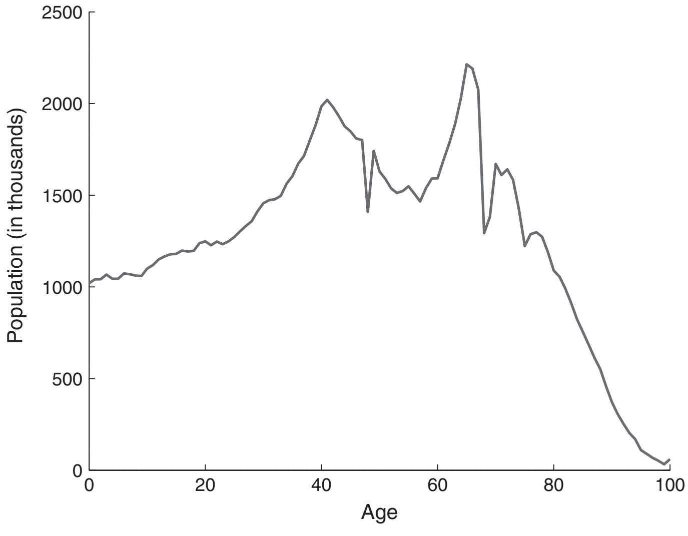

FIGURE 4. Population by age in 2014
Source: IPSS (2012).

A decline in fertility rates and a rise in longevity changed the age distribution and made the shape of the demographic pyramid unusually unstable. Figure 4 shows the age distribution of the Japanese population in 2014. The 40-year stagnation of fertility rates can be seen in the monotonic decline in the population from age 40 to age 0, falling by half, from 2 million to approximately 1 million. Those born during the first baby boom

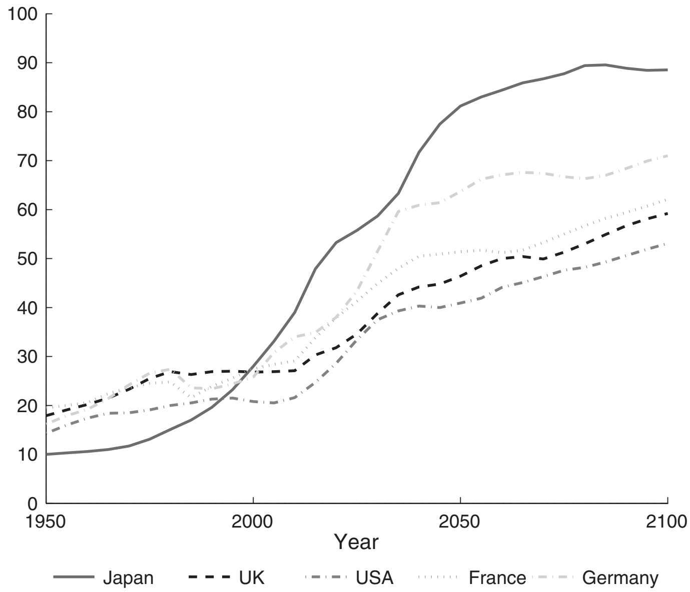

FIGURE 5. Dependency ratio. Data and projection
Source: IPSS (2012) and United Nations (2015).

in the late 1940s are now in their mid-60s, and already reached the normal retirement age. The second baby boomers will follow the wave in approximately 20 years. At the same time, the size of the working-age population will decline monotonically and sharply during the coming decades.

The path of the dependency ratio is shown in Figure 5, representing the ratio of the population aged 65 and above to those aged 20-64. The figure summarizes economic and fiscal challenges that Japan will have to deal with over the coming decades. The ratio, which was around 10% in the 1950s, rose sharply during the following decades due to dramatic improvement in longevity and a decline in mortality risks at younger ages. Low fertility rates below the replacement rate since the 1970s accelerated the rise after the 1990s and will continue to keep the dependency ratio rising, which will reach 60% in the early 2030s and 80% by 2050. It will remain above 80% throughout the century according to official demographic projections. Compared to other developed countries, which will all experience the same trend qualitatively, the magnitude of the rise in the dependency ratio in Japan clearly stands out. The United States, for example, will also see a rise in the number of retiring baby boomers, but the dependency ratio will not exceed 50%, at least until after the 2080s thanks to fertility rates that are much higher than those in Japan.

2.2 Pension policy and reform

The demographic trends described above will pose a major challenge in fiscal management in Japan. Expenditures for the elderly through public pension and health insurance programmes will soar, with the size of the working-age population continuing to shrink and tax revenues declining.

There has been an ongoing increase in not only the number of pension recipients but also the average number of years of receiving public pensions as life expectancy continues to rise. With the pension reform of 2004, the timeline has been set to increase the contribution rate gradually and by 0.354 percentage points every year, from 13.58% of earnings to 18.3% in 2017. It will, however, be fixed thereafter and revenues will keep falling with a decline in the number of workers, unless there is a dramatic rise in total earnings per worker.

As mentioned in Section 1, the pension reform of 2004 was comprehensive, and aimed at making the Japanese public pension system sustainable in the long run. A mechanism called the macroeconomic slide was introduced that would review both benefit payments to retirees and contributions from the insured and limit a rise in pension benefits relative to contributions automatically. The adjustment, however, is restricted so that it does not reduce benefits in nominal terms when the inflation rate is positive, or the adjustment does not exceed the (negative) inflation rate under a deflationary economy. When prices decline, for example, there is no adjustment in real terms even if the demographic change calls for a slide adjustment, foregoing an opportunity to reduce benefits. Since reform was implemented in 2004, the macroeconomic slide was triggered only once, in 2015. There were also times (e.g. 1999–2001, prior to 2004 reform) when deflation called for a nominal reduction of benefits but they were not adjusted as "special cases" (*tokurei*), leading to an increase in benefits in real terms. According to the official fiscal projections ("*zaisei kensho*") of 2014, which assume inflation rates that are well above estimated slide rates as well as unwavering implementation of macroeconomic slide, replacement rates of the public pension system would decline by approximately 20% when the slide adjustment is complete and after that the benefit schedule would be fixed. In Section 5, we analyse reform that includes the reduction of benefits by this magnitude of 20% as well as an increase in the retirement age and study the effects of alternative timings of such reform. Although reform of this magnitude would be considered reasonable and necessary as discussed below, there is much uncertainty as to the timing of reform and when such adjustments will be initiated and completed.

Table 1 compares total pension expenditures relative to output and pension replacement rates in major developed countries, based on estimates of the OECD (2015). Total pension expenditures in Japan are approximately 10% of GDP, which is well above the

Table 1
Pension expenditures and replacement rate

Country	Expenditures (% of GDP)	Replacement rate (%)	
		Gross	Net
Japan	10.2	35.1	40.4
Australia	3.5	44.5	58.0
Canada	4.3	36.7	47.9
France	13.8	55.4	67.7
Germany	10.6	37.5	50.0
Italy	15.8	69.5	79.7
Spain	10.5	82.1	89.5
UK	5.6	21.6	28.5
USA	6.7	35.2	44.8

Source: OECD (2015).

TABLE 2
Normal retirement age of public pension system and life expectancy

Country	Normal retirement age		Life expectancy	Difference	
	Current	Long run		Current	Long run
Japan	65	65	83.3	18.3	18.3
Australia	65	67	82.1	17.1	15.1
Canada	65	67	81.8	16.8	14.8
France	65	67	81.9	16.9	14.9
Germany	65	67	80.7	15.7	13.7
Italy	64	67	82.8	18.8	15.8
Spain	67	67	82.3	17.3	15.3
UK	65*	67	80.5	15.5	13.5
USA	66	67	78.9	12.9	11.9
Average (ex Japan)	65	67	81.4	16.4	14.4

Note: (*) Retirement age in the UK was 65 for men and 62.5 for women in 2014.
Source: OECD (2015) and United Nations (2015).

level of the United States, the UK, Canada and Australia, but close to Germany and Spain and below France and Italy. The Japanese number, however, is expected to rise rapidly as the dependency ratio increases and exceeds that of many, if not all, of these countries. For that reason, although the replacement rate is not remarkably high at this moment compared to other countries, as shown in the table, benefit adjustment through formal mechanisms such as an autonomous macroeconomic slide set in real terms would be necessary to keep expenditures under control.

In terms of the "extensive margin" of the Japanese pension system, Table 2 compares the retirement age and life expectancy in the same group of major developed countries. The Japanese public pension consists of two parts, a basic pension (*kiso nenkin*), which is provided for all retirees conditional on the payment of a required premium, and an employment-based part (*kosei nenkin*), whose benefits are based on the premium contribution made by each individual throughout his or her career. The normal retirement age for the basic pension has been fixed at 65, ever since the national pension system was established in 1961. For the employment-based part, the retirement age was originally 55, but has been raised through a series of reforms and will be 65 by 2018.

Many other countries now have the same normal retirement age of 65, but in all except for Japan the retirement age is set to rise under current regulations in place. As shown in Table 2, in the long-run, Japan will have the lowest normal retirement age among the countries in the absence of new regulation.

Given the life expectancy today across these countries (United Nations, 2015), Japan has the longest expected duration of receiving a public pension, at 18.3 years, except for Italy. In the long run, if life expectancy were to remain constant (obviously counterfactually), the duration of receiving the pension in Japan would remain at 18.3 years, which is by far the longest of all and approximately 4 years longer than the average across these countries, which stands at 14.4 years.

Given these observations about the current and projected status of Japanese demographics and the comparison of pension policies across countries, in the numerical simulations, we consider reform to reduce benefits by a downward shift of the schedule by 20%, which is equivalent to what a successful macroeconomic slide is expected to achieve, and to simultaneously raise the normal retirement age by 3 years, from 65 to 68. We let the adjustment take place slowly so as to mitigate the costs of the transition. Once reform begins, we allow 30 years for adjustments to complete. We will describe the details of policy experiments in Section 5.

2.2.1. More on the Japanese pension system

As stated above, the normal retirement age is defined as the age at which individuals are entitled to receive pension benefits in full and it should not be confused with the age at which individuals exit the labour force. The former is set by the policy and the latter is a choice of an individual. They do not have to coincide and they do, indeed, differ for the majority of individuals. In the model presented in the next section, we let individuals make labour participation decisions and decide when to leave the labour force, taking as given the age at which the government starts to pay them retirement benefits.

In reality, however, individuals could start claiming benefits at as early as 60 years old or delaying the initial take-up until as late as 70 years old. If they do so, benefits are adjusted downwards for early take-up by up to 30% and upwards otherwise by as much as 42%. In Japan, however, the majority of individuals claim benefits at normal retirement age and very few people wait until above normal retirement age to start receiving benefits. According to the report of the Ministry of Health, Labour and Welfare (MHLW), among the recipients of the basic pension (*kiso nenkin*), 85% claimed benefits at the normal retirement age, 14% claimed earlier and only 1.3% claimed at an age above the normal retirement age.[5] There are a small number of papers that endogenize the timing of claiming benefits. See, for example, İmrohoroğlu and Kitao (2012) and Benitez-Sílva *et al.* (2007), who allow individuals of the model to choose the age to take up pension benefits in the context of the US economy and its public pension system.

3. Model

3.1 Economic environment

3.1.1 Demographics

Individuals in the economy start making economic decisions at age $j=1$ and can live up to the maximum age J subject to mortality risks. Age-j individuals at time t survive until the next period $t+1$ with probability $s_{j,t}$. We assume that accidental bequests left by the deceased are distributed as a lump-sum transfer denoted as b_t to all surviving individuals. The size of a new cohort grows at rate n_t.

3.1.2 Endowment, preferences and technology

Individuals choose hours of work h out of a unit of disposable time and the rest $(1-h)$ is enjoyed as leisure. Earnings of an individual are given as $y_t = z\psi_j h w_t$. z represents

5 These numbers are based on figures in table 20 of "Overview of the employees' pension and national pension system" ("*kosei nenkin hoken, kokumin nenkin hoken jigyo-no gaikyo*") issued by the MHLW in 2015. Among those who started to receive benefits in 2014, 86.1% claimed at normal retirement age, and 12.4% and 1.5% claimed at ages below and the above normal retirement age, respectively (table 21).

idiosyncratic and stochastic labour productivity and ψ_j is age-specific deterministic productivity. w_t denotes the market wage rate per efficiency unit at time t.

Here, $u(c,h)$ denotes instantaneous utility determined by consumption and work hours. Individuals maximize the sum of discounted expected utility over their lifetime, $E\{\Sigma_{j=1}^{J}\beta^{j-1}u(c_j,h_j)\}$. The expectation is with respect to the distribution of idiosyncratic labour productivity shocks and timing of death. β denotes the subjective discount factor.

The medical spending of an individual consists of health care and long-term care expenditures, denoted by $m_{j,t}^{h}$ and $m_{j,t}^{l}$, respectively. Individuals pay a fraction μ_j^h and μ_j^l of each type of expenditure as copayments and the government covers the rest of the bill through public health care and long-term care insurance programmes, respectively. Each individual's total out-of-pocket expenditures are given as $m_{j,t}^{o} = \mu_j^h m_{j,t}^{h} + \mu_j^l m_{j,t}^{l}$. The sum of expenditures paid by the government M_t^g and those paid by individuals M_t^o equals total national medical expenditures denoted as M_t:

$$M_t^o = \sum_j m_{j,t}^o \lambda_{j,t}$$

$$M_t^g = \sum_j \left[(1-\mu_j^h)m_{j,t}^h + (1-\mu_t^l)m_j^l\right]\lambda_{j,t},$$

where $\lambda_{j,t}$ denotes the number of individuals of age j at time t.

Goods are produced according to constant returns to scale technology, $Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$, where Y_t denotes aggregate output, K_t aggregate capital, L_t total labour supply and A_t technology. α is share of capital and $\delta \in (0,1)$ denotes the depreciation rate of capital. Factor prices, denoted as r_t^k and w_t, are equated to marginal products of capital and labour, respectively.

3.1.3 The government

The government operates a pay-as-you-go public pension system. Once reaching normal retirement age, denoted as j_R, each individual starts to receive pension benefits $ss_t(j,e)$, which are determined as a function of an index e that summarizes an individual's average lifetime earnings. Note that the normal retirement age j_R is the age at which individuals start to receive public pensions and it is different from the age at which individuals exit the labour force. Individuals in our model endogenously choose the latter and they can continue to work beyond the pension retirement age or they may stop working before reaching age j_R.

The government issues one-period riskless debt D_t and pays interest r_t^d. The interest rate on the government debt is assumed to be different from that paid on capital rented to firms so that the model matches the level of interest rate that the government pays on debt. As in Braun and Joines (2015) and Kitao (2015), we assume that individuals allocate an exogenous fraction ϕ_t of savings to government debt and a fraction $(1-\phi_t)$ to firms' capital. After-tax gross return on each unit of individuals' savings net of taxes is given as $R_t = 1 + (1-\tau_t^k)r_t^k(1-\phi_t) + (1-\tau_t^d)r_t^d\phi_t$.

The government raises revenues through taxes on earnings at rate τ_t^l, income from capital rented to firms at τ_t^k, interest rate earned on government debt at τ_t^d, and consumption at τ_t^c, and through newly issued government debt D_{t+1}. Revenues are used to cover expenditures that consist of G_t, government consumption, debt services, public pension benefits, and health and long-term care insurance benefits. The government must satisfy the budget constraint

$$\begin{aligned} &G_t + (1 + r_t^d)D_t + \sum_x ss_t(x)\lambda_t(x) + M_t^g \\ &= \sum_x \left\{ \tau_t^l y_t(x) + [\tau_t^k r_t^k (1 - \phi_t) + \tau_t^d r_t^d \phi_t](a_t(x) + b_t) + \tau_t^c c_t(x) \right\} \lambda_t(x) + D_{t+1}, \end{aligned} \tag{1}$$

where $\lambda_t(x)$ denotes the measure of individuals in an individual's state x at time t as explained below in Subsection 3.2. We will discuss the fiscal adjustment needed to satisfy the government budget constraint during the transition in more detail in Section 5.

3.2 Individuals' problem

Individuals can purchase and accumulate one-period riskless asset a_t, which is a composite of an investment in firms' capital and holdings of government bonds. Individuals cannot borrow against future income and assets must be non-negative; that is, $a_t \geq 0$. Markets are incomplete and there are no state contingent assets that can be used to insure away idiosyncratic productivity shocks and mortality risks.

Individuals choose a sequence of consumption, saving and labour supply over the life cycle to maximize discounted life-time utility. A state vector of each individual is given as $x = \{j,a,z,e\}$, where j denotes age, a assets saved and carried from the previous period, z idiosyncratic labour productivity, and e an index of cumulated labour earnings that determines each individual's social security benefits. The value function $V(x) = V(j,a,z,e)$ of an individual in state x is given as follows:

$$V(j, a, z, e) = \max_{c,h,a'} \left\{ u(c, h) + \beta s_j EV(j + 1, a', z', e') \right\}$$

subject to

$$(1 + \tau^c)c + a' + m_j^o = R(a + b) + (1 - \tau^l)y + ss,$$

where $y = z\psi_j hw$ denotes labour earnings. The index for cumulated earnings is updated according to a function $e' = f(e, y)$ until individuals reach normal retirement age j_R, after which $e' = e$.

The competitive equilibrium is defined in Appendix I.

4. Calibration

The model period is annual and the decision-making unit is an individual, who represents a household as head. We will first compute the economy in the initial year of the transition, the "initial steady state", which represents and approximates the economy of 2010. As discussed in Section 2, population is currently far from stationary and it is important to capture the actual age distribution so the model can assess the impact of demographic transition starting from the current state of the economy. Therefore, we impose the actual age distribution of 2010 in the initial steady state in computing aggregate statistics. We then compute the final steady state that represents the economy in the long run when demographic transition is complete and the population becomes stationary. Finally, we derive transition dynamics between initial and final steady states by computing an equilibrium in each period.

4.1 Demographics

We assume that individuals enter the economy at age 25 and can live up to the maximum age of 110. Survival rates $s_{j,t}$ and growth rates of new cohort n_t are calibrated to the estimates of the National Institute of Population and Social Security Research (IPSS). Official projections by the IPSS are available up to 2060 and we use them during the transition. We assume that age-specific survival rates will stay constant after 2060 and that the growth rate of newborn individuals will gradually rise after 2060 and reach 0% by 2150.

4.2 Endowment, preferences and technology

We assume that idiosyncratic labour productivity in log, $\tilde{z}_t = \log z_t$, follows a process

$$\begin{aligned} \tilde{z}_t &= \omega_t + \varepsilon_t, \\ \omega_t &= \omega_{t-1} + \nu_t, \end{aligned} \tag{2}$$

where errors ε_t and ν_t are uncorrelated and iid across individuals, with mean zero and variances $\sigma_{\varepsilon t}^2$ and $\sigma_{\nu t}^2$, which are set to the estimates of Lise *et al.* (2014).[6] We compute a life-cycle wage profile of men by age based on the Basic Survey on Wage Structure (BSWS) in 2010, as shown in Figure 6, which is used to calibrate age-specific deterministic productivity ψ_j.

Individuals derive utility from consumption and leisure based on non-separable preference given as

$$u(c,h) = \frac{\left[c^{\gamma}(1-h-\theta_j)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma},$$

where θ_j represents disutility of participation measured in terms of lost leisure time. It varies by age and takes a value of 0 when individuals do not participate; that is, $h=0$. For those who participate, we assume a functional form $\theta_j = \kappa_1 j^{\kappa_2}$ to capture the age-dependent utility cost of participation.

Figure 7 shows the average labour force participation rates of men by age based on the Labor Force Survey (LFS) in 2010. Many individuals stay in the labour force at ages well above 60 and beyond pension's normal retirement age at 65. The average number of work years above 60 is 8 and extrapolating the available data, participation rates do not reach zero until the mid-80s. In order to approximate the pattern of life-cycle labour force participation in the data, we assume that θ_j is zero before 60 and set

[6] We set variance of permanent shock σ_ν^2 at 0.0078 and transitory shock σ_ε^2 at 0.03.

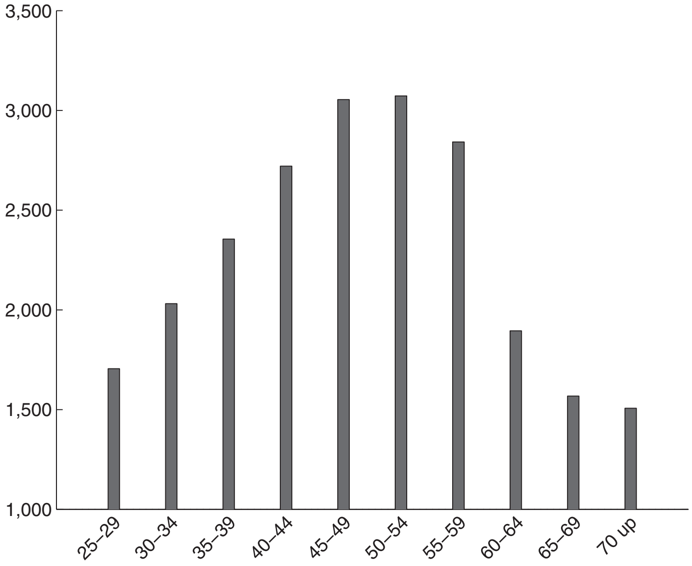

FIGURE 6. Wage rates by age
Source: Hourly wage computed from Basic Survey of Wage Structure (2010).

the values of the two parameters κ_1 and κ_2 at 0.3 and 7.0, respectively, so that the model matches average work years above age 60 and the fact that participation rates fall gradually to reach zero in the mid-80s in the initial steady state.[7]

Here, γ represents the preference weight on consumption and it is set to 0.37 so that individuals on average spend 40% of their disposable time at market work. σ is set at 3.0, which implies relative risk aversion of approximately 1.7, in line with estimates in the literature. We set the discount factor β at 1.029 so the model generates a capital–output ratio of 2.5.

Firms produce output according to the production function, $Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$. The capital share α is set at 0.36 and the capital depreciation δ at 0.089, from Hayashi and Prescott (2002). Based on estimates for the past decade, we assume that total factor productivity A_t grows at $g_t = 1\%$. The initial level of productivity A_0 is set so that average earnings is 1.0 in the initial steady state.

4.3 The government

Individuals start to receive pension benefits once they reach the normal retirement age j_R of 41 (65 years old). The pension benefits of each individual consist of a fixed basic

[7] Without a fixed cost of participation, the average participation rates never fall below 10% throughout a life cycle. In fact, many who survive beyond life expectancy would counter-factually resume working as they run down and deplete their wealth. Of course, the labour supply of the very old depends on what we assume about the fate of their productivity. Because of a lack of data and due to potentially a very severe selection bias in the wage data of very old workers, it is a challenge to estimate their productivity. Either participation costs that increase in age or declining productivity, or some combination of both, would be necessary to generate the pattern of participation observed in the data. For productivity we simply extrapolate the available data and we let age-dependent disutility of participation absorb what is not explained by the wage data so the model approximates the life-cycle pattern of participation in the data.

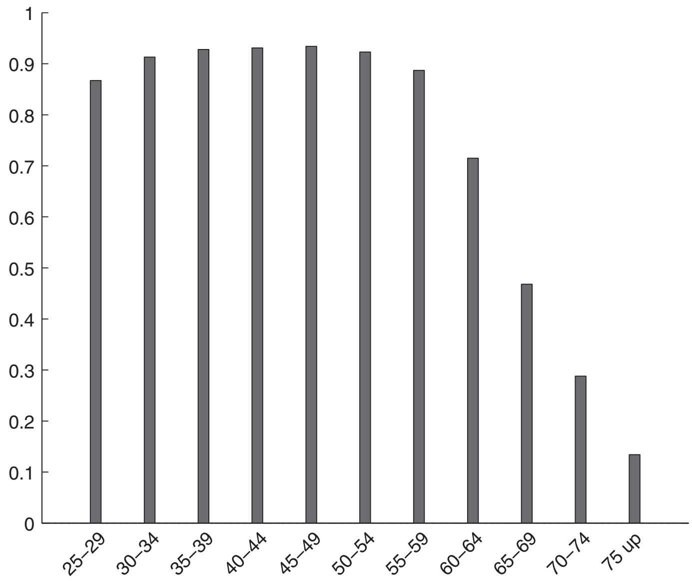

FIGURE 7. Participation rates by age
Source: Labor Force Survey (2010).

pension $\bar{ss}$ and a part that is proportional to an individual's career earnings according to a formula $ss = \bar{ss} + \rho \cdot e$. e denotes an index that summarizes an individual's past earnings and it is updated recursively as

$$e_{t+1} = \frac{e_t \times (j-1) + \min(y_t, \bar{y})}{j}. \tag{3}$$

Here, $\bar{y}$ denotes the cap for counted earnings and is set to the level of maximum annual earnings of approximately 10 million yen, used for the earnings index in the Japanese pension system. The basic pension $\bar{ss}$ is set so it corresponds to the actual average payment of approximately 655,000 yen per year in 2010. For the earnings-related part, the replacement rate ρ is set to 0.30 so that the model matches total expenditures for pension benefits in 2010, which stood at approximately 10% of output.

Health and long-term care expenditures are based on administrative data of the MHLW. The copay rate of health insurance is 30% for individuals aged below 70, 20% at 70–74 years old, and 10% at 75 and above. Long-term care is provided for individuals above age 40 and the copay rate is 10% for all recipients.

Government expenditures, including spending for health and long-term care insurance, are 20% of aggregate output in 2010 according to the National Accounts of Japan (SNA). G_t/Y_t is set to match this data. The government debt D_t is set at 100% of GDP, based on the SNA's net debt data at the beginning of 2010. The interest rate r_t^d on government debt is set to 1.0% based on the average real interest rate paid on outstanding government bonds in 2000s. The fraction ϕ_t of individuals' saving allocated to government debt is determined in each period to guarantee a net debt ratio D_t/Y_t, which we assume is constant at 100%.

We set the capital income tax rate at 40%, which is in the range of estimates of effective tax rates, and the interest income from the government debt is taxed at 20%. Consumption tax is set at 5% in the initial steady state of 2010. The labour income tax rate is determined in the equilibrium of the initial steady state so that it satisfies the government budget constraint and is set at 35.3%. In Section 5, when we compute the transition dynamics, we adjust consumption tax rates to balance the government budget in each period. We will keep the labour income tax rate and other fiscal variables at the level of the initial steady state to facilitate the analysis and comparison over time and across different policies.

5. Numerical results

As described in the previous two sections, we will first compute an equilibrium in the initial steady state that represents the economy of 2010. We then let the economy make a transition, in which demographics will evolve as projected by the IPSS and converge to a stationary distribution eventually. During the transition, we adjust consumption tax rates to balance the government budget in each period and the dynamics of tax rates will highlight the evolution of fiscal cost associated with demographic ageing in Japan during coming decades. Full convergence of all economic variables will take more years after demographics converge but the focus of our analysis is on the economy over the next several decades.

As mentioned in Section 2, we consider pension reform that will be needed and reasonable in light of rapidly rising expenditures and in comparison to pension policies in other developed countries. More precisely, reform will shift the benefit schedule down by 20% and increase the normal retirement age from 65 to 68. We consider three scenarios that differ in the timing of starting reform. In the first scenario, we assume that the reform begins in 2020 and pension replacement rates will decline gradually for a total of 20% over 30 years and the normal retirement age will increase by 1 year every decade for a total increase of 3 years over a 30-year period. Therefore, reform, once started, will be complete in 30 years. In the other two scenarios, we let the same reform start in 2030 and 2040, respectively.

As a basis of comparison, we also compute a transition path in which there is no change in the pension policy and the status quo is maintained. The benefit schedule will remain unchanged and the normal retirement age is fixed at 65. Transition dynamics of key variables under this no-reform scenario are shown in Figure 8. Although a rise in longevity gives incentives to save more for retirement, the effects of a declining population and the number of savers will dominate and aggregate capital starts to decline after the 2030s. Aggregate labour supply declines throughout the transition and reaches approximately 50% of the level in 2015 by 2070. The rise in capital while labour supply falls during the first few decades of the transition implies a rapid decline in interest rates. At the same time, labour supply becomes increasingly scarce relative to capital and the wage rate will rise by more than 10% in 20 years from 2015 to 2035 and stay at a high level during the following decades. Consumption taxes will rise monotonically as a rapid increase in the dependency ratio raises expenditures and reduces tax revenues. The magnitude of a rise in fiscal burden and the scale of

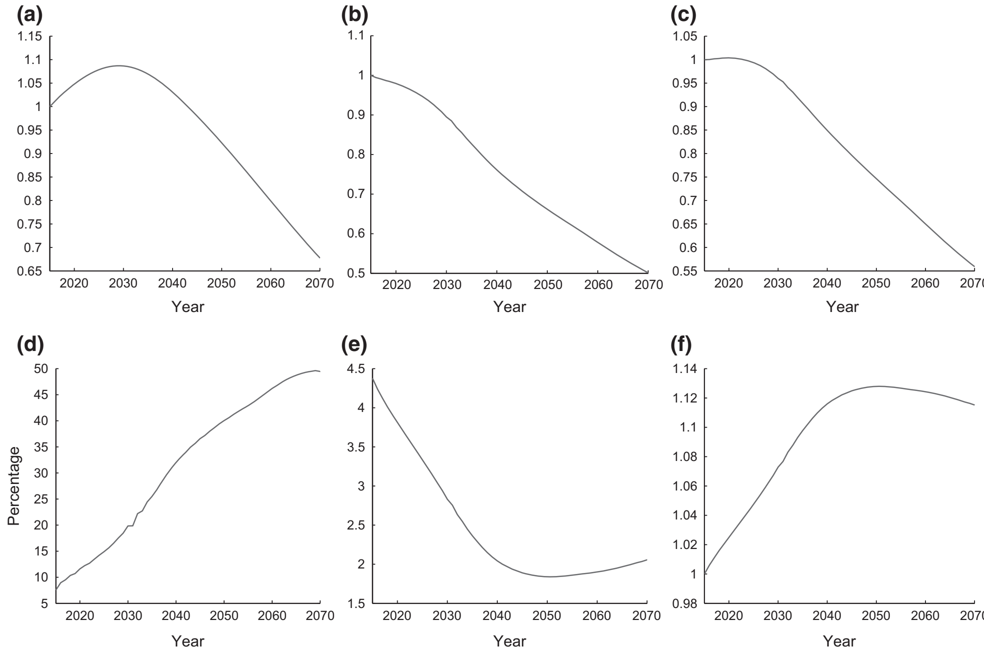

FIGURE 8. Baseline transition without reform. (a) Aggregate capital, (b) Aggregate labour, (c) Aggregate output, (d) Consumption tax (%), (e) Interest rate (%) and (f) Wage rate. Level variables are normalized by the level in 2015

changes in aggregate variables observed in this baseline simulation without reform are in line with findings in other studies such as Braun and Joines (2015) and Hansen and İmrohoroğlu (2016).

We now consider reform and introduce it at three different points in time. In order to highlight the effects of reform and changes in outcomes associated with the timing difference, we express dynamics of macro variables as a ratio or difference to those in the baseline economy without reform, as shown in Figure 9.

Paths of aggregate capital relative to the economy without reform are shown in Figure 9a. Given the decrease in expected pension benefits, individuals need to rely much more heavily on their own savings, and capital will be higher with reform. In the scenario with an early implementation of reform starting in 2020, capital will exceed the level in the baseline simulation immediately, and by 2030 it is 6% higher than the level without reform and more than 10% higher by 2050. The rise in aggregate capital is more gradual when reform is postponed until 2030 or 2040. Under all scenarios capital will be higher by more than 12% by 2070.

Another way to make up for reduced retirement income due to reform is by working longer hours and postponing an exit from the labour market. Figure 9b shows changes in labour supply. Although reform generates more work incentives so that one can accumulate enough savings for retirement, it also generates disincentives in the short run. This is because the insurance benefit of working additional hours to earn greater annuity payments through the pension will be reduced. The negative effect manifests as an initial decline in labour supply that occurs in all reform scenarios, even before the reduction in replacement rates begins because it is career earnings

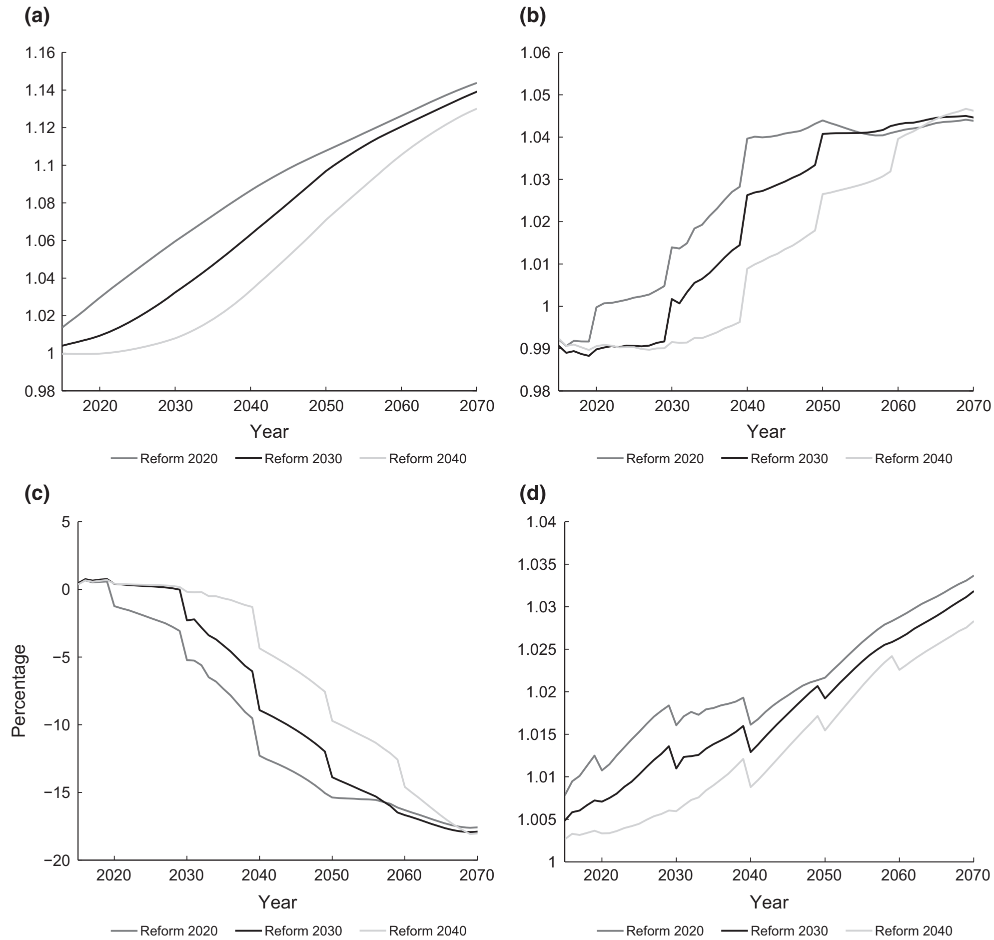

FIGURE 9. Reform starting in 2020, 2030 and 2040. (a) Aggregate capital, (b) aggregate labour, (c) consumption tax (%) and (d) wage rate. For (a), (b) and (d), levels are expressed as ratios to those in the baseline simulation in each year. For (c), difference in consumption taxes in percentage points is plotted

before reaching retirement age that determines the annuity level. Once reform begins and normal retirement age rises, positive effects start to dominate and eventually the labour supply is approximately 4% higher than in the baseline transition without reform (Table 3).[8]

Given that individuals increase savings aggressively and even more intensively than working longer hours in order to supplement retirement consumption, the capital–labour ratio will be higher with reform, implying lower interest rates and higher wages, as shown in Figure 9. In the transition path with reform starting in 2020, workers that enter the labour market in 2020, for example, would enjoy wages that are 0.5 to 1.2% higher throughout their career compared to the case of reform that is delayed by 20 years.

[8] In the year when the retirement age is raised, there is a discrete increase in the labour supply. If the retirement age is raised more gradually, say by 1 month each month, the labour supply will rise more smoothly, but that is difficult to implement computationally in a model with annual frequency.

TABLE 3
Aggregate capital and labour under reform: Difference in percentage relative to the baseline transition without reform

	Aggregate capital (% difference)			Aggregate labour (% difference)		
	R2020	R2030	R2040	R2020	R2030	R2040
2020	3.0	0.9	+0.0	−0.0	−1.0	−0.9
2030	+6.0	+3.2	+0.8	+1.4	+0.2	−0.9
2040	+8.7	+6.3	+3.4	+4.0	+2.6	+0.9
2050	+10.8	+9.7	+7.1	+4.4	+4.1	+2.7
2060	+12.6	+12.1	+10.6	+4.1	+4.3	+4.0
2070	+14.4	+13.9	+13.0	+4.4	+4.5	+4.6

TABLE 4
Consumption taxes under three reform scenarios, R2020, R2030 and R2040: Difference in percentage points relative to the baseline transition without reform

	Consumption tax (%-pt difference)		
	R2020	R2030	R2040
2020	−1.2	+0.4	+0.4
2030	−5.2	−2.3	−0.2
2040	−12.3	−8.9	−4.4
2050	−15.4	−13.9	−9.7
2060	−16.3	−16.7	−14.6
2070	−17.6	−17.9	−18.0

Consumption tax rates immediately fall relative to the baseline economy when reform starts and especially when the retirement age is raised.[9] The peak tax rate in all cases will be around 32%, approximately 18 percentage points lower than in the baseline case without reform. There is also a significant variation in consumption tax rates across the three scenarios during transition years. If reform begins sooner in 2020, consumption tax rates are 5 to 10 percentage points lower until around 2050, compared to the case of starting reform in 2040. Generations that would live through these years will face much lower taxes on consumption if reform has started sooner than later (Table 4).

5.1 Welfare effects

The welfare effects of starting reform at different points in time are displayed in Figure 10. The left plot shows the welfare effects on generations that are currently alive, indexed by age in 2010. We evaluate changes in welfare in terms of consumption equivalent variations (CEV). More precisely, we ask individuals of different ages whether they would prefer a transition with a status-quo pension system or a transition with pension reform starting in a particular year. We then ask what is the percentage increase in consumption that is needed so that individuals will be indifferent between economies with and without reform. A positive number implies that the individual will be better

[9] There will be no new pension recipient in the year of raising the normal retirement age, while the number of retirees will decline due to deaths of existing retirees, which allows the consumption tax rate to drop further. This is seen as discrete declines in budget-balancing consumption taxes in Figure 9, in 2020, 2030 etc.

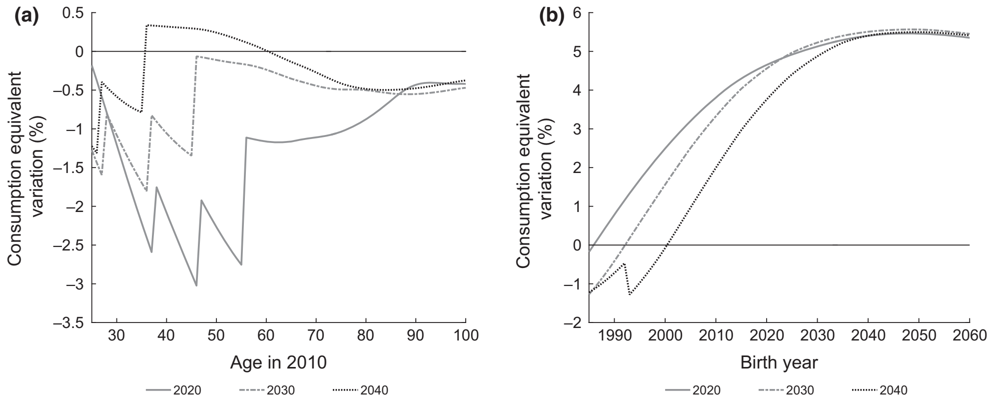

FIGURE 10. Welfare effect of reform: (a) on current generations and (b) on future generations (by the birth year)

off with reform and the magnitude represents the size of the welfare gain in terms of consumption changes in percentage points in all possible states for the remainder of his or her life. For individuals that enter the economy in future, welfare effects indicate a value expressed as a percentage change in consumption in all periods of their life.[10]

Reform will generate changes in individuals' welfare through four channels and the net effect depends on the strength of each factor in the remainder of their life. The first and direct effect comes from a gradual decline in pension benefits through a reduction in the replacement rate and an increase in the normal retirement age. Controlling for everything else, this effect deteriorates welfare as it reduces life-time income. The second and third effects are through a rise in the wage rate and a decrease in the interest rate, respectively. The former will be a positive effect and the latter will have a negative impact on welfare. Higher wages will improve the welfare of those who have many more years to work. Finally, consumption taxes will be lower with reform and this will benefit all individuals, although at different magnitudes as tax rates vary over time and so do the number of years and timing in which each individual enjoys lower taxes.

Current retirees will not benefit much from higher wages because few of them work and not many workable years, if any, remain. They will be worse off with a reduction in benefits and especially if reform happens sooner than later. As shown in Figure 10, retirees will be worse off with reform and the welfare loss is greater if it starts sooner. Middle-aged individuals before reaching retirement age are also worse off with earlier reform. For an individual at age 40 in 2010, for example, if reform begins in 2040, benefits will not start going down until they are 70 years old and the 20% reduction will not be complete until they (ever) reach age 100. If, however, the reform starts in 2020, benefits have been lower for many years by the time they reach retirement age.

Future generations will be much better off with reform and with the scenario where reform starts sooner because they gain more from higher wages and lower consumption taxes for many more years to come. They also have enough time to accumulate

[10] We note that welfare evaluation is based on the objective function of an individual, that is, the discounted sum of expected utility based on an individual's own consumption and labour supply and that it does not take into account preference weight that he or she may place on the welfare of descendants. Under alternative preference specification, in which individuals explicitly value the welfare of their children, for example, ordering over policies will differ. The topic is left for ongoing future research.

sufficient savings and prepare for retirement when they expect lower retirement transfers from the government. They benefit more from the strength of the economy and lower distortions through taxation. Timing of reform makes a significant difference in the welfare of future generations as well. For example, individuals born in 2000, who turn 20 in 2020, will be better off if reform starts in 2020 by 2.5% in terms of consumption equivalence, compared to the baseline transition without reform or a scenario of starting reform in 2040. The sizeable difference in welfare remains for many future generations to come. All future cohorts up to those to be born in around 2030 have higher welfare if they were born in an economy that has already implemented reform in an earlier year.

Postponing reform for as long as possible will come at a large cost of higher taxes, lower capital, labour and economic activities for several decades during the transition. A delay leaves large welfare costs and tax bills that future generations will have to bear, in exchange for additional years of high benefits for current generations.

6. Conclusion

A review of ongoing demographic transition in Japan and the current pay-as-you-go pension system reveals that aggressive reform is needed. The present paper simulated reform that reduces replacement rates of the public pension by 20%, as embedded in pension reform of 2004, and raises the normal retirement age from 65 to 68 gradually over a 30-year period. We considered three scenarios that differ in the timing of initiating reform in 2020, 2030 and 2040, respectively.

Waiting for a decade or two to start reform will generate a sizeable and prolonged decline in capital, labour and economic activities, together with significantly higher taxes during the transition imposed on young and future generations. Of course, however, an earlier reform comes at the cost of retirees for whom losses from lower benefits outweigh gains from positive general equilibrium effects.

Whether reform brings welfare gain or loss depends on what we consider as the benchmark. Perhaps a proper point of reference is not the current system, but the one in which the fiscal burden of demographic transition is shared equally across generations. Whether reform starts soon in 2020 or late in 2040, the analysis reveals that future generations will face both higher taxes and lower benefits than what current generations face. A delay in reform will preserve generous transfers to existing retirees longer, making future generations face even higher tax burden to pay off the accumulated cost of demographic ageing. The result of the paper also implies that current retirees and younger generations both could have gained much more, had reform been implemented years ago. It does not appear to be a sensible decision of a benevolent policy-maker who would care about the welfare of both current and future generations to wait to consolidate the system.

Acknowledgements

This study was conducted as a part of the project “Fiscal and social security policy under low birth rate and ageing demographics”, which the author leads as Faculty Fellow at Research Institute of Economy, Trade and Industry (RIETI). The author is grateful for comments from the editor and an anonymous referee and also acknowledges support by RIETI and through a research grant from the Japan Center of Economic Research (JCER).

Appendix I:

Definition of competitive equilibrium

A competitive equilibrium in each period t consists of individuals' decision rules $\{c_t(x), h_t(x), a_{t+1}(x)\}$ for each state vector $x = \{j,a,z,e\}$, factor prices $\{r_t^k, w_t\}$, consumption tax $\{\tau_t^c\}$, accidental bequest transfer $\{b_t\}$, and the measure of individuals over the state space $\{\lambda_t(x)\}$ that satisfy the following conditions.

1. Individuals solve optimization problems defined in Subsection 3.2.
2. Factor prices are determined competitively and equated to marginal product of each factor:

$$r_t^k = \alpha A_t \left(\frac{K_t}{L_t}\right)^{\alpha-1} - \delta$$
$$w_t = (1-\alpha) A_t \left(\frac{K_t}{L_t}\right)^{\alpha}.$$

3. The lump-sum transfer of accidental bequests equals the amount of assets left by the deceased:

$$b_t = \sum_x a_t(x)(1 - s_{j,t-1})\lambda_{t-1}(x).$$

4. Labour and capital markets clear:

$$K_t = \sum_x [a_t(x) + b_t]\lambda_t(x) - D_t$$
$$L_t = \sum_x z\psi_j h_t(x)\lambda_t(x).$$

5. Consumption tax τ_t^c satisfies the government budget constraint (1).[11]
6. The goods market clears:

$$\sum_x c_t(x)\lambda_t(x) + K_{t+1} + G_t + M_t = Y_t + (1-\delta)K_t.$$

Final version accepted 18 October 2016.

---

[11] Here we define a competitive equilibrium based on the scenario where consumption tax τ_t^c is adjusted to balance the government budget.

REFERENCES

Attanasio, O. P., S. Kitao and G. L. Violante (2007) "Global Demographics Trends and Social Security Reform", *Journal of Monetary Economics*, Vol. 54, No. 1, pp. 144–198.

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

Benitez-Sílva, H., D. S. Dwyer, F. Heiland and W. C. Sanderson (2007) "A Dynamic Model of Retirement and Social Security Reform Expectations: A Solution to the New Early Retirement Puzzle", Working Paper.

Braun, R. A. and D. Joines (2015) "The Implications of a Greying Japan for Public Policy", *Journal of Economic Dynamics and Control*, Vol. 57, pp. 1–27.

Conesa, J. C. and D. Krueger (1999) "Social Security with Heterogeneous Agents", *Review of Economic Dynamics*, Vol. 2, No. 4, pp. 757–795.

De Nardi, M., S. İmrohoroğglu and T. J. Sargent (1999) "Projected U.S. Demographics and Social Security", *Review of Economic Dynamics*, Vol. 2, No. 3, pp. 575–615.

Doi, T. (2008) "Simulation Analysis of Policies to Ensure Japan's Fiscal Sustainability", *Mita Journal of Economics*, Vol. 100, No. 4, pp. 131–60.

Doi, T., T. Hoshi and T. Okimoto (2011) "Japanese Government Debt and Sustainability of Fiscal Policy", *Journal of The Japanese and International Economies*, Vol. 25, No. 4, pp. 414–433.

Hansen, G. D. and S. İmrohoroğlu (2016) "Fiscal Reform and Government Debt in Japan: A Neoclassical Perspective", *Review of Economic Dynamics*, Vol. 21, pp. 201–224.

Hayashi, F. and E. C. Prescott (2002) "The 1990s in Japan: A Lost Decade", *Review of Economic Dynamics*, Vol. 5, No. 1, pp. 206–235.

Hoshi, T. and T. Ito (2014) "Defying Gravity: Can the Japanese Soveriegn Debt Continue to Increase without a Crisis?", *Economic Policy*, Vol. 29, No. 77, pp. 5–44.

Hsu, M. and T. Yamada (2015) "Population Ageing, Health Care and Fiscal Policy Reform: The Challenges for Japan", Working paper.

Ihori, T., R. R. Kato, M. Kawade and S. Bessho (2005) "Public Debt and Economic Growth in an Ageing Japan", Working paper.

Ihori, T., R. R. Kato, M. Kawade and S. Bessho (2011) "Health Insurance Reform and Economic Growth: Simulation Analysis in Japan", *Japan and the World Economy*, Vol. 23, pp. 227–239.

İmrohoroğlu, S. and S. Kitao (2009) "Labor Supply Elasticity and Social Security Reform", *Journal of Public Economics*, Vol. 93, No.7–8, pp. 867–878.

İmrohoroğlu, S. and S. Kitao (2012) "Social Security Reforms: Benefit Claiming, Labor Force Participation and Long-Run Sustainability", *American Economic Journal: Macroeconomics*, Vol. 4, No. 3, pp. 96–127.

IPSS (2012) *Population Projection for Japan, National Institute of Population and Social Security Research*.

Kitao, S. (2014) "Sustainable Social Security: Four Options", *Review of Economic Dynamics*, Vol. 17, No. 4, pp. 756–779.

Kitao, S. (2015) "Fiscal Cost of Demographic Transition in Japan", *Journal of Economic Dynamics and Control*, Vol. 54, pp. 37–58.

Kitao, S. (2016) "Policy Uncertainty and the Cost of Delaying Reform: A Case of Ageing Japan", Working Paper.

Lise, J., N. Sudo, M. Suzuki, K. Yamada and T. Yamada (2014) "Wage, Income and Consumption Inequality in Japan, 1981–2008: From Boom to Lost Decades", *Review of Economic Dynamics*, Vol. 17, No. 4, pp. 582–612.

OECD (2015) "Pensions at a Glance 2015: Retirement-Income Systems in OECD and G20 Countries".

Okamoto, A. (2013) "Welfare Analysis of Pension Reforms in an Ageing Japan", *Japanese Economic Review*, Vol. 64, No. 4, pp. 452–483.

United Nations (2015). *World Population Prospects*, New York: United Nations.

Yamada, T. (2011) "A Politically Feasible Social Security Reform with a Two-Tier Structure", *Journal of the Japanese and International Economies*, Vol. 25, No. 3, pp. 199–224.