Review of Economic Dynamics 27 (2018) 81–100

Contents lists available at ScienceDirect

Review of Economic Dynamics

www.elsevier.com/locate/red

Policy uncertainty and cost of delaying reform: The case of aging Japan

Sagiri Kitao [1]

Keio University, Faculty of Economics, 2-15-45 Mita, Minato-ku, Tokyo, Japan

ARTICLE INFO

Article history:
Received 28 October 2016
Received in revised form 3 October 2017
Available online 16 November 2017

JEL classification:
E20
H55
J11

Keywords:
Pension reform
Policy uncertainty
Aging demographics
Fiscal sustainability
Japanese economy

ABSTRACT

Reform is inevitable in an aging economy with a generous pay-as-you-go social security system. Often, however, the timing and structure of reform are unknown. We explicitly model policy uncertainty in a general equilibrium life-cycle model and let agents update expectations and react as uncertainty is resolved over time. Using the case of Japan, a country facing severe demographic and fiscal challenges, we quantify welfare tradeoff across generations by delaying reform or reducing its scope. Individuals respond to a delay by dis-saving and working less, while facing higher taxes to cover additional expenditures during the transition. Fiscal uncertainty itself has a more significant adverse effect on older individuals, who face greater income risks and a lower return on their retirement savings.

1. Introduction

Japan is aging rapidly. The ratio of the elderly to the working age population is projected to rise from a little below 0.4 in 2010 to more than 0.8 by 2050.[2] We all anticipate that the current pay-as-you-go social security system will not last long as it is. Unknown to us is when and how it will change. This paper explicitly models uncertainty associated with the timing and structure of a social security reform in an aging economy. We focus on the case of Japan, which faces the most significant and rapid transformation of a demographic structure during coming decades.

We build a life-cycle model, in which individuals anticipate a rise in government expenditures and a decline in tax revenues driven by demographic aging. They make optimal decisions taking into account the possibility that the current social security policy and tax system will change in the future. We quantify responses of individuals and the macroeconomy when uncertainty is resolved and measure the welfare costs imposed on current and future generations by reform delays and uncertainty per se.

E-mail address: sagiri.kitao@gmail.com.

[1] The author thanks the editors, three anonymous referees, Frank Caliendo, Ippei Fujiwara, Cagri Kumru, Jaelang Lee, Masayuki Morikawa, Chung Tran and participants at various seminars and conferences for helpful comments and suggestions. The author is also Faculty Fellow at the Research Institute of Economy, Trade and Industry (RIETI). The study has been conducted as part of the project “On Monetary and Fiscal Policy under Structural Changes and Societal Aging” at the RIETI. This work was also supported by JSPS Grants-in-Aid for Scientific Research (C) JP16K03705. All errors are the responsibility of the author.

[2] The old-age dependency ratio is computed as a ratio of the population at and above 65 to that of 20–64, based on estimates and projections of the National Institute of Population and Social Security Research (IPSS) in 2012.

https://doi.org/10.1016/j.red.2017.11.005
1094-2025/

In one scenario, we let replacement rates gradually decline by about one-third but individuals not know when reform will begin. When individuals learn that reform does not occur in a given year and has been delayed, they decumulate wealth and reduce labor supply. Each 10-year delay implies an approximately 2 to 3 percentage decline in capital and output, together with a rise in fiscal burden equivalent to 5 percent of total consumption at maximum. Future generations are worse off by 1.5 to 2 percent in consumption equivalent variation if they are born in an economy where reform has been delayed by 10 years.

Uncertainty itself hurts middle-aged and older individuals. Policy uncertainty implies a rise in volatility of future income at the micro level, and induces more savings by individuals. Interest rates will be lower, reducing returns on retirement savings while the elderly benefit less from higher wages. They also face the chance of a major drop in income very soon, when they are close to the retirement age, or have retired already and do not have much time to accumulate retirement wealth by working longer or saving more. Future generations would prefer a policy that starts reducing benefits and consolidating the system at the earliest timing. Results suggest that reform should have been undertaken much sooner and uncertainty should have been resolved by now, which could have improved the welfare of current and future generations.

There is a wealth of literature that analyzes fiscal policies and social security reforms using a general equilibrium life-cycle model.[3] There has been a series of recent papers focused on the Japanese economy using a similar framework.[4] These papers assume that individuals know the policy path in advance.

Caliendo et al. (2015) and Bütler (1999) are two exceptions that incorporate policy uncertainty and they are perhaps the closest in terms of focus to our paper. Caliendo et al. (2015) build a model of heterogeneous agents with uncertainty in the timing and structure of a social security reform. They find that the welfare cost of policy uncertainty is minimal for those with enough savings, but can be much larger for non-savers.[5] Bütler (1999) studies the roles of policy uncertainty in a life-cycle model calibrated to the Swiss economy. She finds that there can be a substantial increase in savings and labor supply before reform and quantifies changes in the volatility of individuals' policy functions. Gomes et al. (2012) investigate effects of policy uncertainty in terms of ages at which individuals learn that reform reducing social security benefits will take place.

In contrast to these papers, our focus is on uncertainty in social security policy and fiscal challenges associated with and driven by aging demographics. Rapid aging and a rise in the old-age dependency ratio make it increasingly costly to finance transfer expenditures under a status-quo pay-as-you-go scheme. A delay of necessary reforms intensifies the fiscal burden and exacerbates the imbalance each year. We emphasize changes in fiscal and welfare costs across generations, as well as effects of general equilibrium adjustments associated with policy uncertainty in such an economy.

This paper is organized as follows. Section 2 explains Japan's demographic situation and provides a background for the numerical exercises. Section 3 presents the model and Section 4 discusses parametrization of the model. Numerical results are presented in Section 5 and Section 6 concludes.

2. Background: aging Japan

This section provides a brief overview of the Japanese demographic situation and its fiscal challenges. While developed economies will all face a major shift in demographics and rising public expenditures during the coming decades, problems are the severest in Japan. The total fertility rate has been well below the replacement level since the mid-1970s and stands at 1.46 in 2015. The prolonged low fertility rates imply a long-lasting decline in the labor force. The working-age population of ages 20–64 stood above 75 million in 2010, but will fall to 41 million by 2060 according to official projections. At the same time, the first baby-boomer generation born after the war are now reaching retirement age, followed by another wave of retirement by the second baby-boomers in about 20 years. Japanese life-expectancy is among the highest in the world, 81 for males and 87 for females.

As a result of the low fertility rates, retirement of baby-boomers and rising longevity, the old-age dependency ratio, defined as a ratio of the population aged 65 and above to that of 20 to 64, will rise sharply and stay at an elevated level throughout the century. Fig. 1 shows the projections of the dependency ratio in Japan and several other countries. It demonstrates that the speed and magnitude of demographic aging are remarkable even compared to other countries that face similar challenges.

The ongoing shift in Japan's demographics poses a serious issue of fiscal sustainability. Expenditures for the elderly through social security and medical insurance programs will rise rapidly while tax revenues decline as the labor force and population shrink.

[3] Contributions in the literature include De Nardi et al. (1999), Conesa and Krueger (1999), Huggett and Ventura (1999), Attanasio et al. (2007), Nishiyama and Smetters (2007), İmrohoroğlu and Kitao (2012) and Kitao (2014).

[4] See, for example, Braun and Joines (2015), Kitao (2015) and İmrohoroğlu et al. (2017).

[5] One major difference from Caliendo et al. (2015) is that we build a general equilibrium model in which factor prices are determined endogenously. We identify sizeable changes in individuals' saving and labor associated with policy innovations, which induce a major shift in factor prices and affect individuals' welfare. Our model also endogenizes labor supply and the government budget, which Caliendo et al. (2015) assume as exogenous. Imposing a budget constraint is important in the context of demographic aging, which is the focus of our paper but not theirs, because budget-balancing taxes are different depending on the timing of reform and it makes a significant difference in which generation will bear the cost of a demographic transition. Bütler (1999) also assumes exogenous factor prices.

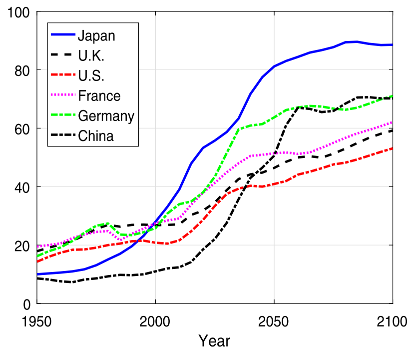


Fig. 1. Old-age dependency ratio. Data and projections. Source: IPSS (2012) and UN Population Revision (2015).

The Japanese public pension system was established in early 1960s, when life-expectancy was around 70, which now has increased by about 15 years. Although the pension fund carries large assets accumulated when revenues from pension premiums exceeded the total payouts, the system is essentially pay-as-you-go and benefits do not explicitly depend on the pension fund balance nor are they funded by recipients' own contributions.

From the results of various surveys, it is apparent that few people expect that the current social security system will last for many years. Nippon Life Insurance surveyed 17,000 individuals across different age groups as to whether they expected to receive public pensions from the government and if so, how much. Almost all individuals aged 50 and above expect to receive some pension benefits, but 6% of individuals in their 40s, 11% in their 30s and 17% in their 20s expect to receive none. Among those who anticipate receiving some benefits, expectation falls as people age. Relative to the average benefit level per household paid to retirees now, expectations are about three-fourth among those in their 50s, 68% in their 40s, and 62% in their 30s.[6] Different surveys confirm the pessimism and doubt about sustainability of the current system, which are more prevalent among younger people. In another survey of "new adults" who turned age 20, about 90% report that they are uncertain whether they can receive a public pension in the future and more than 60% disagree that the pension system is sustainable.[7]

Anticipating a surge in the number of retirees and a decline in tax revenues during coming decades, reform was introduced in 2004 with the goal of reducing benefits by about 20% over a few decades. The adjustment, however, called a "macroeconomic slide" is subject to inflation, and the benefit has been reduced only once, in 2015, out of twelve years since the reform was approved. There remains much uncertainty whether the scheme will work as expected.

3. Model

In this section we will describe the model, present individuals' problem, and explain how uncertainty is modeled in the numerical analysis. The definition of a competitive equilibrium is presented in Appendix A.

3.1. Economic environment

Demographics The economy is populated by overlapping generations of individuals, who enter the economy at age $j = 1$ and face uncertainty about life-span. The maximum age is J years. Individuals of age j at time t survive until the next period $t + 1$ with probability $s_{j,t}$. Assets left by the deceased are distributed in a lump-sum transfer denoted as b_t to all surviving individuals. n_t denotes the growth rate of the size of a new cohort entering the economy.

Individuals' preferences Individuals derive utility from consumption and leisure in each period and maximize the sum of discounted utility over their lifetime. A period utility function is denoted as $u(c_t, h_t)$, where c_t and h_t denote an individual's consumption and labor supply in period t, respectively, and individuals discount future utility by a subjective discount factor β.

Technology Firms are competitive and produce output Y_t, using aggregate capital K_t, labor supply L_t and technology Z_t, according to an aggregate production function

$$Y_t = Z_t K_t^{\alpha} L_t^{1-\alpha}. \tag{1}$$

[6] The average benefits of current retirees are based on the benefits received by a couple that consists of a member receiving an employer-based pension (kosei nenkin) and a spouse who receives basic pension (kiso nenkin) benefits. It must be noted that the numbers reported are expected benefits of a household and they may be lower than those of actual couples since a single person reports his/her own expected benefits. Source: https://www.nissay.co.jp/news/2014/pdf/20141126A.pdf (in Japanese).

[7] Source: http://www.macromill.com/r_data/20150108shinseijin/ (in Japanese).

α denotes the share of capital in production and capital depreciates at constant rate δ. The interest rate r_t^k and wage rate w_t are set in a competitive market.

Endowments and medical expenditures Each individual can allocate a unit of disposable time to market work and leisure every period. Earnings in period t are denoted as $y_t = \eta_j h w_t$ and consist of three parts, η_j, age-specific deterministic productivity, h, endogenously chosen hours of work and w_t, the market wage.

As in Kitao (2015), we assume that there are two types of medical expenditures that individuals face each period, expenditures for health care $m_{j,t}^h$ and long-term care $m_{j,t}^l$.[8] Total out-of-pocket expenditures by an individual are given as $m_{j,t}^o = \lambda_{j,t}^h m_{j,t}^h + \lambda_{j,t}^l m_{j,t}^l$, where fractions $\lambda_{j,t}^h$ and $\lambda_{j,t}^l$ represent a co-pay of the two insurance programs. The remainder of the expenditures are covered by public health and long-term care insurances. M_t denotes total national medical expenditures, which consist of out-of-pocket expenses paid by individuals and a part paid by the government given as $M_t^g = \sum_j \left[(1-\lambda_{j,t}^h) m_{j,t}^h + (1-\lambda_{j,t}^l) m_{j,t}^l\right] \mu_{j,t}$, where $\mu_{j,t}$ denotes the number of individuals of age j at time t.

Government The government runs a pay-as-you-go public pension system and individuals at and above retirement age j_R receive pension benefits, $ss_t(e_t)$, determined as a function of each individual's career earnings, denoted by an index e_t. The benefits consist of basic pension $\overline{ss}$, which is independent of past earnings and a part that is related to the index, e_t. Benefits are expressed as a function

$$ss_t(e_t) = \xi_t \left[\overline{ss} + \rho \cdot e_t\right], \tag{2}$$

where ξ_t is 1.0 without reform. The value of ξ_t will be adjusted when reform starts to reduce pension benefits, as discussed in more detail in Section 3.2.[9]

The government levies taxes on earnings at a proportional 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. The government also issues debt D_{t+1} and pays interest r_t^d to debt holders. Revenues are used to pay for government purchases of goods and services G_t, payment of the principal and interest on debt D_t, public pension benefits, and health and long-term care insurance benefits M_t^g. As in Kitao (2015) and Braun and Joines (2015), we assume that individuals allocate a fraction ϕ_t of assets to government debt and the rest to firms' capital. Therefore 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 budget constraint in each period is given as

$$\begin{aligned} &G_t + (1+r_t^d) D_t + S_t + M_t^g \\ &= \sum_x \left\{\tau_t^l y_t(x) + [\tau_t^k r_t^k (1-\phi_t) + \tau_t^d r_t^d \phi_t](a_t(x) + b_t) + \tau_t^c c_t(x)\right\} \mu_t(x) + D_{t+1}, \end{aligned} \tag{3}$$

where S_t denotes total pension benefit expenditures and $\mu_t(x)$ represents the measure of individuals in state x at time t as defined below.[10]

3.2. Individuals' problem

We will first describe an individual's problem in a model without policy uncertainty and then discuss how it is modified with the introduction of uncertainty.

Model without policy uncertainty Individuals can trade one-period riskless asset a_t, which is a composite of an investment in firms' capital and holdings of government debt and pays after-tax gross interest R_t as defined above. Borrowing against future income and transfers is not allowed and assets must be non-negative.

A state vector of an individual $x = \{j, a_t, e_t\}$ consists of age, j, assets, a_t, and an index of cumulated earnings that affects each individual's pension benefits, e_t. Individuals choose the optimal path of consumption, saving and labor supply to maximize life-time utility. The problem is solved recursively and the value function $V_t(x)$, when there is no policy uncertainty, is defined as follows.

$$V_t(j, a_t, e_t) = \max_{c_t, h_t, a_{t+1}} \left\{u(c_t, h_t) + \beta s_{j,t} \left[V_{t+1}(j+1, a_{t+1}, e_{t+1})\right]\right\} \tag{4}$$

[8] Although the focus of the paper is not on medical expenditures and public health care costs, it is important to take into account the rising health insurance costs when fiscal effects of demographic aging are considered. The Japanese universal public health insurance system consists of health and long-term care insurance programs and provides generous benefits for the old.

[9] The macroeconomic slide included in the pension reform of 2004 adjusts entire benefits and we follow the convention by adjusting both the constant and earnings-related parts equally. An alternative would be to adjust only one part, or both parts asymmetrically, which would also change progressivity of the system.

[10] As we describe in Section 4, labor income tax τ_t^l is set in the initial steady state to satisfy the government budget constraint (3). Thereafter, consumption tax τ_t^c adjusts to balance the budget and τ_t^l is fixed at the value determined in the initial steady state.

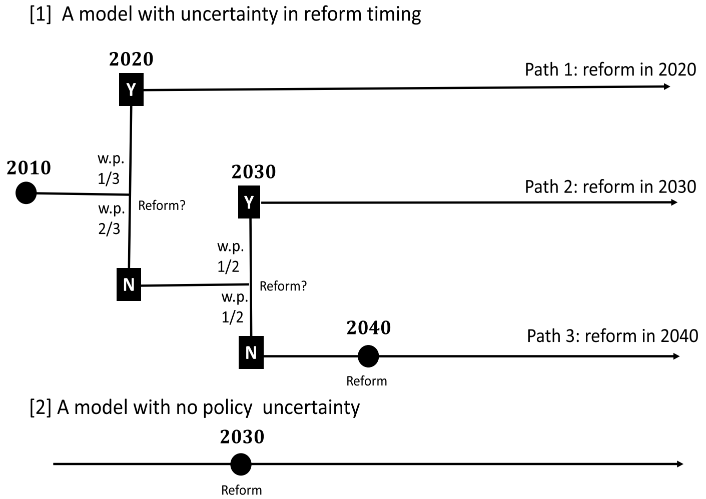


Fig. 2. Modeling policy uncertainty: with and without uncertainty in reform timing.

subject to

$$(1+\tau_t^c)c_t + a_{t+1} = R_t(a_t + b_t) + (1-\tau_t^l)y_t + ss_t(e_t) - m_{j,t}^o$$
$$y_t = \eta_j h_t w_t$$
$$a_{t+1} \geq 0$$
$$e_{t+1} = \begin{cases} f(e_t, y_t) & \text{for } j < j_R \\ e_t & \text{for } j \geq j_R \end{cases}$$

The index of cumulated earnings e_t evolves according to the law of motion, $e_{t+1} = f(e_t, y_t)$, until individuals reach normal retirement age j_R. The pension benefit $ss_t(e_t)$ is zero for individuals below retirement age j_R. In a model without policy uncertainty, individuals know the entire sequence of policy variables including the path of ξ_t and budget-clearing taxes.

Modeling policy uncertainty We now describe how policy uncertainty is introduced in our model. The policy uncertainty is with respect to the sequence of ξ_{t+1} that defines the generosity of pension benefits in equation (2). The problem of individuals is modified and the value function is written as follows.

$$V_t(j, a_t, e_t; \xi_t) = \max_{c_t, h_t, a_{t+1}} \left\{ u(c_t, h_t) + \beta s_{j,t} E_t \left[V_{t+1}(j+1, a_{t+1}, e_{t+1}; \xi_{t+1}) \right] \right\}, \tag{5}$$

where the expectation is with respect to the vector of social security policy, $\boldsymbol{\xi}_{\mathbf{t+1}} \equiv \{\xi_{t+1}, \xi_{t+2}, \xi_{t+3}, \cdots\}$. Given the probability distribution over the possible policy paths, individuals make optimal decisions and respond to policy innovations.

Upon resolution of uncertainty and realization of reform, individuals' optimal decisions, as well as aggregate variables and factor prices change. Tax rates that balance the government budget will also vary across different policy paths. The exercise differs from a comparison of two independent scenarios, where the timing of reform differs and a deterministic policy path is known in each in advance.

To be more precise, we describe in detail how we model policy uncertainty, using a case of uncertainty about reform timing, which we will study in Section 5. Ex-ante, individuals know that particular reform will occur at one of the three possible timings; 2020, 2030 or 2040, with an equal probability of 1/3 each. In 2020, they learn whether the reform occurs that year or not. If it does, there is no more policy uncertainty. If not, the reform will occur in either 2030 or 2040, with an updated probability of 1/2 each. In 2030 individuals learn whether the reform occurs that year or not and there is no more policy uncertainty in either case. If the reform does not take place in 2030, there will be reform in 2040 without uncertainty. Fig. 2 visualizes the timing of events in the scenario.

When there is uncertainty in both timing and structure of reform, there will be an additional possible path in which the government implements a different policy. Computation is similar to the case of uncertainty in timing only, but there will be different final steady states. The computation algorithm of a model with policy uncertainty is provided in Appendix B.

To highlight effects of uncertainty and consequences of reform delay, we also compute another transition path, in which there is no uncertainty about reform timing. We then compare results under the two scenarios, with and without uncertainty, to quantify the roles of policy uncertainty.

4. Calibration

This section presents parametrization of the model. The frequency of the model is annual and the unit of the model is the individual, who represents the head of household. We first compute an equilibrium that approximates the Japanese economy in 2010, which we call the "initial steady state," built as a starting point for the computation of transition dynamics.[11] As explained below, we calibrate some parameters outside of the model independently and other parameters in the initial steady state equilibrium so that the model approximates key features of the economy in 2010.

Demographics We assume that individuals become economically active at age 20 and live up to a maximum age of 110. Conditional survival probability $s_{j,t}$ and growth rate of a new cohort n_t are based on projections of the National Institute of Population and Social Security Research (IPSS), which are available up to 2060. We assume that survival rates will remain constant at the 2060 level thereafter. The growth rate n_t is negative during the projection period due to persistently low fertility rates and we set the growth rate at −1.2% between 2010–2080 based on the projections. We assume that the growth rate will gradually rise after 2080 and converge to 0% by 2150.

Preferences and technology The period utility function takes the form,

$$u(c_t, h_t) = \frac{\left[c_t^{\gamma}(1-h_t)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma}.$$

The parameter γ determines the preference weight on consumption relative to leisure and we set the value at 0.352 so that individuals aged 20 to 64 spend 40% of disposable time for market work on average. σ is related to risk aversion, which is set to 3.0, implying relative risk aversion of 1.70, and the intertemporal elasticity of substitution at 0.59. Discount factor β is set to 1.0209, so that the capital-output ratio in the initial steady state is 2.5, as estimated by Hansen and İmrohoroğlu (2016).

Based on Hayashi and Prescott (2002), the share of capital in production is set at 0.36 and the depreciation rate at 0.089. The level of technology Z_t is set so that output per capita grows at 1% each year along the balanced growth path. The initial level of productivity is set for normalization so that average earnings are unity in the initial steady state.

Endowments and medical expenditures Labor productivity η_j is calibrated based on age-specific wage data from the Basic Survey on Wage Structure (BSWS) in 2010. Wage data for male workers are used to approximate the wage profile of household heads in the model. We assume $\eta_j = 0$ for individuals above the retirement age.

Data on medical expenditures over the life-cycle are taken from the Ministry of Health, Labour and Welfare (MHLW). We assume that per-capita expenditures grow at the same rate as the growth rate of the economy. Co-pay rates of health insurance $\lambda^h_{j,t}$ vary by age; 30% below age 70, 20% at 70–74 and 10% at 75 and above. The co-pay rate for long-term care insurance $\lambda^l_{j,t}$ is 10% regardless of recipients' age. We assume that the co-pay rates are time invariant.

Public pension system The government operates a pay-as-you-go pension system, which provides benefits $ss(e)$ once an individual reaches the retirement age j_R of 46 (65 years old). Benefits are determined as a function of the average earnings e of each individual through his career. The law of motion for the earnings index is given as

$$e_{t+1} = f(e_t, y_t) = e_t + \frac{\min(y_t, \bar{y})}{N_w}, \tag{6}$$

where y is the new earnings data and N_w is the number of working periods, which we set to 45 years, from age 20 to 64. The cap for counted earnings $\bar{y}$ is set at 10.44 million yen, based on the maximum annual earnings used to compute the earnings index in the Japanese pension system.

The benefits are determined according to the function (2), in which $\overline{ss}$ represents the basic pension, the first tier of the Japanese pension system, and the amount of payment does not depend on an individual's past earnings. The average basic pension benefit was 655,000 yen in 2010 and $\overline{ss}$ is set to this value. The parameter ρ is set at 0.303 to match the ratio of total pension expenditures to GDP, which stood at 10% in 2010.[12]

Government expenditures, debt and taxes Government expenditures account for 20% of GDP in 2010, including expenditures for health and long-term care insurance, based on the National Accounts of Japan (SNA). We set the ratio G_t/Y_t to match

[11] Note that we use actual age-distribution for 2010 in computing the initial steady state so that the demographic structure in the initial and subsequent years is accurately captured in the model. The population is not stationary in 2010 and aggregate statistics are computed using the actual age distribution. It is necessary to compute the "initial steady state" in order to obtain the asset distribution across individual states of the model, as the starting point of the transition.

[12] The formula implies a gross replacement rate, defined as the ratio of average pension benefits to average earnings, of 39.6% and a net replacement rate, the ratio of average pension benefits to after-tax average earnings, of 59.5%, in the initial steady state.

the data. Government debt D_t is set at 100% of GDP, based on the net debt outstanding in 2010.[13] We set the interest rate on government debt r_t^d at 1%, the average real interest rate on 7-year government bonds in 2000s. The fraction ϕ_t of individuals' assets allocated to government debt is determined in each period so that the ratio D_t/Y_t is 100%.

Consumption tax rate is set at 5% in the initial steady state, which represents the economy in 2010. After 2010, the consumption tax rate is adjusted to balance the government budget in each year. Capital income tax rate is set at 40%, in the range of estimates of effective tax rates in the literature. The tax rate on interest income from government debt is 20%.

In order to balance the government budget in the initial steady state, we set the labor income tax rate at 33.5%.[14] The labor income tax rate is fixed during the transition and the government budget is balanced through an adjustment of consumption taxes. In Section 5.6, we discuss alternative fiscal adjustments to finance the demographic transition.

5. Numerical results

This section presents our numerical results. First we describe features of the steady states, focusing on individuals' life-cycle profiles and changes between the two steady states. We then study the transition dynamics and effects of uncertainty and discuss fiscal and welfare costs of policy uncertainty and those of delaying reform. In doing so, we will first compute a baseline transition, in which there is no policy uncertainty, and use the dynamics as a benchmark in the comparison. Finally, we discuss the effects of endogenous factor prices and alternative fiscal adjustments to finance the demographic transition.

5.1. Steady states

Before we study transition dynamics driven by the evolution of demographics and fiscal policies, we will describe some features of the economy in the initial and final steady states. As explained in Section 4, the initial steady state is calibrated to approximate the Japanese economy in 2010. The transition will then take place, eventually reaching a final steady state, where all variables including demographics and government policies are stationary. In the baseline transition that we discuss in the next section, we consider social security reform that will reduce benefits by about one-third. The final steady state, which we compare to the initial steady state in this section, represents an economy in the long-run, in which benefits are reduced and the demographic transition is complete, and is stationary.

Fig. 3 shows life-cycle profiles of labor supply, earnings, consumption, and assets in the two steady states of our model. Fig. 4 shows life-cycle profiles in the data from various sources. In our model, labor supply is fairly flat until the early 50s, when it starts to decline as individuals approach retirement age, which compares well to the data. Although we do not have endogenous labor force participation, a decline in labor supply in our model after the mid-50s captures a drop in participation rates after the mid-50s in the data as well as a mild decline in work hours that starts in the late-50s. Labor supply in the final steady state is notably higher than in the initial steady state, especially above age 40. Individuals live longer in the long-run and have incentives to work more to accumulate wealth for a longer retirement period. They also have additional incentives to save because social security benefits replace their earnings at a lower rate.

Earnings rise steeply, reflecting the wage profile in the Japanese data. As described in Section 4, our model uses wage data from BSWS and our earnings profile aligns with the data, which show a sharp rise until mid-50s. In the final steady state, individuals earn significantly more than in the initial steady state because they work longer and at higher wages.

There are not many studies about life-cycle profiles of consumption and wealth due to limited availability of comprehensive individual data. İmrohoroğlu et al. (2016), for example, use two different survey data, the Family Income and Expenditure Survey (FIES) and the National Survey of Family Income and Expenditure (NSFIE) to estimate life-cycle consumption and asset profiles. As shown in Fig. 4, the consumption profile shows a peak at around 50–60 and a mild decline thereafter. In our model, consumption would rise over the life-cycle until mortality risks start to reduce the growth for people in their 70s. With the non-separable preference in consumption and leisure, marginal utility of consumption is higher when individuals supply a positive number of work hours.[15] This brings the consumption higher while individuals work, as shown in Fig. 3(c), though the positive effect diminishes as they start to reduce hours worked as shown in Fig. 3(a). How individuals adjust consumption when they become less attached to the labor force is still in debate, but such a decline in consumption as individuals approach the retirement age is not entirely inconsistent with the data. Aguiar and Hurst (2013), for example, emphasize the importance of disaggregated consumption data and show that work-related spending that complements the labor supply falls when people exit the labor force. In the final steady state, lower interest rates and a decline in social security benefits reduce consumption at older ages compared to the initial steady state.

Lastly, Fig. 3(d) shows the asset profile. Individuals in their 20s already start accumulating wealth for precautionary and retirement reasons. The assets increase until individuals reach the retirement age and they dissave during the retirement period. Note that average consumption in old ages is lower while assets are higher in the final steady state, because indi-

[13] It is computed as the amount of outstanding gross debt of 990 trillion yen net of financial assets of 490 trillion yen held by the government at the beginning of 2010, divided by the GDP of the same year, based on the National Accounts of Japan.

[14] Labor income tax in our model includes all taxes and premiums imposed on earnings, in particular premiums for employer-based pension programs and medical insurance programs.

[15] This holds whenever the coefficient σ that represents risk aversion is greater than 1.0 in the preference specification used in this paper.

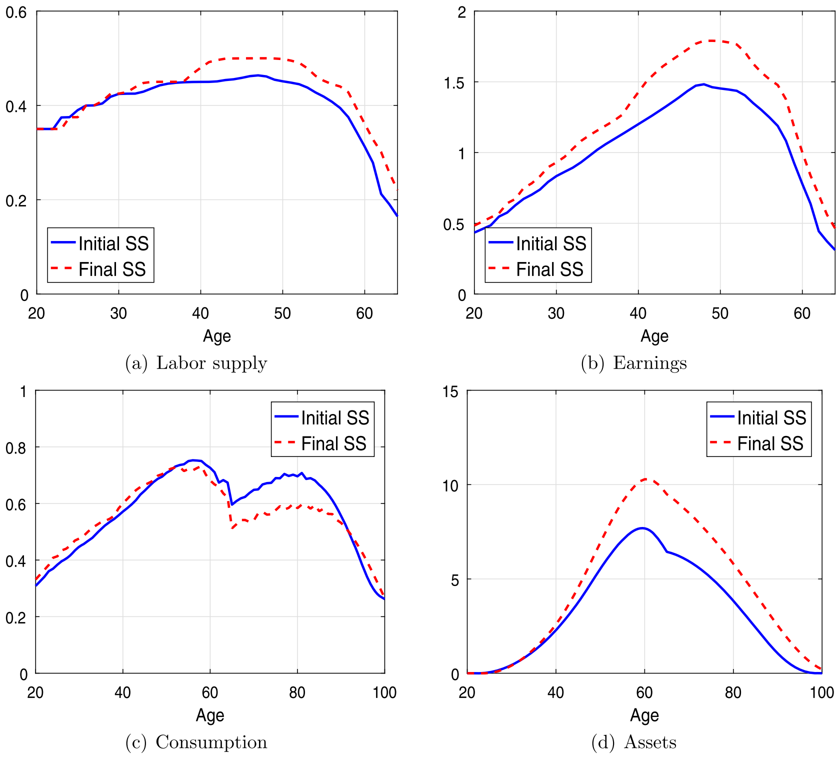


Fig. 3. Initial and final steady states: earnings, consumption and assets are normalized by the average earnings in the initial steady state.

viduals live longer and consume for more years on average and social security benefits are lower than in the initial steady state.

5.2. Transition dynamics with and without timing uncertainty

In computing transition dynamics, we let the economy start from the initial steady state as described above, which approximates the economy in 2010. Then the economy transitions to a final steady state, while demographics evolve as predicted by the IPSS and a fiscal variable is adjusted along the way, so that the period budget constraint of the government is satisfied each year.

In the first exercise, we assume that reform to reduce pension benefits is inevitable and everyone is aware that it will happen in the future. The exact timing, however, of reform is uncertain, while people know how large the benefit cut will be. In Section 5.4, we introduce uncertainty in both the timing and structure of reform.

If the pension reform of 2004 works as expected, the replacement rate will eventually decline by about 20%, according to the government report (*Zaisei Kensho* 2014). Various studies, however, have argued that a benefit cut of such a magnitude will not be enough to control a rapid rise in government expenditures and that a major increase in taxes would still be inevitable to balance the budget.[16] Also some surveys such as the ones mentioned in Section 2 imply that people are anticipating a further cut in benefits in the future. Therefore we consider reform that would reduce benefits by an additional 20% on top of the decline successfully achieved in the 2004 pension reform, resulting in a 36% reduction of benefits in total $(0.36 = 0.2 + (1 - 0.2) \times 0.2)$.[17] We assume that individuals expect that reform will happen not too far in the future and before mid-century and that they anticipate three possible timings of 2020, 2030, or 2040, with equal likelihood. Once reform begins, the benefit schedule will gradually shift downward and the total reduction of 36% will be completed in thirty years after the onset of reform.[18] For the purpose of visual illustration, Fig. 5 shows the value of ξ_t and how the schedule of pension benefits is adjusted over time in each scenario.

We chose to simulate a transition that is based on reform reducing benefits by a given percentage and raising taxes to absorb residual costs, which people appear to think is likely to happen at some point in the future, based on various surveys

[16] See, for example, Braun and Joines (2015) and Kitao (2015).

[17] In Section 5.4 we add a scenario in which benefits will be reduced by only 20%.

[18] We set the distribution of possible timings of reform in years of 2020, 2030 and 2040, and this could be generalized to occur in any year between 2020 and 2040, for example, if we had a greater computational capacity to handle many more potential transition paths. We conjecture, however, that the main results of the analysis will remain under a finer grid setting.

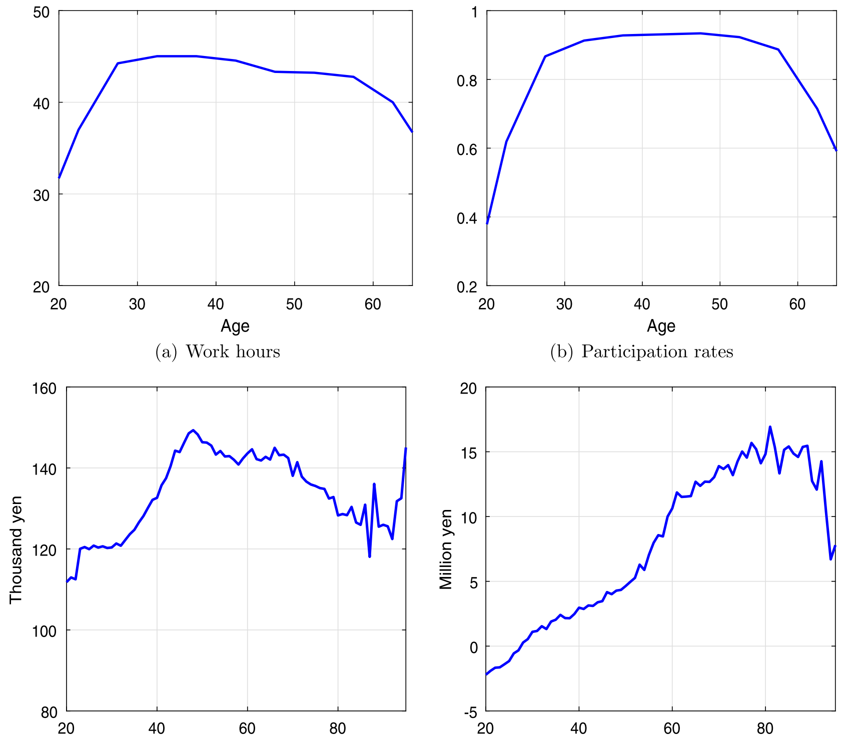


Fig. 4. The data. Work hours: weekly work hours based on the Basic Survey on Wage Structure (BSWS). Participation rates: the Labor Force Survey (LFS). Consumption: monthly consumption from the Family Income and Expenditure Survey (FIES). Assets: net wealth of a household based on the National Survey of Family Income and Expenditure (NSFIE). Work hours and participation rates are from Kitao (2015) and consumption and assets are from İmrohoroğlu et al. (2016).

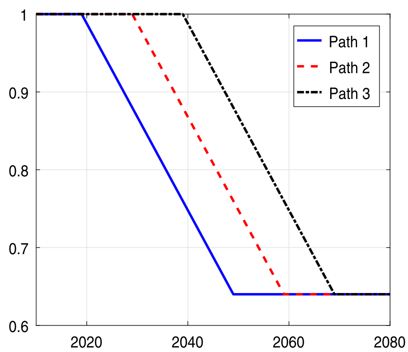
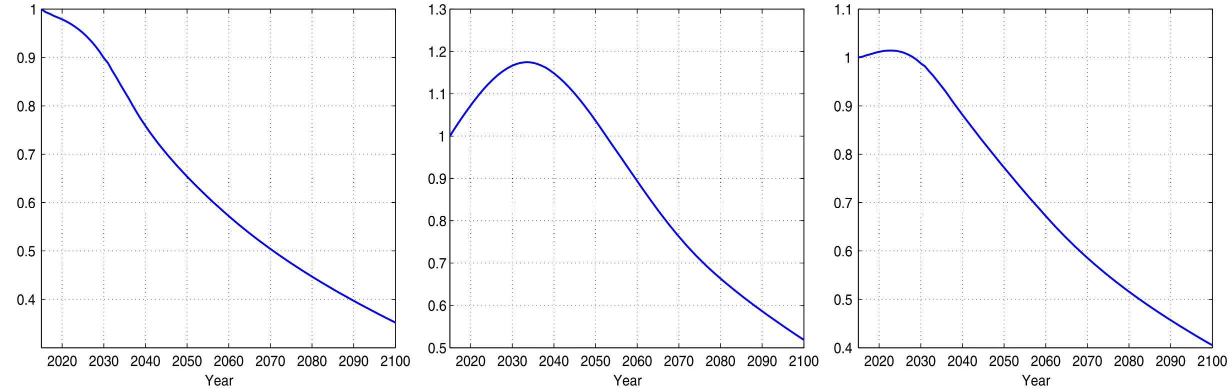


Fig. 5. Benefit adjustment in reform: value of ξ_t.

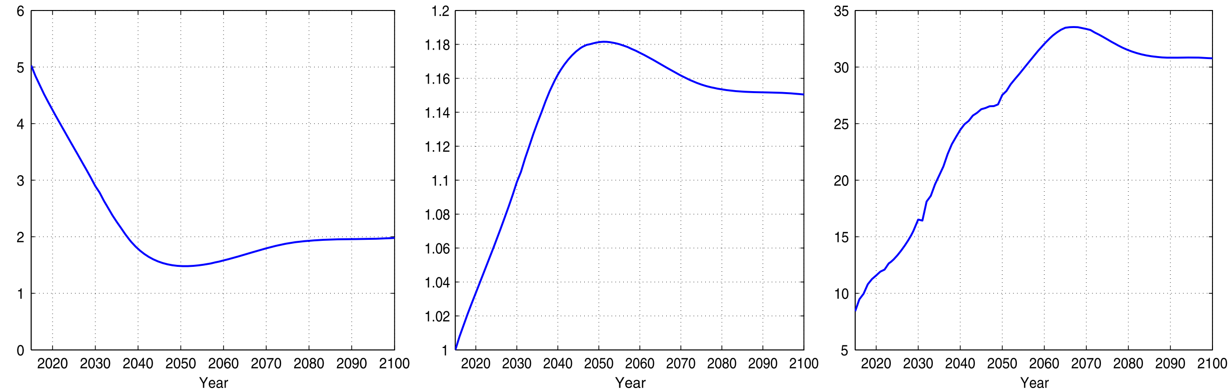
and a general tone in the policy discussion and public sentiments. An alternative theoretical exercise would be to simulate a transition where taxes are fixed and benefits are reduced in each year by an amount necessary to balance the government budget. Another scenario would be to adjust the retirement age over time. These scenarios are studied in Kitao (2014, 2015) under the assumption that there is no policy uncertainty. One could also assume that the debt will be raised to absorb the fiscal imbalance of each year. Borrowing alone, however, alone would not be enough to finance the demographic transition as argued, for example, by Braun and Joines (2015) and we would have to assume that multiple fiscal variables adjust during the transition. We chose to focus on a simpler adjustment using a consumption tax and discuss some alternative scenarios in Section 5.6.

In summary, there are three different potential transition paths depending on the realized timing of reform. Initially, until individuals learn in 2020 whether reform begins that year or not, there is only one path. From 2020 to 2030, there will be two possible paths, one in which reform has already begun in 2020 and the other in which reform is yet to happen and can occur in either 2030 or 2040. In the latter case, individuals will know in 2030 whether reform starts that year or in 2040. For convenience, we refer to the three paths as Path 1, Path 2 and Path 3, respectively, in the following.



(a) Labor supply (b) Capital (c) Output

Fig. 6. Baseline path without uncertainty (1): aggregate variables normalized by value in 2015.



(a) Interest rate (%) (b) Wage (normalized by value in 2015) (c) Consumption tax (%)

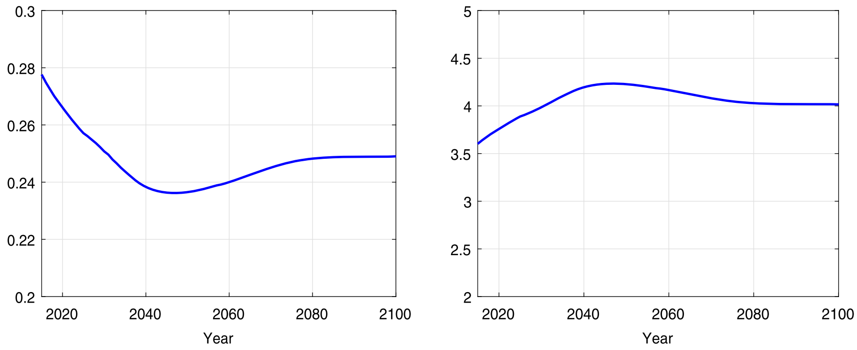
Fig. 7. Baseline path without uncertainty (2).

As a point of reference, we use transition dynamics in which there is no uncertainty about the timing of reform. Under this certainty scenario, the same reform will be implemented in 2020, that is, benefits will be gradually reduced by the same fraction as in other scenarios over the same 30-year period. We refer to the dynamics in this scenario as a baseline transition without uncertainty. Below, we will also consider a no-uncertainty scenario in which reform begins in 2030, instead of 2020. The year 2030 is the expected timing of reform under the uncertainty case, and the welfare effects of uncertainty per se, rather than both uncertainty and possibility of delaying reform, can be explicitly analyzed.

Transition without uncertainty (baseline path) Before we study the effects of policy uncertainty and costs of delaying reform, we will briefly study the baseline transition without uncertainty, which will be used as the basis for comparison. Fig. 6 shows the path of aggregate variables under the no-uncertainty case. As shown in Fig. 6(a), labor supply will decline sharply as many individuals from the two major waves of the baby-boomer generations reach retirement age and leave the labor force, at the same time that low fertility rates reduce the number of new entrants. Aggregate capital rises initially as individuals have a stronger incentive to save for a longer retirement period, but eventually the effects become dominated by a decline in the number of savers. Output falls to about 40% of the level in 2015 as shown in Fig. 6(c).

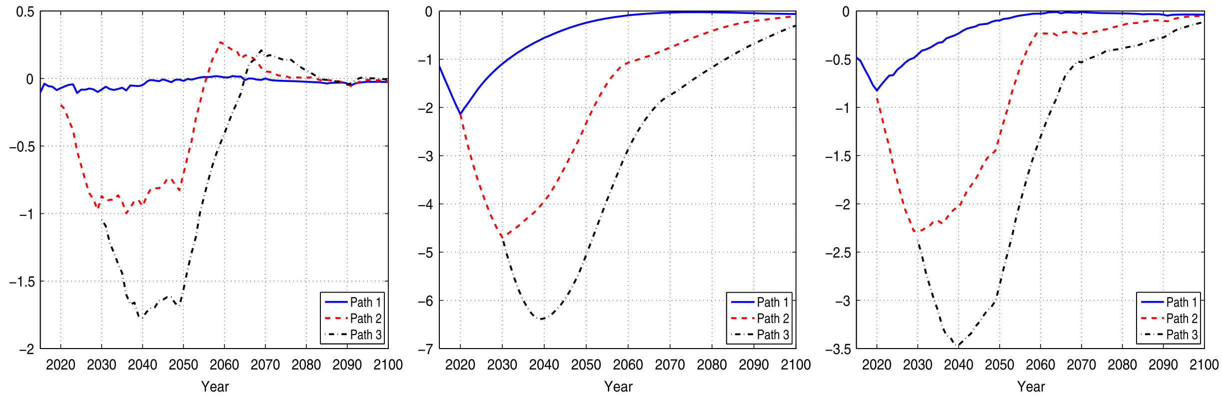
Since aggregate capital rises while labor supply declines during the initial decades of the transition, the capital-labor ratio will sharply increase, leading to a rapid decline in the interest rate, as shown in Fig. 7(a). The path then becomes almost flat after 2040s as the decline in capital catches up with the fall in labor supply. The wage rate will move in the opposite direction and increase by more than 15% by 2040. The consumption tax rate, which balances the government budget each year, will rise sharply as age-related expenditures for pensions as well as health and long-term care insurance programs rise and tax revenues decline. The tax rate will reach a peak of 33% in the 2060s as shown in Fig. 7(c).

Fig. 8(a) shows how the value of ϕ, which represents the ratio of individuals' assets allocated to government debt, evolves during the transition. When individuals increase savings with a rise in longevity as shown in Fig. 8(b), the ratio falls over time until it stabilizes in the 2040s. The value remains in a fairly narrow range of 0.24 to 0.28 throughout the transition, and the change in allocation should not affect transition dynamics in any significant way.



(a) Debt allocation ϕ (b) Total assets (as % of GDP)

Fig. 8. Allocation of individuals' assets to government debt and total assets.



(a) Labor supply (b) Capital (c) Output

Fig. 9. Paths with uncertainty in reform timing (1): aggregate variables expressed as percentage difference from those in baseline transition without uncertainty.

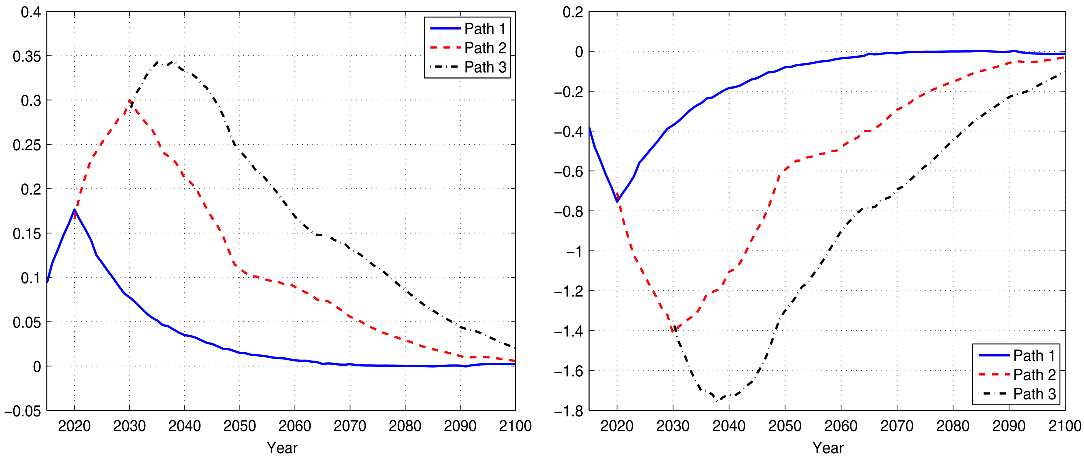
Transition with timing uncertainty Next, we will study transition dynamics, when the timing of reform is uncertain as described above. Fig. 9 shows the transition of aggregate variables under three paths, expressed as percentage differences in each year from those in the baseline transition without uncertainty.

As shown in Figs. 9(a) and 9(b), each time individuals learn that reform is not taking place that year and will occur later, labor supply and capital both decline, relative to a case in which reform has been implemented. Compared to Path 1, where reform occurs in 2020, aggregate labor under Path 2 and 3 will be lower by about 1% by 2030. If reform does not occur in 2030, the labor supply will decline further by about another percentage point by 2040. Fig. 9(b) shows that the difference in aggregate capital will be even larger. Under Path 2, capital is lower by more than 3.5% in 2030 compared to the baseline transition without uncertainty and by more than 6% under Path 3 in 2040. Note that even under Path 1, in which reform takes place in 2020, the same year as in the baseline case ex-post, the aggregate capital is lower by about 1 to 2% for more than two decades than under the baseline transition. The high chance that reform takes place later gives individuals disincentives to save even before 2020. Although capital starts to "catch up" with the baseline after people learn that reform occurs in 2020 under Path 1, it takes several decades to reach the same level as in the baseline transition.

A delay in reform is a major disincentive for both saving and work, since the later reform takes place, the higher the expected receipt of pension benefits from the government after retirement, and individuals are not urged to work and save as much for retirement.

Since aggregate capital declines by more than labor, interest rates will be higher and wages will be lower under the paths with later reform, as shown in Fig. 10, which displays the difference in interest rates and wages relative to the baseline transition without uncertainty. Note that even under Path 1, factor prices deviate from those under the baseline scenario for an extended period, since aggregate capital will be lower by 1 to 2% as discussed above and it takes many years for capital to catch up with to the baseline level.

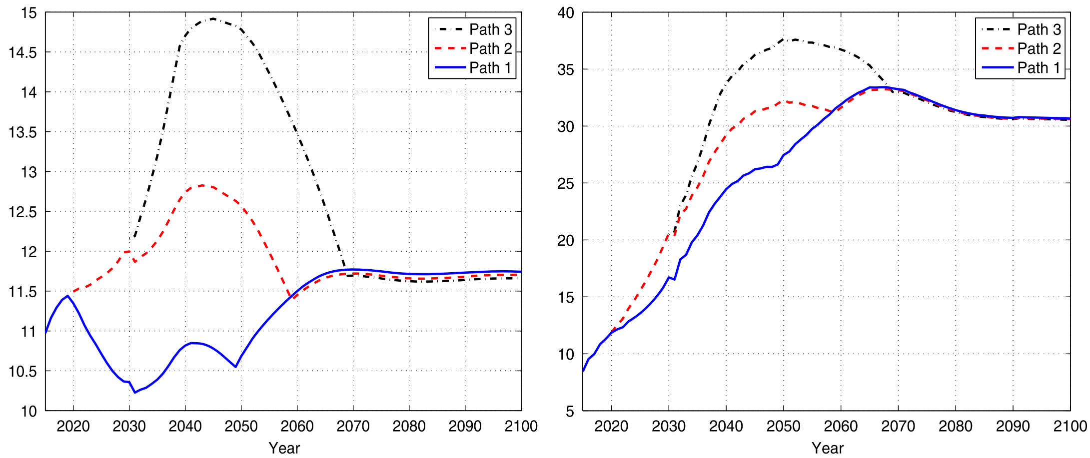
Fig. 11(a) shows the transition dynamics of total pension expenditures relative to aggregate output under the three paths. When reform takes place in 2020 under Path 1, pension expenditures will not show a major rise in the middle of the century as in the other two paths since benefits per individual will decline faster than the rise in the number of recipients. When we wait till 2030 or 2040 to start reform, pension expenditures will rise relative to output and peak at about 13% and 15% of GDP, respectively, in the mid-2040s and continue to stay at higher levels during the subsequent few decades.



(a) Interest rate (percentage points difference from baseline without uncertainty)

(b) Wage (percentage difference from baseline without uncertainty)

Fig. 10. Paths with uncertainty in reform timing (2): factor prices.



(a) Pension expenditures (as % of GDP)

(b) Consumption tax (%)

Fig. 11. Paths with uncertainty in reform timing (3): fiscal variables.

As shown in Fig. 11(b), the rates of consumption taxes, which will cover rising expenditures, are significantly higher when reform is pushed back from 2020 to 2030 or 2040 and the difference will reach over 5% and 10% in the late 2040s under Path 2 and 3, respectively.

5.3. Welfare analysis of uncertainty in reform timing

In order to quantify welfare effects, we compute consumption equivalent variation (CEV). We ask each individual in the baseline transition without uncertainty how much increase (or decrease) in consumption across all possible states is needed so that he will be indifferent between the baseline transition and a transition that involves policy uncertainty. If, for example, the CEV for an individual in the baseline economy is 2.0%, it means that he prefers an economy with uncertainty and needs to be compensated with a rise in consumption by 2.0% so his expected life-time utility is the same in both economies. We compute the CEV for individuals at each age in the initial year of 2010 and also for future generations. For the latter, the CEV is computed for a "new-born" individual who, at age 20, enters the economy and for each possible transition path that can be realized.

Interpretation of welfare numbers in CEV differs depending on the assumption about reform timing in the baseline case without uncertainty that is used as a point of reference. First, we use a case with reform starting in 2020 without uncertainty, the earliest possible timing in the case with uncertainty. Welfare figures in this case can be interpreted as individuals' preferences towards possibility or realization of reform delays. Second, we use a case of reform beginning in 2030 without uncertainty as a baseline. The expected timing of reform is the same as the case with timing uncertainty. Welfare figures in the second analysis represent the cost of uncertainty itself.

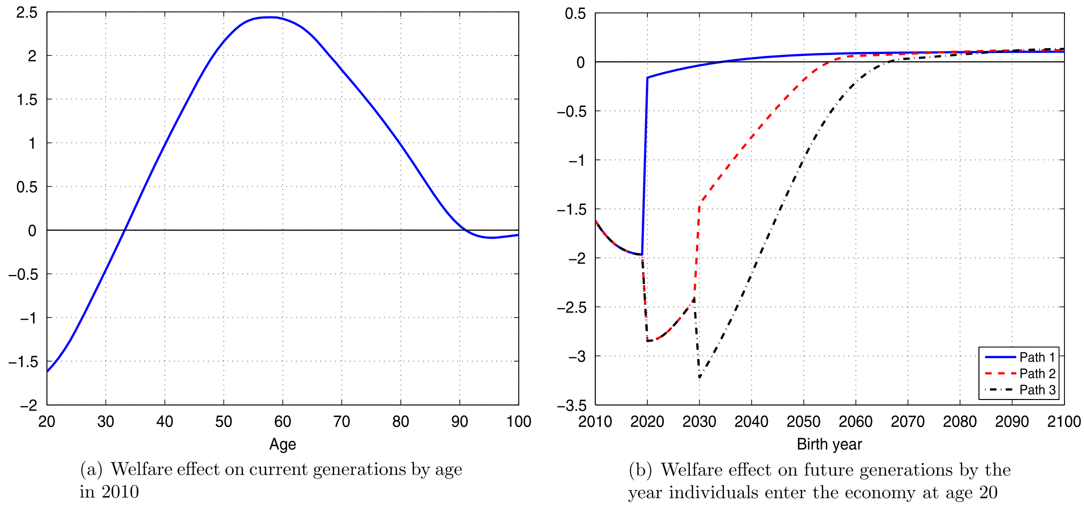


Fig. 12. Welfare effect of uncertainty in reform timing vs a case of reform starting in 2020 without uncertainty: consumption equivalent variation (%).

5.3.1. Welfare effects: possibility of reform delays

First, we study welfare effects using the scenario of reform starting in 2020 as a baseline. Four factors, which individuals take as exogenous and directly influence their life-time utility, are changes in consumption taxes, wages, interest rates and expected pension. Reform taking place later implies higher consumption taxes and lower wages during the transition, which are not desirable for individuals, but, at the same time, it implies higher interest rates and higher expected pension benefits for a given level of past earnings, which are desirable. The net effect depends on an individual's state and which factors dominate others for a particular individual.

Fig. 12(a) shows welfare effects on individuals at each age, who are alive in 2010, the initial year of the transition. An economy with uncertainty is preferred by individuals above their mid-30s and the gain is the largest for middle-aged individuals in their late-50s and early 60s. Compared to the baseline economy, in which pension benefits will start to decline in 2020 for sure, there is a good possibility, two-thirds, that reform is postponed by either 10 or 20 years in an economy with policy uncertainty. Individuals in their 50s and 60s will benefit from the delay in reform, since they would expect to receive a higher level of benefits. For example, those at age 60 in 2010 will have their benefits reduced starting at age 70 in the baseline, but under the regime with uncertainty, the event will not happen until age 80 or 90 with a total probability of two-thirds. They will also benefit from higher returns on their retirement savings as the interest rate will be higher when reform takes place later. These benefits offset negative effects from higher consumption taxes for middle-aged and older individuals, and they do not suffer much from lower wages as retirement is around the corner.

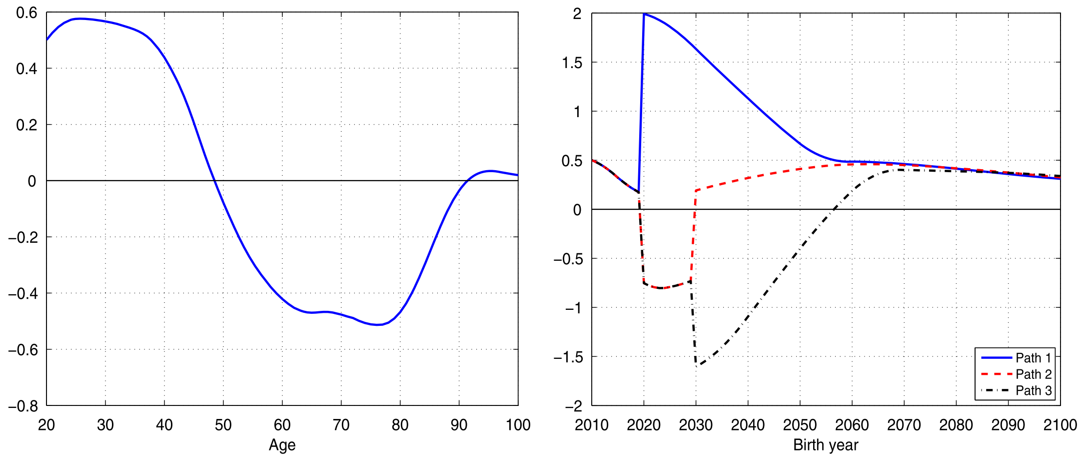
Younger individuals, however, will be better off if reform occurs sooner and does so without uncertainty. Although the downward shift in the pension schedule is not great news, they have enough time to accumulate savings and prepare for their retirement years. Since the increase in savings and aggregate capital dominates the rise in aggregate labor supply when reform takes place sooner, the wage rate would be much higher, which benefits young individuals. A major rise in wages also helps increase the expected pension benefits due to an increase in the earnings index and partially offsets the benefit reduction due to reform. Lower consumption taxes when reform takes place sooner are also beneficial over the many remaining years of their life.

These observations also apply for individuals who enter the economy in the future as shown in Fig. 12(b). A further delay in reform implies an even larger loss relative to the transition without reform uncertainty. Even under Path 1, where, ex post, the policy is the same as in the baseline transition and reform starts in 2020, the welfare loss can amount to a negative 2% in consumption equivalence for generations that enter the economy around 2020. Those who enter the economy in 2030 and find reform taking place at the latest in 2040 would be significantly worse off, and welfare loss amounts to more than 3% in CEV.

The analysis demonstrates a stark welfare tradeoff across generations due to a delay in pension reform. Pushing back the timing of reform as far as possible is in the interest of middle and old-aged individuals, but it deteriorates welfare of young and future generations.

5.3.2. Welfare effects: uncertainty in reform timing

In order to isolate the effects of uncertainty per se, from effects of a possible delay in reform, Fig. 13 shows the welfare effects of the same transition with uncertainty, but the CEV is computed using a different baseline transition, in which reform takes place in 2030 without uncertainty, instead of 2020. The expected timing of reform is 2030 under both scenarios, but one does not involve uncertainty and the other does.



(a) Welfare effect on current generations by age in 2010

(b) Welfare effect on future generations by the year individuals enter the economy at age 20

Fig. 13. Welfare effect of uncertainty in reform timing vs a case of reform starting in "2030" without uncertainty: consumption equivalent variation (%).

Fig. 13(a) shows consumption equivalence for current generations relative to the baseline transition. The magnitude of welfare effects is smaller compared to the effects shown in Fig. 12(a), and the shape and signs of welfare changes are also very different. A pure effect of adding uncertainty is a rise in savings and higher capital, which implies a lower interest rate and higher wages. These effects will favor the young and hurt the old. For example, those aged between 20 and 30 in 2010 would benefit from higher wages for many years to come and the gain would be 0.5 to 0.6% in terms of consumption equivalence. Those who are close to retirement will face a lower return on their retirement savings, while they do not have many years to enjoy the higher wage. They will also have to save enough by cutting back consumption in the case of reform beginning sooner than expected in 2020 with a one-third chance. As shown in Fig. 13(b), future generations continue to prefer early implementation of reform.

5.4. *Uncertainty in reform timing* and *structure*

Next we add a different form of uncertainty, in which the structure of the social security system is uncertain. On top of the three paths we studied above, we add a scenario in which there is in fact no reform to reduce benefits beyond 20% as embedded in the 2004 pension reform. Under this scenario benefits are reduced on a much smaller scale compared to the other scenarios cutting them by 36%. As before, there are three possible timings of reform in 2020, 2030 and 2040, and to these we add another path in which benefits are reduced by only 20% in the end.

If no reform has occurred in 2020 or 2030, individuals will learn in 2040 whether there is reform in that year or not. We call Path 4 the transition path in which there is no aggressive reform and benefits are reduced by only 20% rather than 36%, starting in 2040.

5.4.1. *Transition dynamics with uncertainty in reform timing* and *structure*

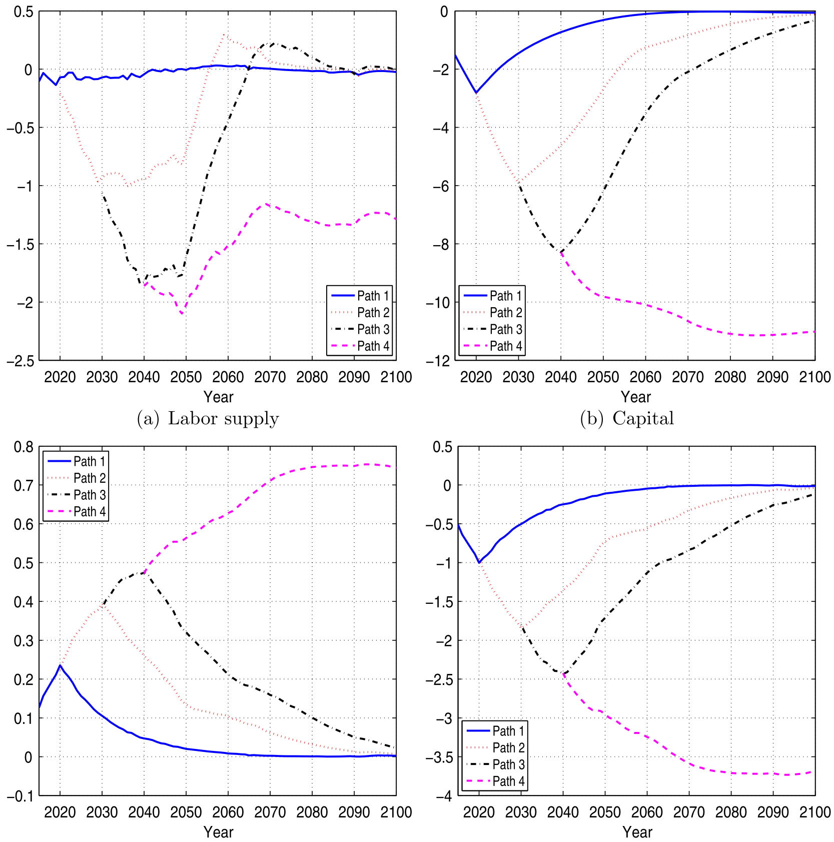
As shown in the top two panels of Fig. 14, aggregate labor supply and aggregate capital will be permanently lower under Path 4 than the other three paths. By 2100, labor supply will be lower by 1.3% and capital lower by more than 10%. As capital continues to fall after 2040, the wage rate keeps declining until the 2070s, reaching 3.7% below the baseline level by 2100.

Fig. 15 shows that pension expenditures relative to aggregate output will continue to rise until the early 2050s under Path 4 and stay at around 15% of GDP after 2070, which is much higher than the level under the three reform paths. As a result, the consumption tax needs to be permanently higher to balance the budget and stays at 38% until the end of the century, while the tax rates will be 31% under the three other paths in 2100.

5.4.2. *Welfare effects: uncertainty in reform timing* and *structure*

Next, we study the welfare effects of uncertainty in reform timing and the final shape of policy. Consumption equivalent variations for current and future generations are shown in Fig. 16. We use a baseline transition path where reform takes place in 2020 without uncertainty as a reference point, and the numbers in the figure are comparable to those in Fig. 12 presented above, which uses the same benchmark.

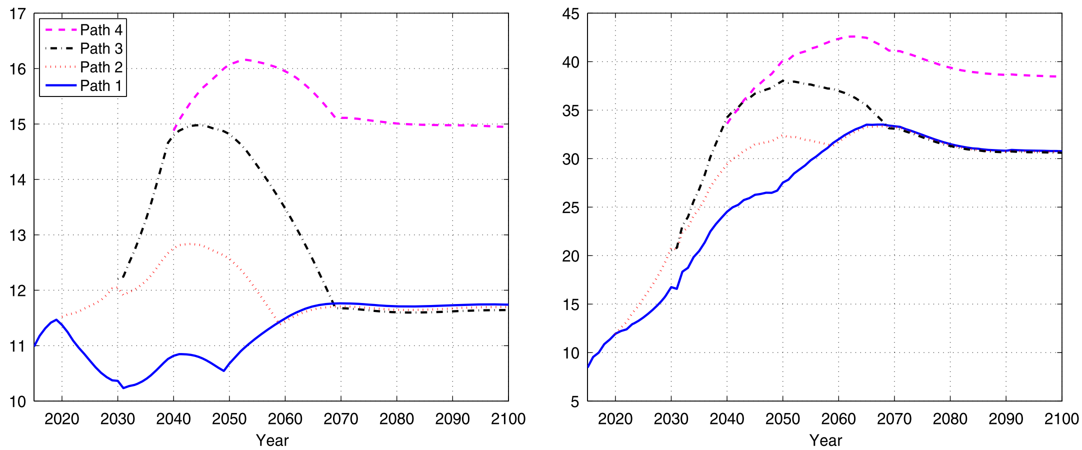
The welfare effects for current generations shown in Fig. 16(a) resemble those in Fig. 12(a). The magnitude, however, of welfare gains for middle-aged and old individuals are different and shift upwards, now with the possibility that aggressive reform never takes place. The welfare gain, for example, of individuals was 2.4% in CEV for those in their late 50s, but it is



(a) Labor supply (b) Capital

(c) Interest rate (d) Wage

Fig. 14. Paths with uncertainty in the timing and structure (1): aggregate variables expressed as percentage difference from those in the baseline transition without uncertainty except for the interest rate which is expressed as a difference in percentage points.

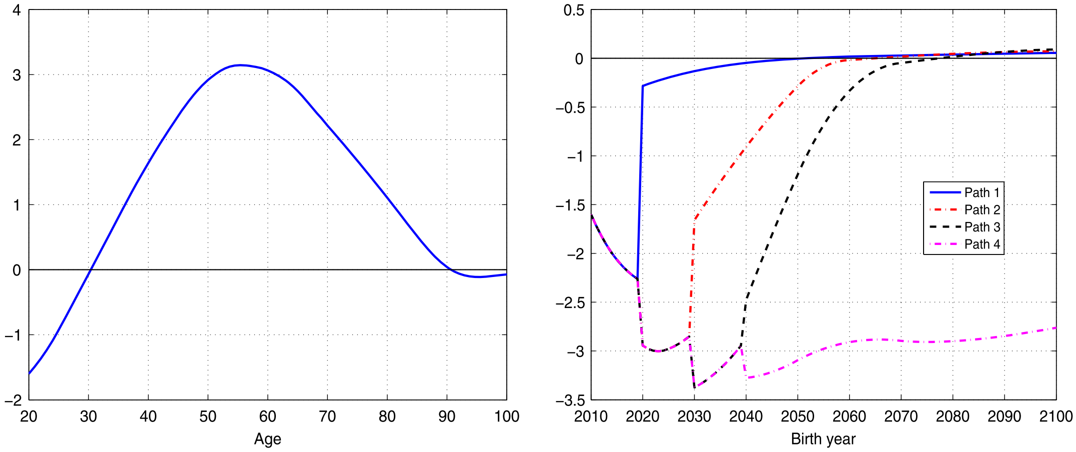


(a) Pension expenditures (as % of GDP) (b) Consumption tax (%)

Fig. 15. Paths with uncertainty in the timing and structure (2): fiscal variables.

3.1%, now with a 1/4 likelihood of no reform. The added chance that benefits will stay high forever will be favored by many current generations and especially those close to the retirement age.

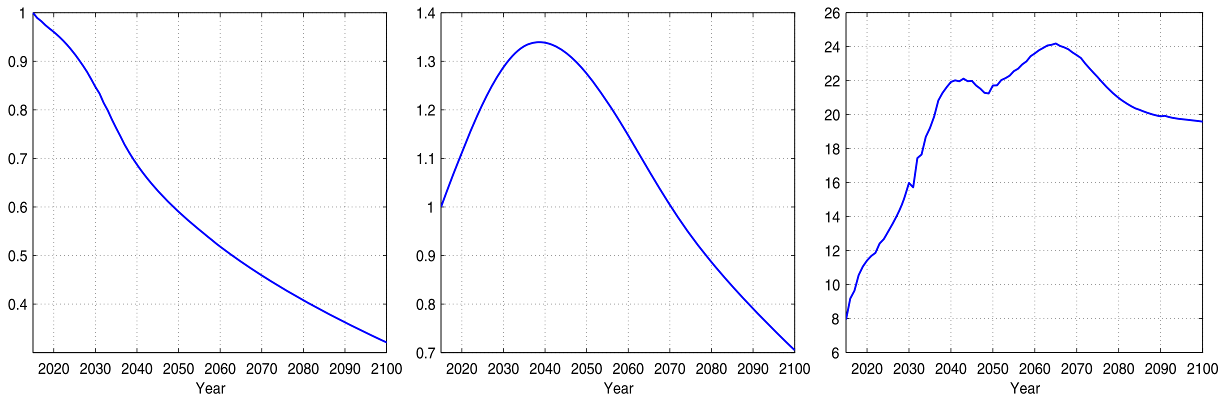
The gain, however, of current generations comes as a trade-off against losses for future generations as shown in 16(b). The scenario of no reform implies much higher consumption taxes and lower wages for many decades to come, which hurt future generations.



(a) Welfare effect on current generations by age in 2010

(b) Welfare effect on future generations by the year individuals enter the economy at age 20

Fig. 16. Welfare effect of uncertainty in the timing and structure vs the case of reform starting in 2020 without uncertainty: consumption equivalent variation (%).



(a) Labor supply (b) "Capital" (c) Consumption tax (%)

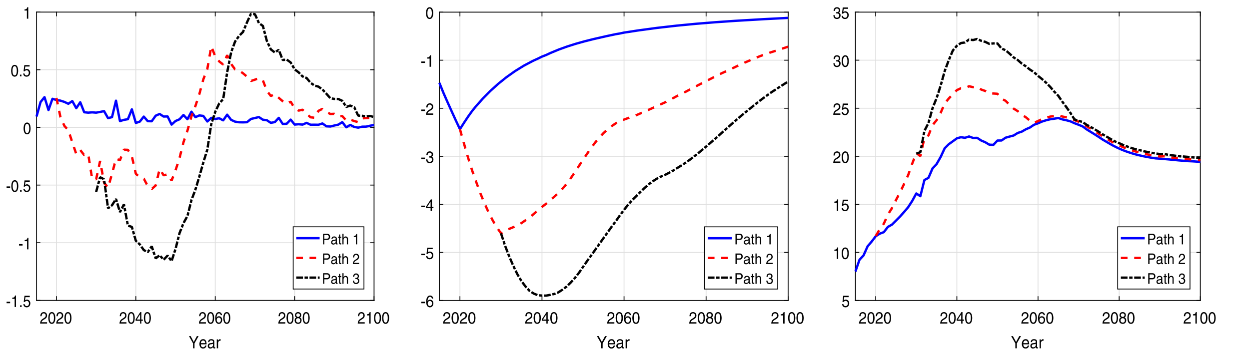
Fig. 17. Partial equilibrium: baseline path without uncertainty. Labor supply and capital are normalized by value in 2015.

5.5. Effects of endogenous factor prices: general vs partial equilibrium

In this section, we simulate a model in partial equilibrium in order to understand the roles played by endogenous factor prices. We fix interest rates and wages at the 2015 level and compute a transition path without requiring market clearing conditions for production factors to be satisfied. Fig. 17 shows paths for aggregate labor supply, implied "capital" and consumption taxes that satisfy the government budget constraint in each period. Note that we solve the model as if the economy was a small open economy and "capital" in the figure represents total saving of individuals net of government debt, which necessarily is not the amount of capital used in domestic production as in a closed economy. In general equilibrium, a rise in longevity and a decline in social security benefits due to reform generate strong incentives to save more for retirement, which makes capital more abundant relative to the limited supply of labor, and brings down interest rates to a lower level. By fixing the interest rate at a higher level, individuals would save even more and the level of "capital" in 2100 would be about 70% of the level in 2015, which is much higher than 52% in general equilibrium as we saw in Fig. 6.

Wages are fixed at a lower level and labor supply turns out to be almost unchanged from the general equilibrium case because income and substitution effects offset each other. Compared to our general equilibrium benchmark, the government raises more revenues from capital income taxation since both interest rates and amount of capital are higher. In addition, lower wages imply lower pension expenditures. As a result, consumption taxes required to balance the budget are much lower with a peak at 24%, about 10 percentage points lower than in the case of general equilibrium.

Some of the variables follow a transition path that is similar to that of a general equilibrium model. Other variables, however, such as total saving and budget-balancing tax rates differ significantly between models with and without endogenous factor prices. Taking into account general equilibrium effects can be critical in quantitative assessment, when incentives to save or work would change by a large margin for reasons such as a major demographic shift or a fiscal policy change.



(a) Labor supply (b) "Capital" (c) Consumption tax (%)

Fig. 18. Partial equilibrium: aggregate variables in the paths with uncertainty in reform timing: Labor supply and capital are expressed as percentage difference from those in the baseline transition without uncertainty.

Figs. 18 shows the transition path of labor supply, capital and budget-balancing consumption taxes when there is uncertainty in reform timing but prices are fixed throughout the transition, irrespective of the realization of reform. Qualitatively, the effects are similar to those under general equilibrium. In Paths 2 and 3, labor supply exceeds the level of the baseline economy before it converges to the same level. To understand this, recall that the basis of the comparison in the figure is the case where reform takes place in 2020 and that downward adjustments of benefit schedules are complete by 2050. In the uncertainty case, when reform is delayed (Paths 2 and 3), benefits rise with past earnings by more than in the benchmark. This provides additional incentives to work, which explains the higher labor supply before they all converge to a similar level by the end of the century. The same was observed with general equilibrium, but that effect is more visible in partial equilibrium in which wage rates do not decline with reform delays and an additional hour of work increases social security benefits more. Consumption taxes are lower for the reasons discussed above in the baseline case, but the difference across paths is similar as in the case of general equilibrium.

5.6. Alternative fiscal adjustment

In the baseline simulations, we used consumption tax as an instrument to balance the government budget. In this section we consider an alternative scenario, in which government debt is also adjusted.

Government net debt has been steadily increasing each year since the 1990s in Japan. While the fiscal gap apparently will not be closed immediately, it is a major question whether and how long such a large and increasing amount of debt is sustainable. How much room is left for the government to borrow has been a major issue while it has unsuccessfully struggled to achieve fiscal balance.

Hoshi and Ito (2014) argue that without reform to curtail expenditures, a debt crisis is inevitable.[19] Braun and Joines (2015) also predict a fiscal crisis before 2040 if no reform were to be implemented. Hansen and İmrohoroğlu (2016) simulate a transition in which an exogenous debt limit is set at 200 to 300% of GDP.

Even though such an extreme scenario triggering a fiscal crisis may or may not occur, it is worth considering a transition path where debt will continue to rise to partially take up rising expenditures. We assume that the debt-to-GDP ratio will double and rise from 100% in 2010 to reach 200% by 2040.[20] The model is not rich enough to endogenize the portfolio choice of individuals or the pricing of government debt, and we continue to assume an exogenous interest rate on government debt and households allocating a fraction of their savings to purchase newly issued debt. We use consumption tax to absorb the residual and satisfy the government budget constraint each year.

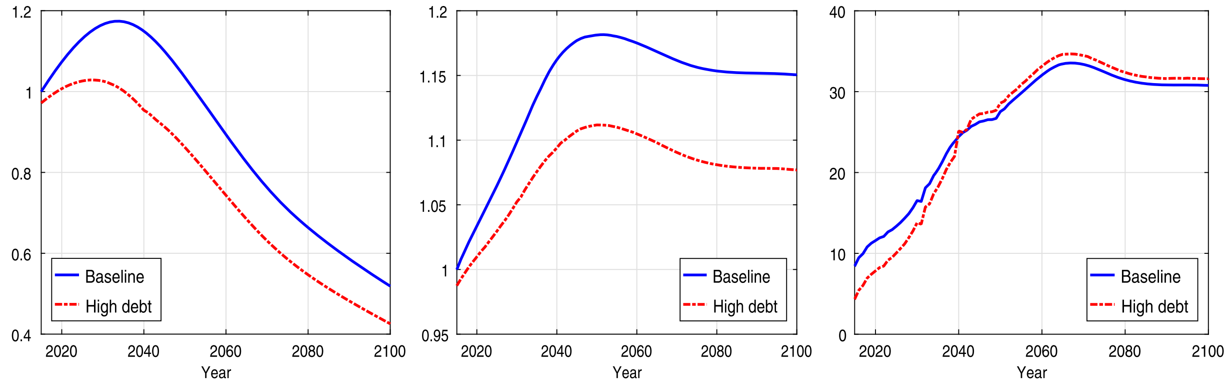
Fig. 19 shows the path of aggregate capital, wage rates and consumption taxes in the baseline simulation and case of rising government debt.

The analysis shows that although debt could be used to partially cover rising expenditures over a few years, it is not a device that can be used to deal with rising expenditures of the scale and length that Japan is to face over the coming decades. Moreover further borrowing would exacerbate the fiscal imbalance even more significantly. It would be difficult also to use government debt to absorb a change in the fiscal imbalance in a model with policy uncertainty as the debt would reach a level that, realistically, cannot be sustained.

As alternatives to finance the demographic transition, taxes on capital income and earnings might be considered. In Japan, however, raising capital income taxes is not a plausible or sensible option in light of its impact on international

[19] Hoshi and Ito (2014) define a crisis as the time when outstanding government debt will reach the nation's total private savings, in light of the fact that most Japanese government debt is held by domestic lenders. When the debt exhausts domestic savings, the government would need to tap foreign lenders, who would demand a higher yield. They predict the crisis will occur in 2022–2027, when the debt-to-GDP ratio would reach almost 250%.

[20] We assume that debt will remain at an elevated level throughout the century and will come down to 100% of GDP only in the long-run.



(a) Capital (b) Wage (c) Consumption tax (%)

Fig. 19. Baseline path and high-debt scenario: capital and wages are normalized by value in the baseline economy in 2015.

competitiveness of businesses. In fact, the Japanese government just started decreasing capital income taxes in 2016. Raising labor income taxes is not a likely option at this moment. The pension reform in 2004 increased the social security tax on earnings by 0.354 percentage points each year from 13.9% to 18.3% in 2017. The tax rate is to be fixed at 18.3% thereafter. Although these other taxes can be considered as policy alternatives in theoretical simulations, they are not plausible options at this stage in Japan and it is unlikely either that they can deal with the rising fiscal burden of the magnitude implied by the ongoing demographic transition.

6. Conclusion

In an economy facing a rapid rise in the old-age dependency ratio, reform to reduce old-age transfers will be inevitable. There is, however, uncertainty as to when reform will take place and how large the adjustment will be. This paper incorporates policy uncertainty into a dynamic general equilibrium model of overlapping generations and quantifies economic and welfare effects associated with policy uncertainty and delay in reform implementation. Individuals' saving and work incentives respond to policy innovations and drive shifts in individual and aggregate variables. The reactions induce an evolution of factor prices and fiscal burden over time, and generate welfare effects that differ across generations. Postponing reform to reduce benefits implies a rise in future taxes, transferring large costs of the demographic transition from old to young and future generations. Uncertainty itself induces more savings and hurts the old via lower interest rates and a rise in their income volatility. To the best of our knowledge this is the first paper that builds a general equilibrium life-cycle model of an aging economy, in which individuals make optimal decisions taking into account uncertainty about the future fiscal system.

This paper focuses on a social security reform driven by aging demographics, but there are different types of policy uncertainty that affect our life-cycle decisions, such as the future of the health insurance system as well as tax and debt policies. Another type of uncertainty is associated with demographics themselves, which the current and other papers in the literature take as given based on official projections. Innovations in future growth of longevity and fertility rates can have a major impact on the micro- and macro-economy. These issues are left for future research.

Appendix A. Definition of competitive equilibrium

We define the competitive equilibrium in our model.[21] Given a set of demographic parameters $\{s_{j,t}\}_{j=1}^{J}$ and $\{n_t\}$, medical expenditures $\{m_{j,t}^h, m_{j,t}^l\}_{j=1}^{J}$, and government policy variables $\{G_t, D_t, \tau_t^k, \tau_t^d, \tau_t^l, ss_t, \lambda_{j,t}^h, \lambda_{j,t}^l\}$, a competitive equilibrium consists of individuals' decision rules $\{c_t(x), h_t(x), a_{t+1}(x)\}$ for each state vector x, factor prices $\{r_t^k, w_t\}$, consumption tax $\{\tau_t^c\}$, accidental bequests transfer $\{b_t\}$, and the measure of individuals over the state space $\{\mu_t(x)\}$ such that:

1. Individuals solve optimization problems defined in Section 3.2.
2. Factor prices are determined in competitive markets.

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

$$w_t = (1-\alpha) Z_t \left(\frac{K_t}{L_t}\right)^{\alpha}$$

[21] In the definition presented above, we assume that the government budget constraint is satisfied by an adjustment of consumption tax.

3. The total lump-sum bequest transfer equals the amount of assets left by the deceased.

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

4. The markets for labor, capital and goods all clear.

$$K_t = \sum_x [a_t(x) + b_t]\, \mu_t(x) - D_t$$

$$L_t = \sum_x \eta_j h_t(x)\mu_t(x)$$

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

5. Consumption tax τ_t^c satisfies the government budget constraint (3).

Appendix B. Computation methods

Equilibrium of the model is computed on a discretized space of individual states. We solve a recursive problem using value functions at each state grid and moving backwards from the last age. We assume that the economy is in the initial steady state in period 0 and a new policy is announced and implemented in period 1. The economy makes a transition to reach the final steady state in period T. T large enough is chosen so that the transition path is not affected by increasing T.[22] First, we describe the algorithm to compute an equilibrium in the initial steady state, where labor income tax is adjusted to balance the government budget. We then describe steps to compute transition dynamics for a case where there is no policy uncertainty. Consumption taxes are adjusted to balance the government budget in each period along the transition.

Initial steady state

Step 1: Guess a set of equilibrium variables, which consists of aggregate capital K, labor supply L, labor income tax rate τ^l, and accidental bequest transfer b.

Step 2: Solve individuals' problems and derive policy functions at each state.

Step 3: Compute distribution of individuals across discrete states using policy functions derived in Step 2.

Step 4: Compute aggregate moments. We use the actual age distribution of 2010 and distribution of individuals at each age as implied by the solution and distribution computed in Steps 2 and 3. Verify if equilibrium conditions are satisfied. If not, update guesses for equilibrium variables and return to Step 2.

Transition dynamics

Step 1: Guess the path of equilibrium variables, which consists of aggregate capital K_t, labor supply L_t, consumption tax rate τ_t^c and accidental bequest transfer b_t.

Step 2: Use value functions of the final steady state as values in the last period T and solve agents' problem backwards from period $T-1$ to 1.

Step 3: Use the distribution of agents in the initial steady state as distribution in period 1 and compute a path of distribution using policy functions derived in Step 2.

Step 4: Compute the path of aggregate capital, labor supply, government revenues and expenditures and accidental bequest transfers using distribution derived in Step 3. Check if equilibrium conditions are satisfied in each period of transition. If not, update guesses for the path of equilibrium variables and go back to Step 2.

When there is uncertainty in policy, for example, if in year t_x the policy will be either A with probability p_A or B with probability $p_B = 1 - p_A$, then there will be one transition path up to year t_x and thereafter there will be two paths. We compute two paths of individuals' policy functions backwards from T to t_x and at time $t_x - 1$, individuals make decisions taking into account the probability distribution over two possible realizations of the policy in the next period, placing weights of p_A and p_B on the two value functions from the two transition paths. Distribution and aggregate statistics in above steps 3 and 4 are computed for each time and each realized policy at time t_x and thereafter. Guesses are checked and iterations proceed as described above.

Appendix C. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.red.2017.11.005.

[22] We set T at 291 and compute transition through 2300, which ensures smooth convergence to the final steady state.

References

Aguiar, M., Hurst, E., 2013. Deconstructing lifecycle expenditure. Journal of Political Economy 212 (1), 437–492.
Attanasio, O.P., Kitao, S., Violante, G.L., 2007. Global demographics trends and social security reform. Journal of Monetary Economics 54 (1), 144–198.
Braun, A.R., Joines, D.H., 2015. The implications of a graying Japan for government policy. Journal of Economic Dynamics and Control 57, 1–23.
Bütler, M., 1999. Anticipation effects of looming public-pension reforms. In: Carnegie-Rochester Conference Series on Public Policy, vol. 50, pp. 119–159.
Caliendo, F.N., Gorry, A., Slavov, S., 2015. The Cost of Uncertainty about the Timing of Social Security Reform. Working Paper.
Conesa, J.C., Krueger, D., 1999. Social security with heterogeneous agents. Review of Economic Dynamics 2 (4), 757–795.
De Nardi, M., İmrohoroğlu, S., Sargent, T.J., 1999. Projected U.S. demographics and social security. Review of Economic Dynamics 2 (3), 575–615.
Gomes, F.J., Kotlikoff, L.J., Viceira, L.M., 2012. The excess burden of government indecision. In: Brown, J. (Ed.), Tax Policy and the Economy, vol. 26. University of Chicago Press, Chicago, pp. 125–163. Chapter 5.
Hansen, G.D., İmrohoroğlu, S., 2016. Fiscal reform and government debt in Japan: a neoclassical perspective. Review of Economic Dynamics 21, 201–224.
Hayashi, F., Prescott, E.C., 2002. The 1990s in Japan: a lost decade. Review of Economic Dynamics 5 (1), 206–235.
Hoshi, T., Ito, T., 2014. Defying gravity: Can the Japanese sovereign debt continue to increase without a crisis? Economic Policy 29 (77), 5–44.
Huggett, M., Ventura, G., 1999. On the distributional effects of social security reform. Review of Economic Dynamics 2 (3), 498–531.
İmrohoroğlu, S., Kitao, S., 2012. Social security reforms: benefit claiming, labor force participation and long-run sustainability. American Economic Journal: Macroeconomics 4 (3), 96–127.
İmrohoroğlu, S., Kitao, S., Yamada, T., 2016. Achieving fiscal balance in Japan. International Economic Review 57 (1), 117–154.
İmrohoroğlu, S., Kitao, S., Yamada, T., 2017. Can guest workers solve Japan's fiscal problems? Economic Inquiry 55 (3), 1287–1307.
Kitao, S., 2014. Sustainable social security: four options. Review of Economic Dynamics 17 (4), 756–779.
Kitao, S., 2015. Fiscal cost of demographic transition in Japan. Journal of Economic Dynamics and Control 54, 37–58.
Nishiyama, S., Smetters, K., 2007. Does social security privatization produce efficiency gains? The Quarterly Journal of Economics 122 (4), 1677–1719.