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Population Aging, Health Care, and Fiscal Policy Reform: The challenges for Japan

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Population Aging, Health Care, and Fiscal Policy Reform: The challenges for Japan[1]

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Abstract

This paper quantitatively studies the influence of a rapidly aging population on the financing of a public universal health insurance system and the corresponding fiscal policies. We construct a general equilibrium life-cycle model to investigate the effects of aging and evaluate various policy alternatives designed to lessen the negative influence of aging. In particular, we analyze the reforms of insurance benefits and tax financing tools that were the recent focus of a great amount of attention and debate in Japan because of the tense financial situation. We show that although the potential reforms significantly improve the welfare of future generations, political implementation of such reforms is difficult because of the large welfare costs for the current population. Our analysis suggests that a gradual reform with an intergenerational redistribution will be more implementable politically than a sudden reform.

Keywords: Universal health insurance, Population aging, Consumption tax, Japan
JEL classification: E21, H51, I10

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1 Introduction

This paper aims to provide a quantitative analysis of the influence of population aging on the cost of maintaining a universal health care system. We focus on Japan because it has a public universal health insurance (UHI) system that provides health insurance coverage to all residents, as in most OECD countries, and because its population has been aging dramatically over the past two decades. We study the tax burden associated with financing the UHI system and its effect on the economy as the population ages. Potential reforms of the UHI system and its financing mechanisms will also be evaluated. Although Japan specifically is studied, the implications of the impacts of aging and policy reforms apply to most OECD countries with public UHI systems and to those emerging economies that are establishing their UHI system and expecting rapid population aging (e.g., Brazil, China, Mexico, Thailand), as these countries may face similar challenges in the near future.

The current cost of health care in Japan is not high (approximately 10% of GDP during 2011-14) compared with the US and European countries. In addition, the Japanese have among the highest life expectancy and lowest infant mortality rates in the world. The health care system in Japan appears to be in remarkably good shape. However, as the population ages, the low cost of the Japanese health care system is unlikely to be sustainable, given its current framework and financing methods. Japan already has the world's oldest population, and it is projected that 40% of Japanese citizens will be 65 or older by 2050 (see Figure 1a).

The aging of the population affects the health care system through two channels. First, as the fraction of the population over 65 increases, the fraction of individuals who pay taxes and premiums that finance the system decreases. In particular, under the current system in 2012, 38.6% of the program's costs are financed by general government revenues, and 48.8% are paid by a premium (a payroll tax) that is levied on employers and workers. Out-of-pocket co-payments contribute only approximately 11.9% of total medical costs. It is clear that the burden of financing health care falls primarily on the working-age population (age 15-64), which is projected to shrink to 50% of the total population in 2050 with the old-age dependency ratio rising above 75.3% (see Figure 1b).[1]

Second, the elderly face greater health risks and require much more care than young people. Data show that the average per-person medical cost for individuals aged 65 and above is approximately four times that of those under age

[1] Projections are based on the latest estimates by the National Institute of Population and Social Security Research released in 2012.

65. Table 1 presents per capita medical costs for different age groups. A larger elderly population implies a higher per capita cost of the UHI program. Figure 2 shows the trend of medical costs in Japan. As a result of population aging, if the current system is to be maintained, then either the government subsidy or the insurance premium (which is a tax on labor income that is charged to workers and employers) must be raised to finance the additional cost of the health care system. Either way, the financial burden on the working age population will increase.

In this paper, we construct a general equilibrium life-cycle model and perform quantitative exercises to understand the following: 1) the effects of demographic changes (particularly population aging) on the costs of financing the UHI system, 2) the effects of the above changes on household working and saving behaviors as well as on aggregate economic performance, 3) the effects of potential reforms of UHI and the methods used to finance the program, and 4) the likelihood that the reforms will occur. Our goal is to identify and compare potential government policy responses to the ongoing changes in the age structure of Japan's population and the influence of these responses on the country's health care system.

We evaluate the welfare gains of the potential reforms relative to a baseline economy in which only the labor income tax adjusts to balance the government budget constraint as the population ages. In this study, we perform both a steady-state comparison and a transition analysis to determine the welfare implications of prospective policy changes for future and current generations. The political difficulty of the reforms is also discussed by means of an investigation of the welfare effects of such reforms on current residents. Transition paths corresponding to each potential reform are constructed to precisely analyze the welfare changes for the current population that affect the political acceptance of the reforms.

We find that without any reform, an additional 6.3% of labor income will be required to finance the additional UHI costs expected based on the projected 2050 population age structure. The total labor tax burden (the sum of the payroll tax, the health insurance premium tax, and the social security tax) must increase to 38.6% from the current 32.3%.[2] If medical costs grow more rapidly than productivity by 0.63% per year, as observed in the US, then an additional 9.8% labor tax will be needed to finance the UHI system, given the projected aging of the population (with the total labor tax increasing to 42%).

The potential reforms that are discussed in this paper include an increase in UHI co-payments (i.e., a benefit cut) and an increase in the consumption tax to

[2] We assume that the government will follow its current plan to increase the social security tax by 2%.

replace some labor taxes. By comparing the steady state under alternative policies and the same age structure of the population, we also find that both types of reform can improve the welfare of future generations significantly. Compared to a scenario without reform, the welfare improvements associated with the reforms arise primarily from two sources: 1) increases in average consumption, and 2) better allocations of consumption over the life cycle and other state variables. Given the hump-shaped profile of income over the life cycle, a high income tax negatively affects the ability of young people to smooth consumption over the life cycle, especially for those who have just entered the workforce without wealth. We show that policy reforms mitigate the disadvantages in an aging economy and ensure the possibility of consumption smoothing.

However, by conducting a transition analysis, we find that the majority of current residents without very young generations will suffer if the reforms are implemented immediately. In particular, older unhealthy people who are close to retirement age or who have already retired would encounter large welfare losses, as they would have little or no time to prepare for the policy changes (e.g., by accumulating more savings) when they are capable to such preparation (i.e., when they are young/working). The acceptance rates for the reforms (the percentages of the population who experience welfare gains) are all below 50%, indicating that it will be difficult for the reforms to gain the support of a majority of the population without any compensation. Our analysis suggests that consumption tax reform has a milder effect on the elderly than an insurance benefit reduction because consumption is smoother over the life cycle than medical expenditures and because healthy people consume more than the less healthy. Furthermore, a gradual reform, which provides the current generation with more time to prepare for the change, is found to affect current residents less and is more easily accepted. We find that significant compensation will be needed to maintain the welfare level of the current population if the reforms are implemented. Our analysis suggests that the necessary compensation for a gradual reform is affordable, and thus it can be a Pareto improvement for both the current and the future generations.

In addition to the literature on the welfare implications of policy reforms, this study contributes to the literature on the effects of health expenditure uncertainty on economic decisions. Kotlikoff (1989) suggests that medical expenditure shocks have a large effect on precautionary savings, and several previous studies consider the effects of health/medical expenditure shocks in life-cycle models. Hubbard et al. (1995) consider medical expenditure shocks and investigate the role of a means-tested social insurance system on savings. French (2005), De Nardi et al. (2010) and French and Jones (2011) estimate life-cycle models to study the effects of the uncertainty of medical expenditures on retirement decisions and retirement savings. İmrohoroğlu et al. (2016) calculate the future fiscal burden for the Japanese economy based on an accounting model including medical expenditures and the public pension system. Our model also considers medical shocks as one of the primary sources of uncertainty over a lifetime, but our study differs from the above studies because we consider the general equilibrium effects of demographic changes and potential policy reforms in a life-cycle framework.

This study also contributes to the literature on dynamic equilibrium models with heterogeneous agents in incomplete markets, a body of literature pioneered by Bewley (1986), İmrohoroğlu (1989), Huggett (1993), and Aiyagari (1994). A general equilibrium life-cycle framework has been used to study various social programs.[3] However, health insurance systems have rarely been studied until recently. Jeske and Kitao (2009) study the effect of the current tax benefit on employer-provided health insurance in the US. Pashchenko and Porapakkarm (2013) study the potential effects of the 2010 Affordable Care Act in the US. In addition, Hansen et al. (2014) study health insurance reform in the US, focusing on Medicare buy-in as an alternative. Similar to the current study, Attanasio et al. (2011) investigate the influence of population aging on the financing of Medicare, a public health insurance program in the US that covers individuals aged 65 and above, and potential reforms to that system. Because of immigration, population aging in the US is slower than that in Europe and is not comparable to that in Japan. We study Japan to gain an understanding of the effects of a rapidly aging population and the implementability of some potential reforms.

This paper proceeds as follows. In Section 2, we construct a general equilibrium life-cycle model. In Section 3, we calibrate parameters to match the current Japanese economy. In Section 4, we discuss our quantitative results. We conclude the paper in Section 5.

2 Model

2.1 Demographics

The economy is populated by overlapping generations of individuals of age $j = 1, 2, ..., J$. The lifespan is uncertain. An individual of age j survives to the next period with probability ρ_j. When individuals reach age J, $\rho_J = 0$, and they will leave the economy in the next period. The size of a new cohort grows at

[3] See, for example, Attanasio et al. (2007), Huggett and Parra (2010), and İmrohoroğlu and Kitao (2012).

a rate of g. The population of age j is denoted by μ_j. The total population is normalized to one, i.e., $\sum_{j=1}^{J} \mu_j = 1$, and thus the population evolves according to $\mu_{j+1} = \frac{\rho_j}{1+g}\mu_j$.

2.2 Endowment, Income Uncertainty and Preferences

Individuals enter the economy with no assets and are endowed with one unit of time. They can spend this time on market work in exchange for earnings or on leisure. If n hours are spent working, then earnings are given by $w\eta_j zn$, where w is the market wage, η_j is age-specific productivity, and z is an idiosyncratic labor productivity shock that evolves stochastically via an N-state Markov chain $\pi_z(z', z)$ to characterize income uncertainty. η_j is zero when an individual reaches retirement age j^{ss}.

Individuals value consumption and leisure over the life cycle and determine the sequence of consumption and labor supply according to a period utility function, $u(c, n)$, which is compatible with a balanced growth path:

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

where γ governs the intertemporal elasticity of substitution and σ determines the working hours supplied to the market.

2.3 Medical Expenditure and National Health Care

2.3.1 Medical Expenditure Uncertainty

Agents confront uncertainty regarding their medical expenditure status x. The medical expenditure status of an individual evolves according to a Markov chain of three states $\{x_l, x_m, x_h\}$ that represent low, middle, and high expenditure states, respectively. Medical expenditures are assumed to be necessary expenditures for recovery from bad health. The transition probability $\pi_j(x', x)$ is age-dependent.[4]

[4] We abstract from the fact that some part of medical expenditures is not fully for recovery or not fully necessary. Shigeoka (2014) estimates that the price elasticity for medical care at age 70 is about 0.2 in Japan, and suggests that changes in medical care consumption would not affect the mortality. The moral hazard problem does not seem severe in Japan. Although we assume that medical expenditures are determined by exogenous shocks in the main analysis, we provide a discussion with a model with endogenous medical expenditures in Section 4.3.5.

2.3.2 Universal Health Insurance

Public UHI is available to every resident and covers a fraction ω_j of realized medical expenditures x. UHI is financed by a premium (a payroll tax) and general government revenue. The coverage rate of medical expenditures ω_j depends on age j. We will discuss details of the co-payment rate in Section 3.5.2.[5] To consider the effect of future increases in medical costs, we use a price factor of medical care q, such that individuals pay $(1-\omega_j)qx$ in out-of-pocket medical expenditures. In the benchmark case, q is set equal to one.

2.4 Production Technology

On the production side, we assume that there is a continuum of competitive firms operating a technology with constant returns to scale. Aggregate output Y is given by the following:

$$Y = F(K, L) = K^{\theta} L^{1-\theta},$$

where K and L are the aggregate capital and effective labor employed in the firm sector. Capital depreciates at a rate of δ during every period, and θ denotes the capital income share.

2.5 Financial Market Structure

Individuals can hold assets that are non-state-contingent claims to capital. The rate of return earned from assets is denoted by r. Households can partially insure themselves against any combination of idiosyncratic labor productivity shocks and medical expenditure shocks by accumulating precautionary asset holdings. Although households are allowed to insure themselves by accumulating positive asset holdings, the market is incomplete because of the absence of state-continent assets and a borrowing constraint $a \geq 0$. The borrowing limit particularly affects the asset holding decisions of low-wealth households because they are unable to smooth their consumption effectively through the use of savings.

2.6 Government

In addition to the UHI system, the government operates a social security program and a means-tested social insurance (safety net) program.

[5] Appendix A provides a description of Japan's health insurance system.

The social security (public pension) program provides elderly individuals with benefit ss in every period after they reach the eligibility age of j^{ss} and retire. The program is financed by the social security tax τ_{ss} that is imposed on the labor income of the working population. We assume that the social security benefit is a constant fraction of efficient labor, ϕwL, where the replacement rate ϕ is endogenously determined by the budget balance constraint for the social security system if the policy social security tax does not change.

The means-tested social insurance guarantees a minimum level of consumption $\underline{c}$ by supplementing income in cases in which a household's disposable income plus assets (net of medical expenditures) falls below $\underline{c}$. We consider a simple transfer rule proposed by Hubbard et al. (1995). A transfer T will be made if a household's disposable income plus assets (net after medical expenditures) is smaller than a minimum level of consumption, and the transfer amount will be exactly equal to the difference.

Government revenue consists of revenues from various tax instruments: a labor income tax τ_l, a capital income tax τ_k, a consumption tax τ_c, a social security tax (pension payment) τ_{ss}, and the UHI premium p^{med}. Although we use the linear labor income tax as a benchmark, we will consider the effects of a progressive labor income tax later. The government uses its revenue to finance all public programs and its own consumption, G.

The government finances a fraction ψ of UHI costs with general revenue. Individuals pay the remaining fraction, $1-\psi$, through the mandatory UHI premium payment. The government budget constraint is as follows:

$$\underbrace{\int [\tau_l w\eta_j zn + \tau_k r(a+b) + \tau_c c] d\Phi(s)}_{\text{Tax Revenue}} = \underbrace{\psi \int (\omega_j qx) d\Phi(s)}_{\text{UHI subsidy}} + \int T d\Phi(s) + G \quad (1)$$

$$\underbrace{\int (p^{\text{med}} w\eta_j zn) d\Phi(s)}_{\text{Premium}} = (1-\psi) \int (\omega_j qx) d\Phi(s) \quad (2)$$

where $\Phi(s)$ is a distribution function over the state variables defined below.

The social security system is self-financed with a pay-as-you-go scheme:

$$\int (\tau_{ss} w\eta_j zn) d\Phi(s) = \int T_{ss} d\Phi(s), \quad (3)$$

where T_{ss} is the social security benefit, which is equal to ss for individuals of age $j \geq j^{ss}$ and zero for individuals younger than j^{ss}.

2.7 The Household's Problem

The states for an agent can be summarized by a vector $s = (j, x, a, z)$, where j is age, x is medical expenditure status, a is asset holdings brought into the current period, and z is an idiosyncratic shock to labor productivity. An agent makes decisions regarding consumption c, labor supply n, and assets to be held into next period a' by solving the following dynamic programming problem:

$$V(s) = \max_{c,n,a'} \left\{ u(c,n) + \rho_j \beta E\left[V(s')\right] \right\},$$

subject to

$$\begin{aligned}
(1+\tau_c)c + a' &= W + T, \\
W &\equiv y(n,j,z) + (1 + (1-\tau_k)r)(a+b) - (1-\omega_j)qx, \\
y(n,j,z) &= (1 - \tau_l - \tau_{ss} - p^{\text{med}})w\eta_j zn + T_{ss}, \\
T &= \max\{0, (1+\tau_c)\underline{c} - W\}, \\
T_{ss} &= \begin{cases} ss & \text{if } j \geq j^{ss}, \\ 0 & \text{otherwise}, \end{cases} \\
c > 0, \;\; n &\geq 0, \;\; a' \geq 0;
\end{aligned}$$

where b is a lump sum transfer of accidental bequests. We assume that accidental bequests are collected and redistributed by a lump-sum transfer to all survivors:

$$b' = \int \frac{1-\rho_j}{1+g} a' d\Phi(s).$$

2.8 Stationary Recursive Competitive Equilibrium

A stationary recursive competitive equilibrium is a set of household decision rules for asset holding a', labor supply n, and consumption c; a set of firm decision rules for capital rented K and effective labor employed L; a price system w and r; a set of government policies on tax rates (τ_{ss}, τ_l, τ_k and τ_c), social security benefits ss, the UHI system (coverage ω_j, premium p^{med} and subsidy ratio ψ), and social insurance $\underline{c}$; government consumption G; and a stationary distribution of households over the state variables $\Phi(s)$, such that:

a) given the price system, the decision rules for K and L solve the firm's problem

b) given the price system and government policies, the decision rules (a', n, c) solve the household's problem

c) government policies $(\tau_{ss}, \tau_k, \tau_l, \tau_c, ss, \omega_j, p^{med}, \psi, \underline{c}, G)$ satisfy the government's budget constraints, equations (1), (2) and (3)[6]

[6]In the benchmark model, we fix a set of policy variables $(\tau_{ss}, \tau_k, \tau_c, \omega_j, \psi, \underline{c}, G)$, and τ_l, ss, and p^{med} are determined endogenously to satisfy the equilibrium conditions.

d) all markets clear: $L = \int (\eta_j z n) d\Phi(s)$ and $K' = \int a' d\Phi(s)$;

e) the resource feasibility condition is satisfied:

$$Y = C + K' - (1-\delta)K + qX + G;$$

where C is aggregate consumption and X is aggregate medical expenditure.

3 Calibration

In this section, we describe the calibration and parameter selection for the steady-state analysis. We choose the economy in 2013 as an initial steady state before some recent reforms in Japan.[7] Table 3 summarizes certain key parameters.

3.1 Preferences and Production Function

We set the subjective discount factor β equal to 0.99, such that the capital-output ratio K/Y in the model matches the data for Japan. The K/Y ratio in the benchmark model is approximately 2.5, which is close to the value estimated by İmrohoroğlu and Sudo (2010). Regarding the preference parameters γ and σ, we follow Kitao (2015a,b). She set the labor share parameter σ at 0.37 so that individuals spend approximately 40% of their time endowment for labor supply. The parameter γ, which determines inverse of the elasticity of intertemporal substitution, is set at 3. In our model with the CRRA utility function, the Frisch elasticity is defined as $\xi \frac{1-n}{n}$, where $\xi \equiv \frac{1-\sigma+\sigma\gamma}{\gamma}$ and n is the labor supply, which is an endogenous variable. According to Kuroda and Yamamoto (2008), who estimate the Frisch elasticity in Japan, if both intensive and extensive margins and both genders are considered, the Frisch elasticity is 0.97. Given the setting of parameters, our model-implied average Frisch elasticity is approximately equal to 1 in the benchmark case and close to the empirical estimates.

The parameters of the production function, the capital share θ, and the depreciation rate δ are obtained from İmrohoroğlu and Sudo (2010), who estimate these parameters based on the calibration approach of Hayashi and Prescott (2002) and use more recent data. The capital share is set at 0.377, and the depreciation rate is 0.08.

[7] The consumption tax rate increased from 5% to 8% in 2014 and it was planned to increase from 8% to 10% in 2015. However, the later reform was postponed due to recessions and political reasons.

3.2 Demographics and Survival Probability

A household enters the economy at age 20, becomes a retiree from 65, and lives to (at most) 100. The National Institute of Population and Social Security Research (IPSR) provides future projections of Japanese demographic changes. We use the projection released in 2012, which provides forecasts of demographic changes from 2010 to 2060. The projection consists of three variations of fertility rates -high, medium, and low- and three variations of mortality rates, and we use the medium variants for both fertility and mortality rates. For a steady state comparison, the survival probabilities $\{\rho_j\}$ are obtained from the life table for males in 2013 (*initial* steady state) and 2050 (*final* steady state). The population growth rate g is set at zero in the initial steady state and at -1.6% in the final steady state.[8] Figure 3 plots the actual and simulated population distributions in 2013 and 2050, respectively. The fraction of retired households, which is defined as the ratio of households aged over 65 to those aged between 20 and 64, in the model (26.46%) is quite close to the actual data (26.75%) for 2013. Under the assumption of a negative population growth rate, the fraction of retired households in the model (43.79%) is also close to the data (44.12%) for 2050.

3.3 Medical Expenditures

Micro-level panel data on medical expenditures are not publicly accessible in Japan. Thus, to obtain a reasonable measure of medical expenditure shocks in Japan, we use the report of Kan and Suzuki (2005), who study the concentration and persistence of medical expenditures in Japan using a special permit to access health insurance claim (*rezept*) data from 111 Japanese health insurance societies (insurers) between 1996 and 1998. The medical expenditures in the data are total costs before insurance reimbursements.[9] The data are panel data and include observations on 35,970 individuals between the ages of 0 and 69.

[8] To find a set of equilibrium prices w and r in numerical computations, we require the capital-output ratio K/Y. As both capital and output decline at the same rate in a steady state, we can find a set of equilibrium prices with a negative demographic growth rate.

[9] Publicly sponsored UHI is the primary health insurance in Japan, and private health insurance (PHI) complementary to UHI is not popular. According to the OECD project on studying PHI across countries by Colombo and Tapay (2004), the proportion of total medical cost financed by PHI is only 0.3% in Japan. Matsuda (2013) mentions that PHI in Japan is historically developed as a supplement to life insurance and usually pays a lump sum for hospitalization and/or for cancer/other specific chronic diseases. There are no further data that we can use to estimate the coverage of PHI. Therefore, although a (small) part of medical expenditures might be covered by private insurance, we abstract from the coverage of PHI in this paper. This simplification should not affect our main results because we focus on government financing issues and related public tax burdens.

3.3.1 Transition Probabilities

Kan and Suzuki (2005) analyze the transition of medical expenditures in five age groups (0-17, 18-35, 35-45, 46-55, and above 55). They divide all samples into 10 medical expenditure quantiles and report the corresponding transitions from 1996 to 1998 for each age group.

Our purpose is to estimate the annual transition of medical expenditures for each year of age (from 20 to 100). To obtain a clear transition pattern across age groups, we re-classify the 10 quantiles of medical expenditures into three categories: "low" (low expenditures), "middle" (medium expenditures), and "high" (high expenditures). The "low" category includes those in the bottom 50% of medical expenditures, the "middle" category includes those in the sixth to ninth quantiles, and the "high" category includes those with the highest 10% of expenditures. The three uneven categories are constructed to capture the long tail in the distribution of medical expenditures and the small probability of incurring large and catastrophic expenditures.

The original report by Kan and Suzuki (2005) presents the transition of medical expenditure in a two-year period. Because our model period is one year, we transform the two-year transition matrices into one-year transition matrices. Table 2 displays the one-year transition of the three states. We can observe that the probability of transitioning to a "low" medical expenditure status is monotonically decreasing in age. By contrast, the probability of transitioning to a "high" medical expenditure status generally shows the opposite pattern across age groups. We linearly interpolate the transition probabilities, such that that transition matrices change smoothly over the life cycle. We also extrapolate the transition probabilities for ages 70-100, which are outside the age range in the data. In Figure 4, we display the unconditional probabilities of being in the three medical expenditure states over the life cycle that are implied by the transition matrices.

3.3.2 Medical Expenditures

The expenditure level is represented by the average of each category. Because there is a gap in medical expenditures between the aggregate data and the micro data to ensure that the medical costs in the model match the aggregate medical costs, we need to make an adjustment on the expenditure levels. Based on the report of Kan and Suzuki (2005), the bottom 50% of the distribution contributes only 7.1% of total medical expenditures, the next 40% of the distribution contributes 38.1% of total medical expenditures, and the top 10% of the distribution contribute as much as 54.8% of total medical expenditures. We maintain the three categories' expenditure shares and adjust the levels of expenditure with a common multiplier such that the aggregate medical expenditure to output ratio in the benchmark model economy (X/Y) can match that in the aggregate data at 8.9%.

3.4 Labor Productivity

We approximate the labor productivity shock z using an AR(1) process:

$$\ln z_{j+1} = \lambda \ln z_j + \varepsilon_j.$$

It is difficult to estimate the stochastic hourly wage process, as micro data on earnings and hours worked in the Japanese labor market are limited. As a target to calibrate the productivity shock process, income inequality as estimated in Abe and Yamada (2009) is employed. They study the income process of Japanese households based on data from the National Survey of Family Income and Expenditure. As labor supply in our model is endogenous, the corresponding income inequality is also endogenously determined. The parameters $\{\lambda, \sigma_\varepsilon^2\}$ are chosen such that Japanese income inequality can be replicated in our model. We then approximate the AR(1) process with a five-state Markov chain using the method of Tauchen (1986).

To calibrate age-specific efficiency $\{\eta_j\}$, we use data from the Basic Survey on Wage Structure (*Chingin Kozo Kihon Tokei Tyosa*), which is compiled by the Ministry of Health, Labor, and Welfare. Following the method proposed by Hansen (1993), we compute labor efficiency for each age group, as shown in Table 4.[10]

3.5 Health Care, Social Security System, and Tax

3.5.1 Price of Medical Care

We consider two factors that increase per capita medical costs: population aging and health care inflation. Following Attanasio et al. (2008), we assume that the health care inflation rate is 0.63% per year above TFP growth.[11] We use a parameter q to capture health care inflation and normalize it to one in the benchmark year (2013). The price of medical care is thus expected to increase

[10] For details, see also Braun et al. (2009).

[11] This number is deflated by both a general inflation rate and the aggregate productivity (TFP) growth rate. Thus, the *relative* price of medical care increases by 0.63% per year. In Japan, according to Iwamoto (2006), health care costs are estimated to increase 2% per year. However, this rate is not adjusted for productivity growth. The average TFP growth rate is estimated to be approximately 1% in Japan (İmrohoroğlu and Sudo (2010)). Therefore, the estimated health care inflation rate in the US may not differ significantly from that in Japan.

by approximately 26.16% relative to consumption goods in the next 40 years (i.e., $q_{2050} = 1.2616$).

3.5.2 Health Care System

All residents are covered by UHI. The co-insurance rate ω_j (or out-of-pocket ratio, $1 - \omega_j$) depends on age. According to the current rule, the co-insurance rate is 30% for those under age 70, 20% for those between 70 and 74, and 10% for those aged 75 and above. The current UHI premium cannot fully sustain the UHI system. According the Abstract of National Health Expenditure (*kokumin iryohi no gaikyo*) by the Ministry of Health, Labour, and Welfare, we observe that 38.6% of the total UHI cost is financed by general government revenue (i.e., $\psi = 0.386$) in 2012.

3.5.3 Social Security

The payroll tax rate for the social security system in 2013 was 17.12%. Thus, we set the payroll tax rate τ_{ss} in the initial steady state at 17.12%. As a part of past social security reforms, the government plans to increase the social security tax rate by 0.354% per year until 2018. Therefore, the social security tax rate in the final (future) steady state is set at 18.3% in our simulations below. We also consider the gradual nature of the increase in social security tax in our transition analysis. In all cases, the replacement rate ϕ is endogenously determined in the model according to the social security tax.[12]

3.5.4 Social Insurance

The social insurance system (safety net) is represented by a consumption floor $\underline{c}$, which is set at 10% of average consumption to prevent individuals with low wealth from being severely affected by large medical expenditure shocks and possible negative consumption.

3.5.5 Tax System

In the benchmark model, we assume a linear tax rate, as the purpose of this paper is to quantify the burden of the future health care system, and it is difficult to interpret the results if the tax code is non-linear. We will discuss the robustness of this assumption in Section 4.3.3. Note that the labor tax rate τ_l balances

[12] Because the focus of this paper is the health insurance system, we assume that the social security system will be self-financed, given the social security tax rate. This assumption implies a decline in the replacement rate as the population ages.

the government's budget constraint in equation (1). The consumption tax rate τ_c is set at 5% as the rate in Japan in 2013. It was raised to 8% in 2014 and was planned to increase to 10% in 2015. In our model, capital tax τ_k is set at 39.8%, following İmrohoroğlu and Sudo (2010).

We set government expenditures G according to the ratio of government expenditures to output G/Y in the data. Japanese government expenditures in 2013 were 100.2 trillion yen, including expenditures of 29.8 trillion yen for social security and medical care. Thus, government expenditures without social security/health insurance related expenditures were 70.3 trillion yen.[13] As nominal GDP in Japan was 483 trillion yen in 2013, G/Y was 14.56%. The G/Y in 2013 is, however, slightly higher than previous figures because of the fiscal stimulus after the Great Recession. Therefore, we use the average value of G/Y during the period from 2000 to 2013, 13.16%, in our analysis.

According to Gunji and Miyazaki (2011), who estimate average marginal tax rates on factor incomes in Japan from 1963 to 2007, the average labor tax burden (including social security and health insurance premiums) has ranged between 30% to 34%. The setting of parameters in our benchmark model implies that the total labor tax burden ($\tau_l + \tau_{ss} + p^{med}$) is 32.3%, which is consistent with the empirical finding (See Table 5).

4 Analysis

4.1 Fiscal Burden from Population Aging and Increased Medical Costs

We first compare the tax burden in a steady state economy, given the 2013 demographic structure, with that in an economy with a population structure as projected in 2050 and/or with a health care inflation rate as projected during the 2013-2050 period. The benchmark economy is shown in the first column of Table 5, in which key parameters are calibrated to match the Japanese economy in 2013. The social security tax is assumed to increase to 18.3% (from 17.12%) in 2050 (second column) following the government's plan, and social security is self-financing. Two scenarios for the consumption tax are considered: 1) an increase to 10% in line with the government's plan and 2) the same 5% as in 2013. The ratio of government expenditure to GDP (G/Y) is assumed to be fixed at

[13]The long-term nursing care expenditures are includes in the government expenditure G in our calibration. As the long-term nursing care would be affected by population aging, the fiscal burden from aging may be underestimated. However, as our main focus in this paper is public health insurance reforms, we do not consider the long-term nursing care explicitly.

13.16%, as in 2013, in future steady states. Thus we can isolate the additional burden of financing the UHI system. The following scenarios are investigated:

Population aging In 2050, the elderly dependency ratio is forecasted to approach 80%. Clearly, there will be an increase in UHI costs resulting from demographic changes because there will be more elderly people who demand more medical care and fewer tax/premium payers. In this case, we assume that the relative price of medical care q remains constant. Although we assume that the government's subsidy to UHI is fixed, the government still requires additional revenues to finance its share of the increase in UHI costs. We assume that the government adjusts the labor income tax to ensure that it is able to finance the subsidy with two consumption tax scenarios. The remainder of the UHI cost must be financed by the UHI premium (which is also a labor income tax). We simulate the economy in a steady state given the 2050 population age structure and the above assumptions. The simulation results are presented in the second column (10% consumption tax) and fourth column (5% consumption tax) of Table 5. The numerical exercise shows that the aging of the population and the associated additional UHI costs in 2050 correspond to an 6.3% labor tax burden (including both payroll taxes and premium taxes) for young people if the consumption tax remains at 5%. The total labor tax burden increases from the current 32.3% to 38.6%, of which 1.2% consists of the scheduled increase in the social security tax. The extra labor tax burden can be lowered down to 1.9% if the consumption tax rate increases to 10% from 5%. This increase in the tax burden is likely to be a lower bound, as we assume that health care prices remain constant through 2050.

Aging with health care cost inflation If the rise in health care prices (relative to those of consumption goods) is similar to that in the US, with a 0.63% annual rate of growth above productivity growth, then medical care in 2050 will be approximately 26.16% more expensive than that in 2013 (i.e., $q = 1.2616$).[14] Given this growth in health care prices, an additional 9.8% tax burden on labor will be

[14] The medical cost inflation might be partially caused by technological improvements, which have positive impacts on welfare and are not directly considered in the analysis. Although the potential improvements, e.g. better quality of medical services and higher effectiveness of treatments, are not discussed, the consequence, increased survival rates, is exogenously considered to be a factor of population aging. Our main focus in this paper is on how government responses to the impact on the financial burden caused by population aging and/or increased medical cost, and the consequent welfare implications are derived only from the comparison among alternative financing schemes or alternative fiscal reforms given the financial situation. Therefore, even if we consider the benefits of technological improvements, the main results in our analysis will not change.

needed, and the total labor tax burden will reach 42% with 5% consumption tax. The labor tax can be lowered down to 37.7% if the consumption tax increases to 10%. The results are shown in the third and fifth columns of Table 5.

Even under the assumptions that social security is self-financing through a scheduled tax rate and that government consumption can be adjusted proportionally with the output/income, the above experiments still suggest that a sharp increase in the labor tax burden will be needed to finance the more costly health care of an older population in 2050. This additional tax burden is partly because of the smaller aggregate labor supply, which declines by 16-17% relative to the 2013 benchmark. Decomposing the changes in L into changes in the number of workers and hours worked, we find that the reduction in workers dominates the rise in hours worked. The aging-driven increase in per capita medical costs and the UHI feature whereby the elderly benefit more than the young also partially account for the sharp increase in the labor tax burden. The total medical cost to output ratio (X/Y) increases to 10% from 8.6% in 2013 and may rise as high as 13% with rapid medical cost inflation.

4.2 Potential Reforms

A high labor income tax burden is undesirable for two reasons: 1) individual work incentives will decrease while output further decreases, and 2) given the hump-shaped profile of income over the life cycle and borrowing constraints, the high income tax will further undermine the ability of young people to smooth consumption, especially for those entering the workforce. Potential reforms should be designed to reduce the extent of the redistribution between generations caused by increased UHI costs and the increased labor tax burden. We focus on two types of reforms: 1) an increase in UHI co-payments (i.e., a benefit reduction) that requires the elderly to cover more of their medical costs, and 2) a higher consumption tax to replace a portion of the labor tax (i.e., the elderly share more of the tax burden). We evaluate the welfare gains of the reforms relative to the baseline economy in which only the labor income tax adjusts to balance the government's budget constraint as the population ages, as shown in the fourth column of Table 5.

4.2.1 Reform of UHI Policy

To reduce the tax burden on the young, given the age structure of the population in 2050, we first consider the following potential UHI policy alternatives by adjusting the co-payment rate, which has already been increased several times by the government in the past:

1. Increasing the co-payment rate for the elderly who are aged between 70 and 74 to 30% from the current rate of 20%
2. In addition to (1), further increasing the co-payment rate for the elderly with age 75 and above to 20% from the current rate of 10%
3. Re-setting the co-payment rate for the elderly (70+) to 30% to match that of the young
4. Raising the general co-payment rate to 35% for all ages

We continue to assume that the ratio of government subsidy to total UHI costs is fixed at 38.6%, as in the benchmark scenario, and that the remaining UHI cost is fully financed by the premium tax. We also assume that the ratio of government consumption to GDP (G/Y) is fixed at 13.16% and that the government will adjust the labor income tax rate to balance its budget. We assume that $q = 1.2616$ in the new steady state and thus that health care inflation is 0.63% per year between 2013 and 2050.

In addition to the tax burden, the welfare effects of alternative UHI policies are also evaluated. Welfare is measured by the ex-ante expected lifetime utility aggregated over the equilibrium distribution of *newborns*. Welfare deviations from the steady state under the original policy are calculated using the certainty equivalent consumption variation (CEV) measure. [15]

The results of the UHI policy experiments are presented in Table 6. For the sake of comparison, the baseline economy is also shown in the first column of Table 6. We can observe that K/Y increases as the UHI co-payment rate is raised because individuals must accumulate more savings to defray the medical expenditure risk that arises during their retirement years.

In addition, the policy reform of increasing co-payments requires the elderly to share more of the medical cost burden and reduces the labor income tax burden on the young, which fosters labor supply. In equilibrium, the output rises while the X/Y ratio falls, and aggregate medical expenditures X are the same as in the baseline economy without the reform. As a result, we observe a significant welfare improvement for newborns as a result of this type of policy reform (see CEV in Table 6). The reduction of the labor tax burden reduces labor supply distortions and improves the ability of the young to smooth consumption over the life cycle.

[15] The details of the calculation of CEV are explained in Appendix B.

4.2.2 Reform of Financing Policy

We also investigate alternative financing policies for the UHI system and government spending, given an aging population. We assume that the consumption tax rate is 5% in the initial steady state, which is much lower than the tax in other developed countries. Some government proposals to increase the consumption tax have attracted significant attention. In fact, the Japanese government already increased the consumption tax to 8% in 2014 and planned to increase it to 10% in 2015, although the planned increase in 2015 was postponed. Therefore, we particularly focus on the consumption tax (τ_c), which can be a substitute for the labor tax and is less distortive of the labor supply, as it spreads the tax burden over the full population. We investigate two potential reforms: increasing the consumption tax rate τ_c to 10% and increasing the rate to 15%. The corresponding changes in the steady state given the expected population structure in 2050 are examined. The results of this policy experiment are presented in Table 7.

Imposing a higher consumption tax to substitute for the labor tax has a redistributive effect across generations, similar to that of the UHI co-payment reform. The decrease in the labor tax burden reduces labor market distortions, increases the labor supply/output, and improves welfare, as with the UHI reform. The new financing policy reform also affects asset accumulation –individuals must save more for their retirement to finance their increasingly costly consumption. Thus, we find higher K/Y ratios in the simulation results under each policy experiment, as shown in Table 7.

In general, the welfare effects and the mechanism of the financing policy reform are similar to those of the above UHI policy reform, but the CEV for newborns is lower than that resulting from a UHI co-payment increase. This finding is observed because although the labor tax burden is reduced, the consumption tax burden is higher for both the young and the old, and the young do not consume less than retirees. By contrast, the young in the economy with a UHI co-payment reform enjoy more (non-medical) consumption because young people consume much less medical care than the elderly. However, an increased consumption tax hurts the elderly less than a UHI co-payment increase, which results in greater uncertainty for them.

Overall, our policy experiments indicate that all of the above policy reforms that reduce the labor tax burden significantly improve the welfare of future generations under a more aged population structure.

4.2.3 Decomposition of Welfare Changes

To obtain a better understanding of the welfare changes that result from these reforms, we decompose the change in CEV (for newborns) into two components; (1) that arising from distributional changes and (2) that arising from aggregate-level changes. Our approach to welfare decomposition is similar to that of Benabou (2002), Heathcote et al. (2008), and Conesa et al. (2009). The aggregate-level component captures the welfare change that would occur if the distribution of consumption and/or labor supply (across types, across the life cycle, and across states of the economy) is the same as in the baseline economy, but the average level becomes that of the economy with reform. The distributional component captures the reverse situation.[16] Table 8 presents the results. We find that both the distribution effect and the level effect are important in accounting for the welfare changes caused by the above policy reforms. However, the welfare improvements arise primarily from changes in consumption. There is a welfare gain from the distribution of leisure over the life cycle, but the loss in leisure caused by the level change offsets this gain.

Under the reforms (especially the UHI co-payment reform), the higher expected costs for the elderly and the lower tax rates for the young encourage both capital accumulation and increased labor supply, thus increasing the aggregate output/consumption level. The lower labor income tax burden also gives individuals (especially the young, who are more likely to be financially constrained) a greater ability to allocate their own resources to consumption and savings over the life cycle and with respect to other state variables. The decomposition analysis shows that both the level increase and the distributional change in consumption are crucial for the significant welfare gains, as measured by CEV.

4.3 Discussion of Robustness

4.3.1 Consumption Floor

In the previous analysis, we assume that the consumption floor provided by the social insurance is 10% of average consumption. We have performed a robustness check for this assumption and found that the choice of the consumption floor does not significantly change the results. Table 9 presents the results of benchmark economy with alternative assumptions for the consumption floor – from 10% to 30% of average consumption. In the benchmark case, the labor income tax is used to balance the government budget. We find that even if the consumption floor is set at 30% of average consumption (instead of 10% in the

[16] For more details, see Appendix C.

main text), the additional labor income tax needed to balance the budget is just 0.0018% while 4.8% of the population is covered by social insurance. Therefore, it is not likely that the setting of consumption floor will significantly affect the fiscal burden in our analysis.

4.3.2 Health Insurance Premium for Retirees

In practice, the operation of the universal health insurance system in Japan is complicated, and there are several possibilities for old people to have the insurance coverage. Traditionally old parents live with their children and become children's dependents in Japan. In this case, they receive health insurance benefits as long as household heads (i.e. their children) pay the UHI premium tax. In the above analysis, we implicitly assume that retirees have health insurance coverage through this channel without paying the premium tax by themselves. However, it is possible that richer old people live and pay the UHI premium by themselves but that the rate is generally lower than that for younger people (below 65).

Here, we perform a robustness check by considering two additional cases: (1) All retirees pay the full premium tax as young people do. In this case, the premium tax is levied on retirees' pension, and the flow income of retirees becomes: $(1 - \tilde{p}^{med})ss$ and $p^{med} = \tilde{p}^{med}$, where ss is the pension payment, $\tilde{p}^{med}$ is the UHI premium tax rate for old people and p^{med} is the UHI tax rate for young people. (2) Retirees pay on average a lower premium, 50% of young people's, $\tilde{p}^{med} = 0.5p^{med}$.

In each case, we simulate the benchmark economy (with a 2013 economic and demographic structure) and the aging economy (with a 2050 demographic structure and increased medical price). We compare the two additional cases with our original case and check whether the additional considerations lead to significant deviations from the original results. Table 10 presents the comparison. In both cases (1) and (2), labor tax burdens are slightly lower than that in the original case because retirees share some part of the UHI cost. However, the differences are not significant. Even in the extreme case, every retired individual pays the same UHI tax as young people in case (1), and the impact of aging still preserved. This is because the level of retirees' income is much lower than that for working-age individuals, and thus, the additional UHI premium tax revenue from retirees is not enough to provide significant cost sharing.

4.3.3 Nonlinear (Progressive) Income Tax System

In the benchmark model, the government collects labor income tax with a flat rate τ^l. In reality, the income tax system is progressive, and it is worth checking whether the policy/welfare implications deviate if we adopt a progressive tax system. Theoretically, the tax burden on young/poor individuals might be overestimated with a linear tax system. Therefore, we adopt the log-linear tax system used in Heathcote et al. (2014) to approximate the income tax system in Japan for a robustness check. Suppose that disposable income is determined by $\alpha(y)^{1-\tau}$, where τ governs the progressivisty of the tax system. Then, the after-tax earnings $\tilde{y}$ can be defined as

$$\tilde{y} = \alpha(y)^{1-\tau} - (\tau_{ss} + p^{med})y,$$

where y is before-tax labor income and $(\tau_{ss} + p^{med})y$, is the compulsory payment for public pension and health insurance, and thus $y - \alpha(y)^{1-\tau}$ is the labor income tax.

We use OECD tax database to estimate coefficient τ, and α is endogenously determined in the model to balance the government budget.[17]. The estimation result is $\tau = 0.0852$, which implies a progressive tax system. Figure 5 compares the statutory tax schedule based on the OECD tax database with the log-linear approximated tax system. The difference becomes larger when earnings are higher than 20 million yen, but there are not many individuals located there because the mean is at about 5 million yen.

We adopt the same calibration strategy for everything except the labor income tax system. The benchmark economy with the non-linear labor tax system slightly deviates from the linear-tax one. First, the progressive tax system leads to a lower aggregate labor supply because it discourages workers with high productivity more. Hence, the average hours worked per worker decrease from 0.35 (in the linear-tax case) to 0.33. Second, savings are lower than that in the linear-tax case because the progressive tax system provides a better insurance for individuals against the labor income risk – individuals pay less taxes (or even receive transfers) when they are hit by bad labor income shocks. The capital-output ratio decreases slightly from 2.47 in the linear-tax case to 2.46.

In addition, we find that policy/welfare implications do not change with the progressive tax system. Tables 11 and 12 present the results of UHI policy reform and financing policy reform as counterparts of that in Section 4.2.1 and in Section 4.2.2, respectively. Compared with Tables 6 and 7, the welfare and policy implications do not significantly change.

Overall, the deviation from the linear-tax case is insignificant and all policy and welfare implications remain the same when a progressive tax system is considered. This is probably not surprising because the income inequality in the model (and actual Japanese economy) is not as high as that in the U.S. Therefore,

[17] For the details of the OECD tax database, see http://www.oecd.org/tax/tax-policy/tax-database.htm#A_RevenueStatistics.

as is obvious from Figure 5, the majority of households/tax payers encounter an almost linear tax system.[18]

4.3.4 Availability of Annuity

In our analysis, the assets of the deceased agents are allocated to the currently alive generations. This might matter for the welfare results because the aggregate capital changes between policy experiments. Therefore, we perform a robustness check with the introduction of perfect annuity as in Storesletten et al. (2004), such that that assets of the deceased are allocated among surviving agents of the same cohort. We repeat all the policy experiments and find that welfare implications are still preserved as in the original analysis without perfect annuity (Table 13).

4.3.5 Endogenous Medical Expenditure

Although we assume in the main analysis that medical expenditures are determined by exogenous shocks, here we provide a discussion with a model with endogenous medical expenditures.

We assume that individuals value both (non-medical) consumption (c) and medical care expenditures (m) as in De Nardi et al. (2010). We also assume that the marginal utility of medical expenditures depends on age (j) and health shocks (x). We assume that the labor supply is inelastic in this discussion. Thus, an agent makes decisions regarding consumption c, medical expenditures m, and assets to be held into next period a' by solving the following dynamic programming problem:

$$V(s) = \max_{c,m,a'} \left\{ \frac{c^{1-\sigma}}{1-\sigma} + \mu(j,x)\frac{m^{1-\sigma}}{1-\sigma} + \rho_j \beta E V(s') \right\}$$

subject to

$$\begin{aligned}(1+\tau_c)c + a' &= W - (1-\omega_j)qm, \\ W &\equiv y(z,j) + (1+(1-\tau_k)r)(a+b), \\ y(z,j) &= (1-\tau_l-\tau_{ss}-p^{\text{med}})wz\eta_j + T_{ss}, \\ c > 0,\ \ m &> 0,\ \ a' \geq 0.\end{aligned}$$

[18] A recent article in the Wall Street Journal by Schlesinger in 2015 also reported that in Japan, the share of national earnings taken by the top 1% earners was 9% in 2012, the latest year available. This number in the US was 17.5% in 2013. http://www.wsj.com/articles/japan-may-be-exception-to-pikettys-thesis-1423451451. For the international comparison of economic inequality in Japan, see also Lise et al. (2014).

We adopt a partial equilibrium model to reduce the computational time cost that implicitly assumes constant prices (r and w) in the aggregate economy. The government has to balance its budget every period as in the main analysis. In the benchmark, the tax rates, medical insurance coverage rate and social security replacement rate are set to be the same as in the benchmark of the main analysis. Government consumption G is a residual in the benchmark and will be fixed in all experiments as in the benchmark. Calibration strategy is similar to that in the main analysis. The major difference is in the determination of medical expenditures. We assume that the utility parameter $\mu(j, x) = \mu_j \mu_x$, and calibrate $\mu_j = e^{a_i + b_i \times j}$ for six age groups (where i indicates the age group) and $\mu_x \in (\mu_x^1, \mu_x^2, \mu_x^3)$ corresponding to three health shock statuses (in total 15 unknowns) such that the average medical expenditures over the life cycle and the aggregate medical expenditure to income ratio in the model can match the data (15 data moments in total). Given that medical price varies over age because the UHI co-payment rate is age dependent, the calibration ensures that individuals' responses to the medical price for each age group on average are consistent with the data. Figure 6 shows the life-cycle patterns of medical expenditures in the model and the data. The average medical expenditure of age group 21-25 is normalized to one. The aggregate medical expenditure to income ratio is 10%, which is consistent with the medical expenditure to GDP ratio during 2011-14 in Japan.

Given the benchmark, the same experiments of population aging are performed as in the main analysis. In the new steady state representing 2050, the social security tax is fixed at 18.3% according the the government's plan, as in the main analysis. The baseline scenario is that the government uses the labor income tax to finance the additional cost in the aging society (while the consumption tax and capital income tax remain unchanged). Figure 7 presents two cases of the baseline experiment: (a) the medical price is constant ($q = 1$) and (b) the medical price grows at a rate 0.6% per year until 2050 ($q = 1.26$).

In case (a), there is only an income effect on medical expenditures because the medical price does not change. The total tax rate on labor income (payroll tax + social security tax + health insurance premium) increases to 38.07% from 32.26% in the benchmark case. This result is close to that in the main analysis with exogenous medical expenditures (at 38.59%; see the 4th column in Table 5). The negative income effect on medical expenditures, especially for old people, comes from the fact that the labor tax rate is higher and the social security payment is lower (because it has to be self-financed by the 18.3% social security tax on labor income, and the original replacement ratio cannot be maintained). Therefore, in case (a), we observe that the medical expenditures in old ages are significantly lower than those in the benchmark case.

In case (b), there are both price and income effects, and thus, the whole life-cycle pattern of medical expenditures shifts down compared with that in the benchmark case. The tax burden on labor income increases from the benchmark case, 32.26% to 36.77%, which is smaller than in case (a) because of the lower level of medical expenditures. This result deviates from that in the main analysis with exogenous medical expenditures (total labor tax burden at 42.05%; see the 5th column in Table 5). Table 14 summarizes the comparison between endogenous and exogenous cases.

In general, we find that if the demand elasticities of medical care are considered, the impact of medical price changes will be smaller. However, the impacts of population aging without medical price inflation are close to the case of exogenous medical expenditures in the main analysis. It is worth noting that in this discussion the medical price is exogenously given and we do not model the medical care market. In reality, the medical price is determined by both the demand and supply of medical care. If medical price inflation is driven by the demand side, our result of the impact will be largely underestimated because the current setting implies that the medical price increase is fully determined by the supply side change and that consumers will respond by reducing their consumption of medical care. Further research on the medical care market is necessary for a precise estimation of changes in the medical care price and consumption.

4.4 Transition: Welfare Implications for Current Residents

In the analysis above, we calibrate the benchmark economy to match the main economic features of Japan in 2013 with an assumption that it is on a steady state (balanced growth path). We also assume the economy will reach another steady state in 2050 (with a negative population growth). The steady state comparisons deliver *long-run* welfare implications of reforms.

Although we find significant welfare gains in the long run for future generations, especially under the reform involving an increase in the UHI co-payment rate, the cost/benefit ratio along the transition path –i.e., the direct welfare effect on current residents who politically determine the policy- has not been considered. Here, we consider the transitional cost to obtain a better understanding of the welfare effects of the alternative polices on current generations.[19]

For the policy analysis, we take the economy in 2013 as a *reference year* and evaluate several potential reforms in 2013. However, the Japanese economy has already experienced several reforms on health insurance and social security system in recent decades. We take into account those past reforms and choose 1990

[19] The numerical procedure we used here is similar to that in Nishiyama and Smetters (2005).

as the initial year of the transition to reduce the errors caused by the assumption of a counterfactual initial distribution. We treat the economy in 1990 as an initial "steady state" in which all policy parameters are re-adjusted to match the condition in 1990. The actual past policy reforms that we considered are listed as follows:

1. The UHI co-payment rate was 10% for all individuals in 1990. In the reform in 1997, the co-payment rate increased from 10% to 20% for individuals less than age 70. The co-payment rate for individuals aged below 70 increased from 20% to 30% in 2003. The co-payment rate for individuals aged between 70 and 74 also increased from 10% to 20% in 2008.

2. The consumption tax rate was 3% in 1990, and it increased to 5% in 1997.

3. The social security tax rate was 13.58% in 1990. A reform in 2004 set a gradual increase in the tax rate every year until it reached 18.3% in 2018.[20]

We assume that these reforms are not anticipated. Up to the reference year 2013, households have experienced reform shocks occurring in 1997 (consumption tax), 2003 (UHI and social security) and 2008 (UHI). Therefore, we can obtain a more precise distribution in the reference year because households' consumption/saving behaviors have responded to the previous policy changes.

Regarding the population dynamics, we use the actual population distribution between 1990 and 2010, and use the official forecast by the IPSS for the period between 2010 and 2060. After 2060, we assume the economy will slowly converge to a new steady state in 2200 and reach a stable zero population growth rate.

To calculate welfare along the transition path, we require one additional state variable, t, the time period (year). The state vector s now becomes the following: $s = (j, h, a, z, t)$. We calculate CEV by age for those who are alive in 2013 to understand the effects of potential policy reforms on current residents. The CEV of individuals of age $j = j_x$ in 2013 is defined as follows:

$$CEV_{j_x,\,2013} = \left(\frac{\int V_{\text{new}}(s|j = j_x, t = 2013) d\Phi_{\text{original}}(s|j = j_x, t = 2013)}{\int V_{\text{original}}(s|j = j_x, t = 2013) d\Phi_{\text{original}}(s|j = j_x, t = 2013)} \right)^{\frac{1}{\sigma(1-\gamma)}} - 1.$$

We perform a transition analysis for the following four potential policy reforms:

[20] To reduce the computational burden, we assume that individuals are informed with the social security reform in 2003. Thus there are two shocks in 2003: the UHI co-payment rate change and the social security reform plan

- Policy 1: a sudden UHI policy change - increasing the UHI co-payment rate of the elderly to 30% from the current 20% for those aged 70-74 and from 10% for those 75 and over *in 2014*
- Policy 2: a gradual UHI policy change - increasing the co-payment rate of the elderly gradually every year until reaching 30%, as Policy 1, in 2044.
- Policy 3: a sudden financing policy reform - increasing the consumption tax to 15% from 5% *in 2014*
- Policy 4: a gradual financing policy reform - increasing the consumption tax 1% every 3 years to 15% in 2044.

The welfare changes by age and medical expenditure status of individuals living in 2013 are represented as "Policy 1," "Policy 2," "Policy 3," and "Policy 4" in Figures 8.

We first discuss the implication of Policy 1. With the implementation of Policy 1, a UHI co-payment increase, we find that the majority of the current population will experience welfare losses. In particular, the results suggest that older unhealthy individuals would experience greater losses under the reform, whereas younger individuals may experience welfare gains. An increase in the UHI co-payment rate requires elderly individuals to share more of their medical care costs than under the current policy. For those aged 65 and above, the average welfare loss is above 4% of their lifetime consumption and could even be much worse for those with high medical expenditures (up to 17%). The large loss arises first because the elderly confront higher probability of medical shocks and thus incur greater harm from increased co-payments. Second, because the new policy is implemented immediately after 2013, those who have already retired have no opportunity to prepare during their working years (i.e., to accumulate more assets) for the sudden out-of-pocket medical cost increase.

To avoid the disadvantages associated with a sudden UHI policy reform, as discussed above for Policy 1, we then consider a gradual reform of the UHI policy (Policy 2): the elderly's co-payment rates increase slowly per year until reaching 30% in 2044. We find that the welfare (CEV) pattern across age groups under this gradual reform policy is less harmful for elderly and unhealthy individuals. Note that the three lines representing the three medical expenditure statuses in Figure 8(b) decline less in old age, and the differences among the three lines are much smaller. These changes occur because a gradual reform allows more time for people to prepare for the policy change. However, younger people have to bear a higher tax burden compared with Policy 1, and will not prefer this gradual reform.

Regarding the reform of financing policy, we find that Policy 3, a consumption tax increase that can reduce the labor tax burden on young people as in Policy 1, has a much milder effect on those who are currently elderly, although they will still experience welfare losses (Figure 8(c)). The general pattern of welfare losses across age groups is similar to that of Policy 1: only young individuals have welfare gains, and older individuals suffer, especially those who are close to or above the retirement age. Because the tax is imposed only on non-medical-care consumption, the redistribution between individuals with high medical risk and those with low medical risk is much smaller than under the UHI co-payment reform. Hence, the welfare changes corresponding to different medical expenditure statuses are not significantly different.

Moreover, we find that a gradual reform of the consumption tax (Policy 4, presented by Figure 8(d)) that allows 30 years from 2013 for 15% to be achieved has a welfare effect benefiting old people because, for the first 10 years after 2013, the consumption tax is even lower than that in the benchmark (in which the consumption tax becomes 8% in 2014 and 10% in 2015). Similar to Policy 2, young people do not prefer this policy because of a higher labor tax burden during the transition.

The results suggest that consumption tax reform may be more politically palatable than a one-time full change in the UHI co-payment rate, which largely hurts the current elderly and unhealthy population, although both reduce the tax burden on young people. In addition, gradual reform is better for current residents than immediate reform because it allows more time for individuals to prepare for such a policy change and prevents a sudden shock to current elderly/retired persons who have limited abilities to adjust their resources for consumption smoothing.

4.5 Policy Implication and Political Dilemma

4.5.1 Political Support

The analysis above indicates a difficulty for reforms: the majority of the current population will suffer as a result of reforms, despite the significant welfare improvement for future generations.[21]

To better understand the levels of support for reforms among the current generation, following Conesa and Krueger (1999), we calculate agreement rates

[21] We disregard the possibility of time inconsistency when discussing the political feasibility of reforms in this section. As we need to consider off-the-equilibrium beliefs to include such possibilities in our model, we have to change the concept of equilibrium from the recursive competitive equilibrium to Markov equilibrium, which makes computation much harder. For details, see Corbae et al. (2009) and Song et al. (2012).

by age for each of the reform policies discussed in the transition analysis.[22] We assume that if an individual expects a welfare improvement from a reform policy, then the individual will agree with the reform. Figure 9 presents the agreement rates by age for each reform policy for the current generations (who are alive in 2013).

We find that for Policy 1 young individuals aged 35 and under are rather supportive; however, individuals above 40 do not support the reform. The agreement rate for Policy 2, which gradually increases the UHI co-payments of the elderly, is even lower because it loses some support from younger individuals, although this policy has a milder negative effect on the elderly. Young individuals, especially those below age 40, can enjoy a lower tax burden under an immediate reform scenario relatively sooner than under a gradual reform scenario.

Support for Policy 3 is the highest among the four potential reforms. A major part of individuals below the age of 40 would agree with this reform. Policy 4 is preferred by older people, but it loses the support from younger individuals for similar reasons as discussed for Policy 2.

4.5.2 Reform with Compensation

The above transition analysis shows that the majority, especially those retired or close to retirement, of the population will suffer at the time when the reforms are implemented. This finding indicates that if people do not care much about future generations, the implementation of the reforms would be politically difficult.

Here, we further ask whether the welfare gain from a policy reform along with the transition is able to compensate the welfare loss due to the reform if the government can make transfers across generations. We investigate how much the government must compensate current residents (who are alive in 2013) under each reform scenario to ensure that their welfare can be maintained at its original level.[23] Therefore, we calculate the present value of net future welfare gain (from the generation born in the next period) and compare it with the monetary value of net welfare loss of the current population.

Suppose that $V_{\text{original}}(j, x, a, z, t = 2013)$ is the level of welfare of a household alive in 2013, with state variables (j, x, a, z) in an economy without reform. To maintain the same welfare level, if a reform is implemented, the government can make a transfer $\tilde{a}$ to the household as compensation, such that its

[22] Following the same method, Yamada (2011) suggests a political feasibility of social security reforms in Japan.

[23] The approach that is used to calculate this compensation is similar to the lump-sum redistribution authority approach employed by Nishiyama and Smetters (2005).

welfare V_{new} is equal to the pre-reform value: $V_{\text{new}}(j, x, a + \tilde{a}, z, t = 2013) = V_{\text{original}}(j, x, a, z, t = 2013)$. For households with welfare gains under the reform, $\tilde{a}$ will be negative.

Total compensation T_c is defined as follows:

$$T_c = \int \tilde{a} d\Phi_{\text{original}}(j, h, a, z, t = 2013).$$

We calculate the amount of compensation for each policy reform. Compared with GDP in 2013, the total compensation is equal to 23.94%, 19.03%, 17.09%, and 8.8% of 2013 GDP for Policies 1, 2, 3 and 4, respectively. Table 15 summarizes the results.

Similar to the idea of the lump-sum redistribution authority in the work of Nishiyama and Smetters (2005), we calculate the maximum amount (in terms of present value, denoted by T_f) that the government is able to borrow from the future to finance the needed compensation and to ensure that future generations obtain the same benefits as they would in the baseline economy without any reform. Let a_f denote the maximum (negative) transfer on a future agent born at time $t > 2013$, where a_f is defined by the following:

$$V_{\text{new}}(j = 20, x, 0 + a_f, z, t) = V_{\text{original}}(j = 20, x, a = 0, z, t).$$

Because the policy reforms improve welfare for most future generations, a_f is typically negative.[24] We can calculate the maximum debt T_f that the government can raise in 2013 for the needed compensation under each reform policy from the following:

$$T_f = \sum_{t=2014}^{2200} \left(\frac{1}{1 + \tilde{r}_t} \right)^{t-2013} \int -a_f d\Phi_{\text{new}}(j = 20, x, a = 0, z, t),$$

where $\tilde{r}_t$ is the interest rate on government debt (government bonds) at time t. If T_f is greater than T_c for a given policy reform, then the government can theoretically ensure that some generations reap greater benefits without causing harm to others through intergenerational redistribution.

We find that the interest rate $\tilde{r}_t$ on government bonds is crucial. In recent years, interest rates on Japanese government debt have been below 1%. If we assume that the government can issue debt at an interest rate of $\tilde{r}_t = 1\%$, then affordable compensation levels for T_f in terms of 2013 GDP are 22.36%, 20.71%, 16.46%, and 11.04% for Policies 1, 2, 3 and 4, respectively. The above results are summarized in the second and third rows of Table 15. The results indicate that

[24] As negative assets are outside the state space in the benchmark value function, we use linear interpolation to compute this value.

the government will be able to provide sufficient compensation T_c for gradual reforms, Policies 2 and 4, because these policies have less negative effects on the current population. In particular, Policy 4, a gradual reform in consumption tax, can generate a greatest net welfare gain if the transitional cost is considered.

5 Concluding Remarks

In this study, we examine the effects of Japan's rapidly aging population on the cost of its health care system and the tax burden using a structural approach that captures income and medical expenditure profiles/uncertainties over the life cycle. The implications of this study may be useful for countries confronting similar problems, including many European countries. We find that if the population age structure in 2050 conforms to current projections, then the government will require an additional 6-10% in labor income taxes if consumption tax is 5% or an additional 2-5% in labor income taxes if consumption tax is 10% to finance the additional cost of the UHI system. This additional revenue is needed because the UHI system requires lower co-payments from the elderly and because financing the system primarily relies on labor income taxes. However, a higher tax burden on the working-age population is undesirable because it discourages labor supply and further undermines the abilities of young individuals' to smooth consumption over the life cycle and other economic states. Potential reforms that lower the labor tax burden on the young are expected to reduce the negative effect of aging under the current UHI/tax system.

We particularly focus on reforms of UHI policy (a co-payment increase) and of government financing policy (a consumption tax increase). We find that both types of reform policies can reduce the labor tax burden on the young and bring significant welfare gains in new steady states for future generations. The welfare gains primarily arise from both the increase in consumption levels and the improved allocation of consumption over age brackets and other economic states. However, we find that the immediate reforms are significantly harmful for current residents along the transition path, especially for those who are close to retirement age or have already retired. Seniors suffer under the reforms largely because they lack sufficient time to adjust their resources to a more expensive (and more risky, in the case of a UHI co-payment increase) retirement life after reform implementation.

Our experiments suggest that a consumption tax increase has a less negative effect on those who are currently elderly or unhealthy than a UHI co-payment increase and that such a change will have stronger support from the current population compared with other policy scenarios. A gradual reform also has less influence on the current population, especially the elderly, by giving them more time for preparation. However, we find that without any compensation, the majority of the population would oppose the reforms because of the associated welfare losses and that a gradual reform would lose support among the younger population, although its negative effects on the elderly/unhealthy would be smaller. When we factor in compensation for the current population, we find that although such compensation must be substantial, the government can achieve a redistribution that leads to a Pareto improvement for both current and future generations if the reforms are implemented gradually and if the interest rate on government debt is low.

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Appendix

A Health Insurance System in Japan

As in many OECD countries, Japan provides a public universal health insurance system, which covers all residents including employees, the self-employed, the unemployed, children and retirees. There already existed several independent health insurance programs separately based on jobs and occupations before World War II. The Japanese government re-organized the health insurance programs and achieved universal health insurance coverage in 1961.[25]

Although the coverage of the health insurance system has been basically universal after 1961, the actual application of insurance to any given person is complicated due to historical reasons. There are hundreds of insurers that are managed by societies organized by large companies or central/local governments, providing health insurance coverage and collecting premiums. Although there exist many different insurers, an individual cannot choose an insurer freely. Which insurer is assigned to a specific individual depends on individual characteristics such as job/occupation, employment status, and age. Basically employees and their dependents under age 75 (e.g., children, spouse, parents, grandchildren and grandparents without sufficient income) are covered through the employee's health insurance. The remaining individuals under age 75 (e.g., the self-employed, the retired and unemployed who are not dependents of those employees) are required to enroll in health insurance plans run by local governments based on their residential location. Those aged 75 and above are covered by the elderly health care system (*chojyu iryo seido*).

More precisely, the current public health insurance can be divided into three categories: (a) employment-based health insurance, (b) residential-based health insurance (*Kokumin Kenkou Hoken*; *Natioal Health Insurance*) and (c) health insurance for the elderly. Most employees are included in the employment-based health insurance system. Even in category (a), there are several health insurance schemes based on occupation:

- Most employees who work in the private sector are covered by *Kenko Hoken*. Depending on the size of firms in which they work, there are two types: union-based health insurance and government-administered

[25] For a brief history and the development of universal public health insurance system in Japan, see Kondo and Shigeoka (2013). Following Finkelstein (2007), in which she examines the impacts of the introduction of Medicare in 1965, Kondo and Shigeoka (2013) examine the impact of the introduction of the universal public health insurance system in Japan, which was implemented in 1961.

health insurance. Employees of large companies are typically covered by union-based health insurance, and those of small firms are covered by the Japan health insurance association (*Zenkoku Kenkou Hoken Kyokai*). There were about 1.5 thousand societies under the union-based health insurance scheme in 2010, and they covered approximately 30 million individuals, including dependent family members. The Japan health insurance association covers approximately 35 million individuals.

- Employees of public sectors (both central and local public sectors) and teachers are covered by mutual-aid health insurance (*Kyosai Kumiai*), which is also society-managed health insurance. There were 76 societies under this scheme in 2009, and it covers 9 million individuals.

Residential-based insurance, according to *Kokumin Kenkou Hoken*, covers people who are not included in category (a), e.g., the self-employed, the unemployed, irregular employees and retired people.[26] It is organized by local governments. There were about 2 thousand insurers, and the number of covered people is about 39 million. Individuals above 75 are covered by the health insurance for the elderly.

Although the UHI premium rate depends on the employees' job/occupation as described above, it is mainly based on their salary. The basic rate is roughly 10% of earnings although several deductions and other supports may apply. In addition to collecting premium, insurers also receive government subsidies for the insurance payment.

Moreover, all the insurance benefits are set by the government regardless the insurer. The general coverage of the UHI system is 70% of medical expenditures (i.e. a 30% co-payment). For senior people aged between 70 to 74, the co-payment rate is reduced to 20%, except for those with an income higher than a threshold. An additional benefit for the elderly aged 75 and above was introduced in 1983. The co-payment rate was further reduced to 10% except those with an income higher than a threshold. Although most documents describing the health insurance in Japan are in Japanese, Matsuda (2013) provide useful information about the system in English.

[26] Dependent children and spouses are covered by household heads' health insurance.

B Welfare Measure

Given the utility function, CEV for a representative agent can be expressed as follows:[27]

$$\text{CEV} = (V_{\text{new}}/V_{\text{original}})^{1/[\sigma(1-\gamma)]} - 1,$$

where V_{new} is the welfare in the economy under a new policy and V_{original} is the welfare in the original economy.

We adopt a welfare measure for comparison – CEV for new-born agents (i.e., based on the ex ante expected lifetime utility), which is defined as follows:

$$\text{CEV} = \left(\frac{\int V_{\text{new}}(j=20,h,a=0,z) d\Phi_{\text{new}}(j=20,h,a=0,z)}{\int V_{\text{original}}(j=20,h,a=0,z) d\Phi_{\text{original}}(j=20,h,a=0,z)} \right)^{\frac{1}{\sigma(1-\gamma)}} - 1.$$

where Φ_{new} is the stationary distribution of the population over the state variables under a new policy and Φ_{original} is the distribution under the original policy.

C Decomposition of the Welfare

To understand the large CEV values, we decompose the welfare changes by the following manner. Generate consumption and hours profiles for 50,000 households by simulation: $\{\{c_{i,j}\}_{j=20}^{100}, \{n_{i,j}\}_{j=20}^{64}\}_{i=1}^{50000}$. First, we compute the benchmark profiles using equilibrium prices and policy functions; denote them as $\{\mathbf{c}, \mathbf{n}\}$. Second, we compute consumption and hours profiles of the households with a policy change: $\{\mathbf{c}^*, \mathbf{n}^*\}$.

Using the simulated profiles, we can compute the expected life time value $W(\{\mathbf{c}, \mathbf{n}\})$ and $W(\{\mathbf{c}^*, \mathbf{n}^*\})$. By definition, these simulated CEV values must be equal to those calculated from value functions, $V(j = 20, h, a = 0, z)$, although there exist some differences due to simulation errors.

Level Effect: Compute the *average* consumption and hours profiles: $\{\bar{c}_j, \bar{n}_j\}$ and $\{\bar{c}_j^*, \bar{n}_j^*\}$. The two average profiles $\{\bar{c}_j, \bar{n}_j\}$ and $\{\bar{c}_j^*, \bar{n}_j^*\}$ differ from two points of view; (i) the average level and (ii) its shape. We first adjust the average level of two profiles by the following steps:

1. Compute the ratio of aggregate consumption and hours level: $1 + \alpha_c = C^*/C$ and $1 + \alpha_n = N^*/N$, where capital letters are aggregate consumption and aggregate labor.

[27] See Conesa et al. (2009).

2. Compute the adjusted value, $W\left(\left\{\frac{\bar{c}^*}{(1+\alpha_c)}, \frac{\bar{n}^*}{(1+\alpha_n)}\right\}\right)$.

3. The ratio between original value and the adjusted value is the level effect. It represents shift-up effect of aggregate variables that affect utility due to some policy change. and the CEV is defined as follows:

$$\text{CEV}_{\text{Level}} = \left(\frac{W(\{\bar{c}^*, \bar{n}^*\})}{W(\{\bar{c}^*/(1+\alpha_c), \bar{n}^*/(1+\alpha_n)\})}\right)^{\frac{1}{\sigma(1-\gamma)}} - 1.$$

There remains a difference: its shape. Some policy change affects the allocation of consumption and leisure over the life cycle through risk sharing opportunities and liquidity constraints. After adjusting for the effect, we compute the welfare change as follows:

$$\text{CEV}_{\text{Dist}} = \left(\frac{W(\{\bar{c}^*/(1+\alpha_c), \bar{n}^*/(1+\alpha_n)\})}{W(\{\bar{c}, \bar{n}\})}\right)^{\frac{1}{\sigma(1-\gamma)}} - 1.$$

In this form, we compare the average profile of the benchmark case to the level-adjusted profile with policy changes. The shape difference is mainly due to the effect of the liquidity constraint.

Note that all decompositions are divided into two sub-categories: "Only c" and "Only n". This means that either hours worked or consumption is fixed at the benchmark case, and do the same procedures explained above.

Tables and Figures

Table 1: Medical cost over age groups (2012)

Age group	Per person medical cost (1,000 yen)	Percentage of total average (%)
Total	307.5	–
Under 65	177.1	57.59
0-14	149.9	48.75
14-44	113.0	36.75
45-64	276.9	90.05
Over 65	717.2	233.24
Over 70	804.6	261.66
Over 75	892.1	290.11

Source: Estimates of National Medical Expenditure, Japan

Table 2: Transition of medical expenditure status

age: 18–35		high	middle	low
	high	0.7784	0.2040	0.0176
	middle	0.3087	0.6356	0.0557
	low	0.1137	0.3284	0.5579
age: 36–45		high	middle	low
	high	0.7566	0.2232	0.0202
	middle	0.2817	0.6523	0.0660
	low	0.0603	0.3452	0.5945
age: 46–55		high	middle	low
	high	0.7332	0.2390	0.0278
	middle	0.2130	0.6888	0.0982
	low	0.0399	0.2443	0.7158
age: 56–		high	middle	low
	high	0.6907	0.2849	0.0244
	middle	0.1818	0.6850	0.1332
	low	0.0131	0.1531	0.8338

Note: Calculation based on Kan and Suzuki (2005).

Table 3: Parameters of the model

Parameters		Value
Discount factor	β	0.99
Intertemporal elasticity of substitution	γ	3.0
Share of labor supply	σ	0.37
Capital share	α	0.377
Depreciation rate	δ	0.08
Persistence of labor productivity shock	λ	0.98
Std. dev. of labor productivity shock	σ_ε	0.09
Government share of UHI	ψ	0.386
Price of medical expenditure	q	$\{1, 1.2616\}$

Table 4: Age-efficiency profile

Age	η_j	Age	η_j
20–24	0.545	45–49	1.243
25–29	0.718	50–54	1.271
30–34	0.884	55–59	1.130
35–39	1.030	60–64	0.770
40–44	1.149	Over 65	0.654

Table 5: Effects of population aging/medical cost inflation on UHI

		C tax 10%		C tax 5%	
	Bench	Aging	Aging & Price	Aging	Aging & Price
Demographic	2013	2050	2050	2050	2050
Medical price	$q = 1$	$q = 1$	$q = 1.2616$	$q = 1$	$q = 1.2616$
Change in K	–	17.32%	12.81%	10.82%	6.43%
Change in L	–	-16.17%	-16.14%	-16.75%	-16.77%
-Change in workers	–	-22.65%	-22.65%	-22.65%	-22.65%
-Change in hours	–	3.47%	3.59%	2.73%	2.85%
Frisch elasticity	1.08	1.03	1.03	1.02	1.02
K/Y	2.47	3.04	2.97	2.95	2.87
X/Y	8.6%	10.04%	12.85%	10.30%	13.19%
G/Y	13.16%	13.16%	13.16%	13.16%	13.16%
Tax burden					
Consumption tax	5.0%	10.0%	10.0%	5.0%	5.0%
Capital tax	39.8%	39.8%	39.8%	39.8%	39.8%
Payroll tax (A)	8.79%	8.09%	9.48%	12.35%	13.58%
Premium tax (B)	6.35%	7.74%	9.90%	7.94%	10.17%
(A)+(B)	15.14%	15.83%	19.39%	20.29%	23.75%
Social security tax (C)	17.12%	18.30%	18.30%	18.30%	18.30%
Total labor burden (A)+(B)+(C)	32.26%	34.13%	37.69%	38.59%	42.05%
Increased labor tax burden	–	1.87%	5.43%	6.33%	9.79%

Note: K/Y – capital output ratio; X/Y – medical cost output ratio;
G/Y – government expenditure-output ratio.

Table 6: Alternative UHI policies – steady state comparison

	Baseline	UHI policy reform Co-payment rate			
	$q = 1.2616$	30%(70-74)	20%(75+)	All 30%	All 35%
Change in K	–	0.59%	3.05%	7.30%	10.47%
Change in L	–	0.13%	0.30%	0.71%	1.44%
K/Y	2.97	2.98	3.02	3.09	3.13
X/Y	12.8%	12.8%	12.7%	12.5%	12.3%
Tax burden					
Consumption tax	10.0%	10.0%	10.0%	10.0%	10.0%
Capital tax	39.8%	39.8%	39.8%	39.8%	39.8%
Payroll tax (A)	9.5%	9.4%	9.4%	9.3%	9.1%
Premium tax (B)	9.9%	9.8%	9.3%	8.6%	7.9%
Social security tax (C)	18.3%	18.3%	18.3%	18.3%	18.3%
Total labor burden (A)+(B)+(C)	37.7%	37.5%	37.0%	36.2%	35.2%
Welfare comparison					
CEV	–	0.31%	1.81%	4.07%	5.35%

Note: Demographic structure in 2050 is used.

Table 7: Alternative financing policies – steady state comparison

	Baseline	Financing policy reform Consumption tax rate τ_c		
	$\tau_c = 10\%$	5%	15%	20%
Change in K	0.0%	-5.66%	5.57%	11.21%
Change in L	0.0%	-0.75%	0.63%	1.23%
K/Y	2.97	2.87	3.06	3.15
X/Y	12.8%	13.2%	12.5%	12.2%
Tax burden				
Consumption tax	10.0%	5.0%	15.0%	20.0%
Capital tax	39.8%	39.8%	39.8%	39.8%
Payroll tax (A)	9.5%	13.6%	5.4%	1.4%
Premium tax (B)	9.9%	10.2%	9.7%	9.4%
Social security tax (C)	18.3%	18.3%	18.3%	18.3%
Total labor burden (A)+(B)+(C)	37.7%	42.1%	33.4%	29.2%
Welfare comparison				
CEV	0.0%	-3.50%	3.18%	6.06%

Note: Demographic structure in 2050 is used.

Table 8: Decomposition of welfare change

	UHI policy reform Co-payment rate				Financing policy τ_c	
	30%(70-74)	20%(75+)	All 30%	All 35%	15%	20%
CEV	0.31%	1.81%	4.07%	5.35%	3.18%	6.06%
Level change	0.19%	0.98%	2.42%	3.42%	1.67%	3.18%
Only c	0.28%	1.10%	2.72%	4.28%	2.05%	3.98%
Only n	-0.10%	-0.12%	-0.30%	-0.84%	-0.38%	-0.73%
Distribution change	0.14%	0.87%	1.76%	2.20%	1.49%	2.81%
Only c	0.11%	0.69%	1.35%	1.68%	1.22%	2.30%
Only n	0.04%	0.18%	0.42%	0.53%	0.27%	0.51%

Table 9: Robustness check – Consumption floor

		Consumption floor	
	Benchmark	$\underline{c}$=20%	$\underline{c}$=30%
K/Y	2.47	2.47	2.47
X/Y	8.60%	8.60%	8.60%
G/Y	13.16%	13.16%	13.16%
Tax burden			
Consumption tax	5.00%	5.00%	5.00%
Capital tax	39.80%	39.80%	39.80%
Payroll tax (A)	8.8026%	8.8026%	8.8043%
Premium tax (B)	6.3564%	6.3564%	6.3565%
(A) + (B)	15.1590%	15.1591%	15.1608%
Social security tax (C)	17.12%	17.12%	17.12%
Total labor burden (A) + (B) + (C)	32.2790%	32.2791%	32.2808%
Increased labor tax burden	–	0.0001%	0.0018%
Covered by social Insurance (% of Pop.)	0.00%	1.03%	4.80%

Table 10: Robustness check – UHI premium tax for retirees

UHI for retirees	Original – no UHI tax		(1) Same UHI premium tax		(2) Lower UHI premium tax	
	Bench $q = 1.0$	Aging & $q = 1.26$	Bench $q = 1.0$	Aging & $q = 1.26$	Bench $q = 1.0$	Aging & $q = 1.26$
Change in K	–	12.8%	–	14.8%	–	13.9%
Change in L	–	-16.1%	–	-16.0%	–	-16.0%
K/Y	2.47	2.97	2.50	3.04	2.48	3.00
X/Y	8.6%	12.8%	8.6%	12.8%	8.6%	12.8%
G/Y	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%
Tax burden						
Cons. tax	5.0%	10.0%	5.0%	10.0%	5.0%	10.0%
Capital tax	39.8%	39.8%	39.8%	39.8%	39.8%	39.8%
Payroll tax (A)	8.8%	9.5%	9.0%	9.8%	8.9%	9.7%
Premium tax (B)	6.4%	9.9%	5.4%	8.3%	5.9%	9.0%
(A) + (B)	15.1%	19.4%	14.4%	18.1%	14.8%	18.7%
S.S. tax (C)	17.1%	18.3%	17.1%	18.3%	17.1%	18.3%
Total labor burden (A) + (B) + (C)	32.3%	37.7%	31.6%	36.4%	31.9%	37.0%
Increased labor tax burden	–	5.4%	–	4.9%	–	5.1%

Table 11: Nonlinear tax system – Alternative UHI policies

	Baseline	UHI policy reform Co-payment rate		
	($q = 1.2616$)	30%(70-74)	20%(75+)	All 30%
Change in K	–	0.61%	3.21%	7.56%
Change in L	–	0.15%	0.41%	0.90%
K/Y	2.96	2.97	3.01	3.08
X/Y	12.9%	12.9%	12.7%	12.5%
Tax burden				
Consumption tax	10.0%	10.0%	10.0%	10.0%
Capital tax	39.8%	39.8%	39.8%	39.8%
Premium tax (B)	10.0%	9.8%	9.4%	8.6%
Social security tax (C)	18.3%	18.3%	18.3%	18.3%
Welfare comparison				
CEV	–	0.34%	1.83%	4.14%

Note: Demographic structure in 2050 is used.

Table 12: Nonlinear tax system – Alternative financing policies

	Baseline	Financing policy reform Consumption tax rate	
	($q = 1.2616$)	15%	20%
Change in K	0.00%	5.66%	11.40%
Change in L	0.00%	0.82%	1.58%
K/Y	2.96	3.05	3.14
X/Y	12.9%	12.6%	12.3%
Tax burden			
Consumption tax	10.0%	15.0%	20.0%
Capital tax	39.8%	39.8%	39.8%
Premium tax (B)	10.0%	9.7%	9.5%
Social security tax (C)	18.3%	18.3%	18.3%
Welfare comparison			
CEV	–	3.19%	6.17%

Note: Demographic structure in 2050 is used.

Table 13: Robustness check – Assumption of perfect annuity

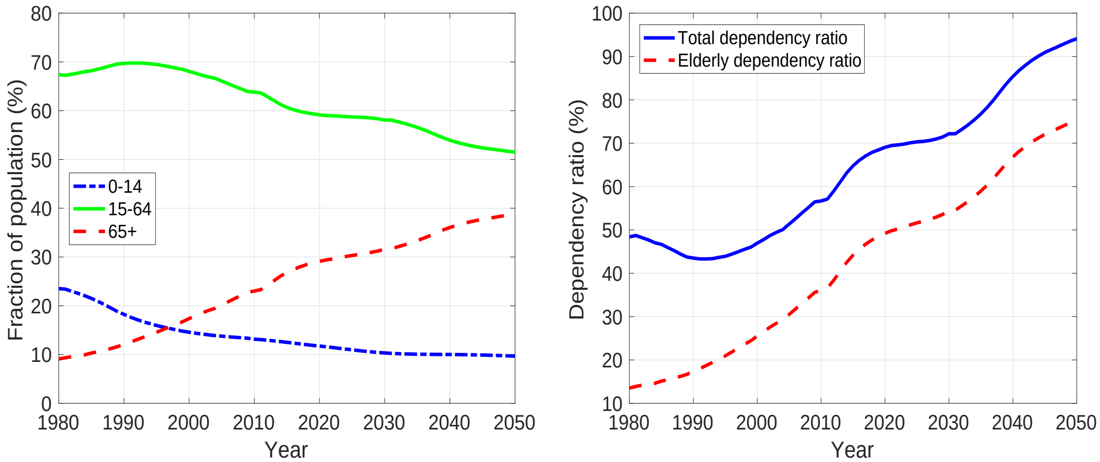
	Baseline	UHI co-payment reform			Cons. tax reform	
	$q = 1.2616$	30%(70-74)	20%(75+)	All 30%	$\tau_c = 15\%$	$\tau_c = 20\%$
K/Y	3.14	3.15	3.19	3.25	3.25	3.35
Cons. tax	10.0%	10.0%	10.0%	10.0%	15.0%	20.0%
Capital tax	39.8%	39.8%	39.8%	39.8%	39.8%	39.8%
Total labor tax burden	38.8%	38.6%	38.1%	37.3%	34.7%	30.6%
CEV	–	0.35%	1.51%	3.33%	3.49%	6.70%

Table 14: Effects of population aging – endogenous medical expenditures

		Exogenous m		Endogenous m	
	Bench	Aging	Aging & Price	Aging	Aging & Price
Demographic	2013	2050	2050	2050	2050
Medical price	$q = 1$	$q = 1$	$q = 1.26$	$q = 1$	$q = 1.26$
Consumption tax	5.0%	5.0%	5.0%	5.0%	5.0%
Capital tax	39.8%	39.8%	39.8%	39.8%	39.8%
Payroll and premium tax	15.14%	20.29%	23.75%	19.77%	18.47%
Social security tax (C)	17.12%	18.30%	18.30%	18.30%	18.30%
Total labor burden (A)+(B)+(C)	32.26%	**38.59%**	**42.05%**	**38.07%**	**36.77%**
Increased labor tax burden	–	6.33%	9.79%	5.81%	4.51%

Table 15: Compensations and affordable debt (in terms of 2013 GDP)

	Policy 1	Policy 2	Policy 3	Policy 4
Full Compensation T_c	23.94%	19.03%	17.09%	8.80%
Maximum Debt T_f ($\tilde{r} = 1\%$)	22.36%	20.71%	16.46%	11.04%



(a) Japan's population structure 1980 – 2050 (b) Japan's dependency ratios 1980 – 2050

Figure 1: Demography in Japan

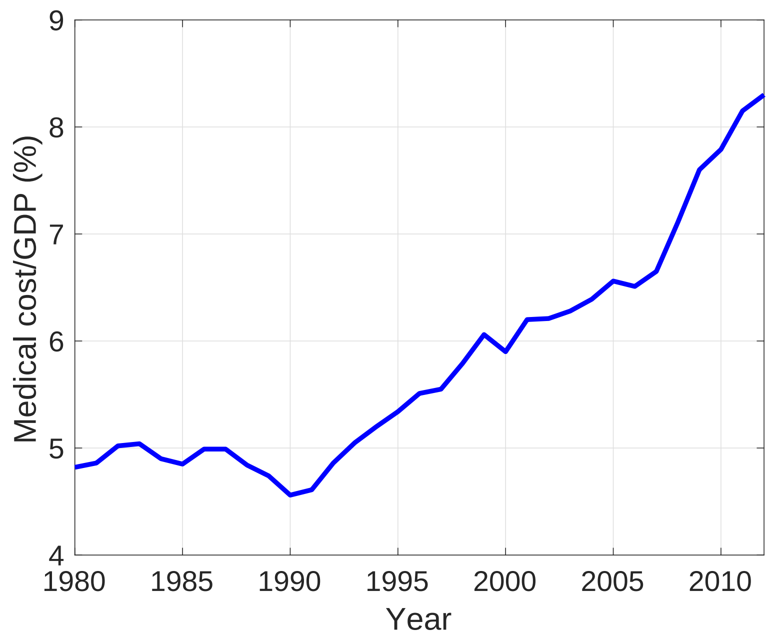
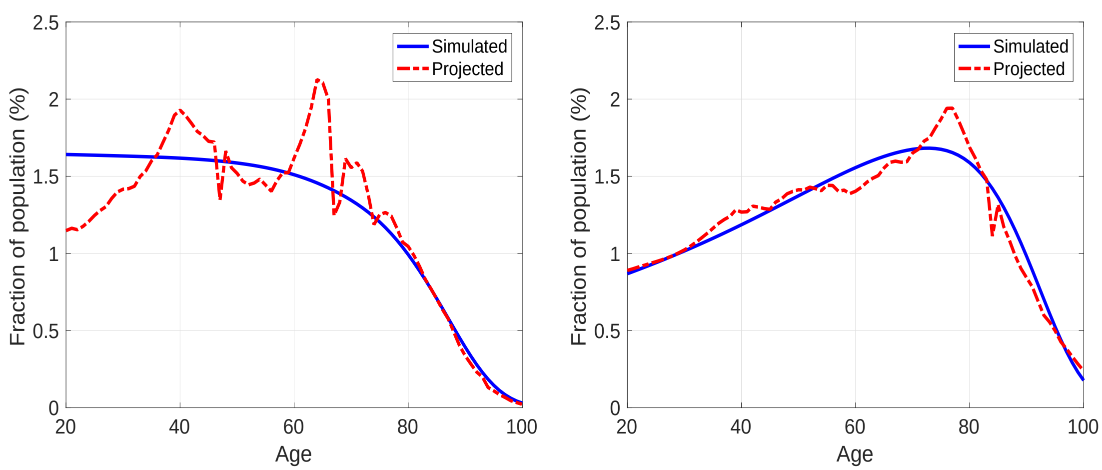


Figure 2: Trend of Japan's medical care cost 1980 – 2012



(a) Population distribution in 2013 (b) Population distribution in 2050

Figure 3: Actual and simulated population distribution

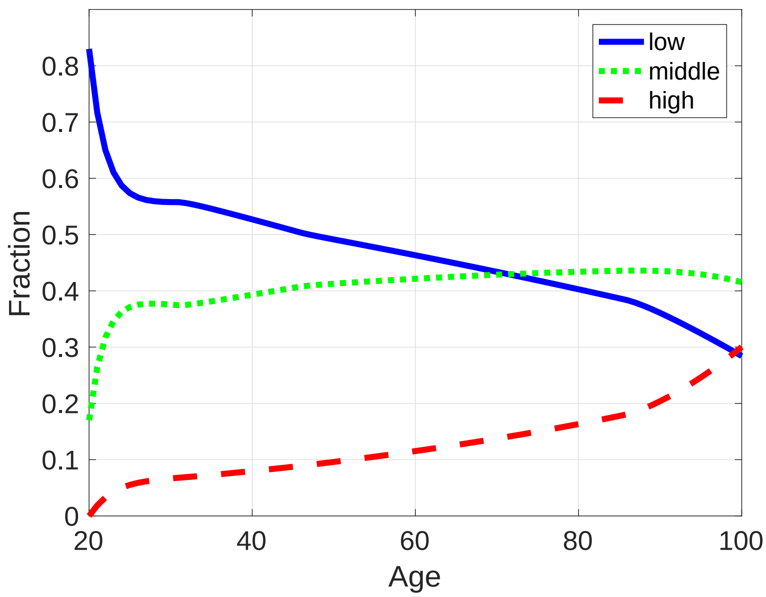
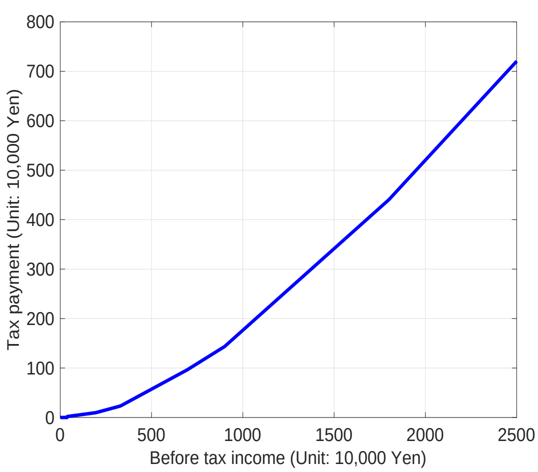
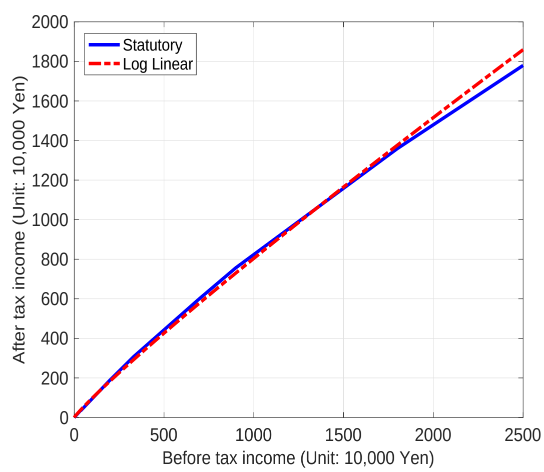


Figure 4: Distribution of the medical expenditure states over life-cycle



(a) Statutory tax schedule



(b) Disposable income

Figure 5: Log-linear approximation of the tax system in Japan

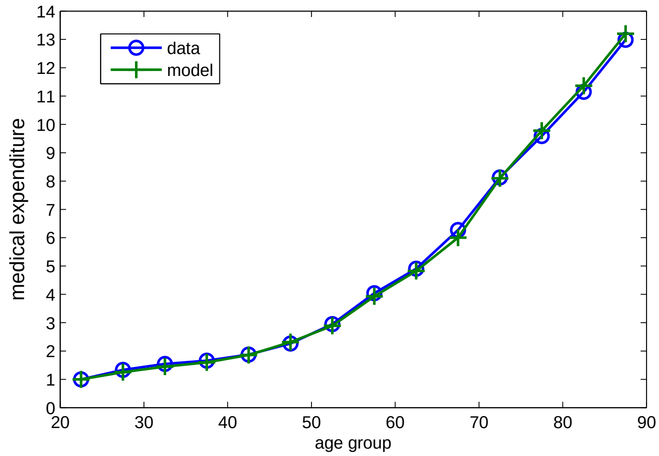
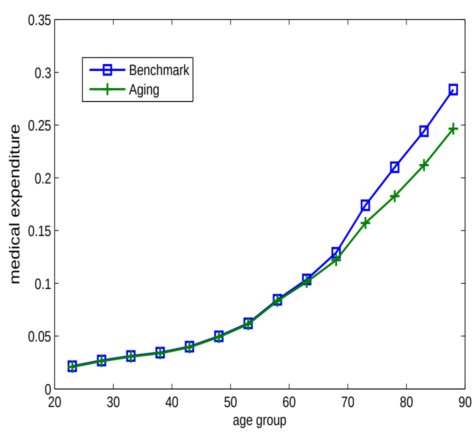
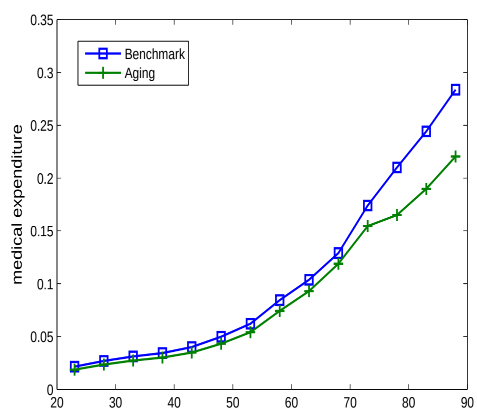


Figure 6: Life-cycle profile of medical expenditures (age 21-25=1)

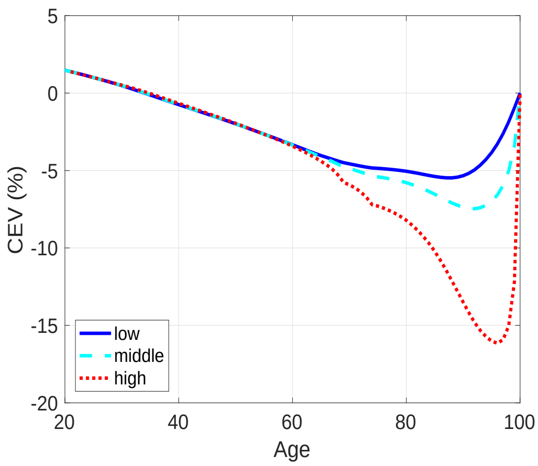


(a) Impact of aging ($q = 1$)

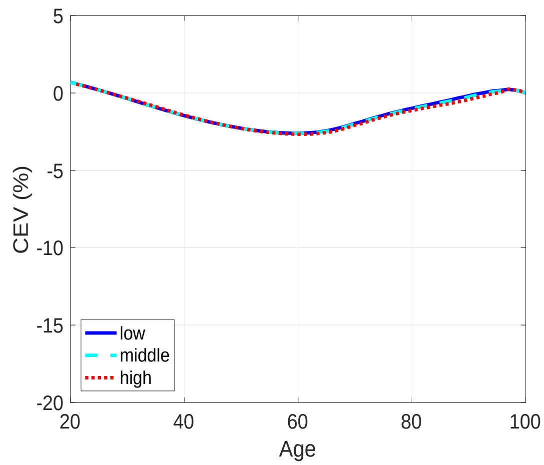


(b) Impact of aging ($q = 1.26$)

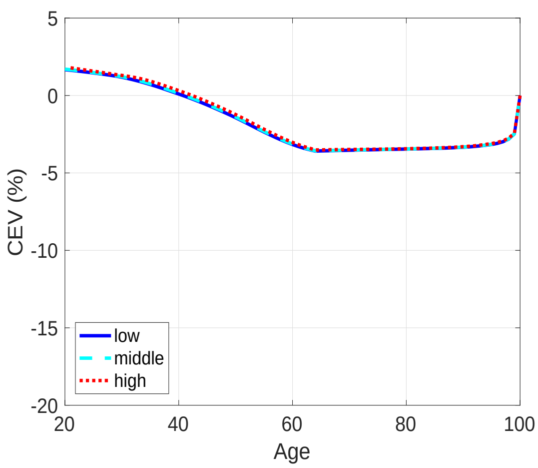
Figure 7: Aging and medical expenditures over life-cycle



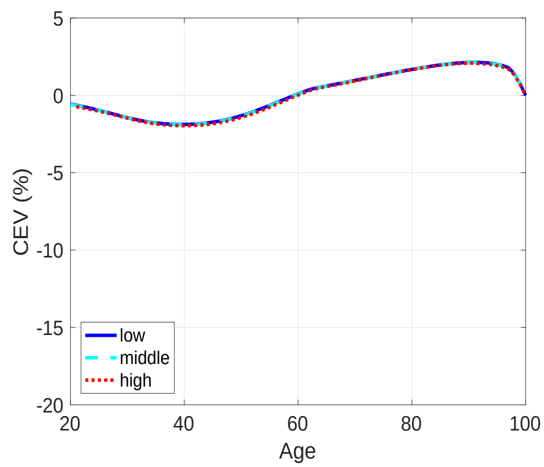
(a) Policy 1



(b) Policy 2



(c) Policy 3



(d) Policy 4

Figure 8: CEV by age and medical expenditure status

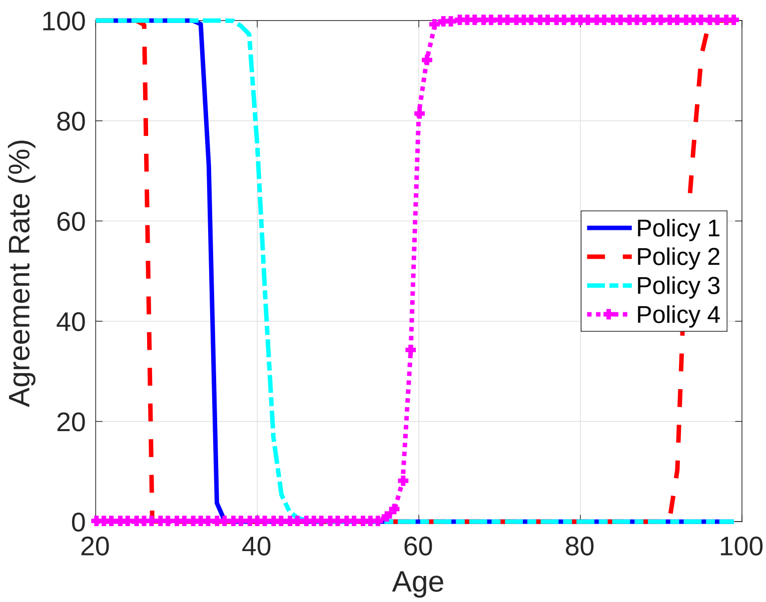


Figure 9: Agreement rates of the reform policies