Financing Health Care in Japan:  
A Rapidly Aging Population and the Dilemma of Reforms*

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Abstract

This paper aims to provide a quantitative analysis of the influence of an aging population on the financing of Japan’s universal health insurance system and potential reform policies. We construct a general equilibrium life-cycle model to study the effects of aging on the tax burden, individual behaviors, the aggregate economy, and welfare. We also evaluate various policy alternatives designed to lessen the negative influence of aging on the economy. In particular, by investigating both steady states and transition paths, we analyze reforms of insurance benefits and tax financing tools that have welfare implications for future and current generations. 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.

Keywords: Universal Health Insurance, Population Aging, Japan  
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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 its population has been aging dramatically over the past two decades. We study the tax burden that is associated with financing the UHI and its effect on the economy as the population ages. Potential reforms of the UHI and its financing mechanisms will also be evaluated.

The current cost of health care in Japan is relatively low (approximately 7.8% of GDP in 2010) compared with other OECD countries. In addition, the Japanese have among the highest life expectancies 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 1).

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, 38.1% of the program’s costs are financed by general government revenues, and 48.5% are paid by a premium (a payroll tax) that is levied on employers and workers. Out-of-pocket co-payments contribute only approximately 12.7% of total medical costs (2010). 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 51% of the total population in 2050 with the old-age dependency ratio rising above 75% (see Figure 2). \(^1\)

Second, the elderly confront greater health risks and require much more care than young people. The data show that the average per-person medical cost for individuals aged 65 and above is approximately four times that of those under age 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 3 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

\(^{1}\)Projections are based on the estimates by the National Institute of Population and Social Security Research.
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 better understand the following: 1) the effects of demographic changes (particularly population aging) on the costs of financing the UHI 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 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.

The current UHI system, which provides benefits to the elderly and which taxes the working age population to finance the costs of these benefits, involves redistribution from young to old. The rapid aging of the population is likely to result in a much higher labor tax burden, given the current UHI and tax system. Disadvantages of the high labor income burden arise from two sources: 1) incentives to work are undermined, and 2) 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 much asset accumulation. Potential reforms that can mitigate these disadvantages should be designed to ensure that the extent of redistribution between generations is reduced.

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 replace some labor taxes. The former type of reform has happened once in 2003 that increased the co-payment rate for the working-age from 20% to the current 30%. The later type of reform has been decided by the Japanese government to increase the consumption tax gradually to 10% from the current 5% by 2015, although it is still controversial and has not been implemented yet.

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 will also be 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 9% 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 40% from the current 29%.\(^2\) If medical costs grow more rapidly than productivity by 0.6% per year, as observed in the US, then an additional 14% labor tax will be needed to finance the UHI, given the projected aging of the population (with the total labor tax increasing to 45%).

By comparing stationary equilibria under alternative policies and the same age structure of the population, we also find that both types of reform (the UHI co-payment and consumption tax reforms) 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) better allocations of consumption over the life cycle and other state variables and 2) increases in average consumption.

However, by conducting a transition analysis, we find that most current residents (except for the young) will suffer if the reforms are implemented. Moreover, older people (who are close to the 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 and/or 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 are 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.

The method of our transition analysis is similar to that of Nishiyama and Smetters (2005, 2007), who explicitly consider transition paths of both fiscal and social security reforms. Fuster, İmrohoroğlu and İmrohoroğlu (2007) study the welfare effects of an elimination of social security in a dynastic framework and provide a steady-state comparison and analysis of welfare along transition paths.

\(^2\)We assume that the government will follow its current plan to increase the social security tax by 2%.
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, Skinner, and Zeldes (1995) consider medical expenditure shocks and investigate the role of a means-tested social insurance system on savings. French (2005), De Nardi, French, and Jones (2010) and French and Jones (2010) estimate life-cycle models to study the effects of the uncertainty of medical expenditures on retirement decisions and retirement savings. 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 by considering 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. 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 Porporakkarm (2012) study the potential effects of the 2010 Affordable Care Act in the US. In addition, Hansen, Hsu, and Lee (2012) also study the health insurance reform in the US, focusing on Medicare buy-in as an alternative. Similar to the current study, Attanasio, Kitao, and Violante (2011) that investigates 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 of that system. Because of immigration, population aging in the US is slower than 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. In addition to evaluating the welfare effects of potential reforms on future generations (i.e., in a steady state), as in Attanasio et al. (2011), we also discuss the welfare implications of potential reforms for current residents, whose support is politically crucial to a reform policy, by analyzing corresponding welfare changes along the transition path.

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

See, for example, Attanasio, Kitao, and Violante (2007), Huggett and Parra (2009), and İmrohoroğlu and Kitao (2010).
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 \( \rho_j \), as determined by her/his age \( j \). 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 a rate of \( g \). The population of age \( j \) is denoted by \( \mu_j \), which evolves according to \( \mu_{j+1} = \frac{\rho_j}{1+g} \mu_j \). The total population is normalized to one, i.e., \( \sum_{j=1}^{J} \mu_j = 1 \).

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 \( w_\eta_j z_n \), where \( w \) is the market wage, \( \eta_j \) 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. \( \eta_j \) is zero when an individual reaches the retirement age, \( \eta^{ss} \).

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:

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

where \( \gamma \) governs the intertemporal elasticity of substitution and \( \sigma \) governs the working hours supplied to the market.

2.3 Health, Medical Expenditure, and National Health Care

2.3.1 Heath Status and Medical Expenditure Uncertainty

Agents confront exogenous uncertainty regarding their health status \( h \). The health status of an individual evolves according to a Markov chain of three states \( \{h_g, h_f, h_b\} \) that represent good, fair, and bad health states, respectively.
The transition probability $\pi_j(h', h)$ is age dependent. We assume that idiosyncratic medical expenditures $x_j(h)$ are a function of health status.

2.3.2 Universal Health Insurance

Public UHI is available to every resident and covers a fraction $\omega_j$ of realized medical expenditures $x$. UHI is financed by an income-dependent premium (a payroll tax) and general government revenue. The coverage rate of medical expenditures $\omega_j$ depends on age $j$. According to the current UHI system in Japan, the co-payment rate, $1 - \omega_j$, is 30% for those under age 70 (i.e., a 70% coverage rate), 20% for those between 70 and 74, and 10% for those aged 75 and above.\(^4\)

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:

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

where $K$ and $L$ are the aggregate capital and effective labor employed in the firm sector. $A$ is total factor productivity, which is normalized to one in the benchmark case. Capital depreciates at a rate of $\delta$ during every period, and $\theta$ 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 borrowing constraint $a \geq 0$. This 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.

\(^4\)Appendix A provides a description of Japan’s health insurance system.
2.6 Government

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

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 $\tau_{ss}$ 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, $\phi wL$, where the replacement rate $\phi$ 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 $c$ by supplementing income in cases in which a household’s disposable income plus assets (net of medical expenditures) falls below $c$. 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 $\tau_l$, a capital income tax $\tau_k$, a consumption tax $\tau_c$, a social security tax (pension payment) $\tau_{ss}$, and the UHI premium $p^{med}$. The government uses its revenue to finance all public programs and its own consumption, $G$.

The government finances a fraction $\psi$ of UHI costs with general revenue. Individuals pay the remaining fraction, $1 - \psi$, through the mandatory UHI premium payment. Currently, $\psi$ is equal to 0.25 in Japan. The government budget constraint is as follows:

$$\int \left[ \tau_l w j n + \tau_k r (a + b) + \tau_c c \right] d\Phi(s) = \psi \int (\omega_j q x) d\Phi(s) + \int T d\Phi(s) + G \quad (1)$$

$$\int \left( p^{med} w \eta_j z n \right) d\Phi(s) = (1 - \psi) \int (\omega_j q x) d\Phi(s) \quad (2)$$

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

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

$$\int (\tau_{ss} w j n z n) d\Phi(s) = \int T_{ss} d\Phi(s), \quad (3)$$

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 \( s = (j, h, a, z) \), where \( j \) is age, \( h \) is health 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:

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

subject to

\[
(1 + \tau_c)c + a' = W + T,
\]

\[
W \equiv y(n, j, z) + (1 + (1 - \tau_k)r)(a + b) - (1 - \omega_j)qx,
\]

\[
y(n, j, z) = (1 - \tau_l - \tau_{ss} - p_{med})\eta_j zn + T_{ss},
\]

\[
T = \max\{0, (1 + \tau_c)c - W\},
\]

\[
T_{ss} = \begin{cases} 
    ss & \text{if } j \geq j^{ss}, \\
    0 & \text{otherwise},
\end{cases}
\]

\[
c > 0, \ n \geq 0, \ a' \geq 0;
\]

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:

\[
b' = \int (1 - \rho_j)a'd\Phi(s).
\]

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 \( (\tau_{ss}, \tau_l, \tau_k \text{ and } \tau_c) \), social security benefits \( ss \), the UHI system (coverage \( \omega_j \), premium \( p_{med} \) and subsidy ratio \( \psi \)), and social insurance \( c \); 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 the government policies, the decision rules \( (a', n, c) \) solve the household’s problem
c) government policies (τ_{ss}, τ_k, τ_c, ss, ω_j, ψ_j, \psi, \xi, \varphi, G) satisfy the government’s budget constraints, equations (1), (2) and (3)\textsuperscript{5}

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. Table 4 summarizes certain key parameters.

3.1 Preferences and Production Function

We set the subjective discount factor \( \beta \) equal to 0.98, such that the capital-output ratio \( K/Y \) in the model matches the data for Japan; the capital-output ratio in the model is approximately 2.5, which is close to the value estimated by İmrohoroğlu and Sudo (2010). The elasticity of intertemporal substitution \( 1/\gamma \) is assumed to be 0.5; i.e., \( \gamma \) is set at 2, and the labor supply parameter \( \sigma \) is set at 0.33. Both values are widely used in the macroeconomic literature.

The parameters of the production function, the capital share \( \theta \), and the depreciation rate \( \delta \) 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.

3.2 Demographics and Survival Probability

A household enters the economy at age 20, retires at age 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 2006, which provides forecasts of demographic changes from 2005 to 2055. The projection consists of three variations on fertility rates-high, medium, and low-and three variations on mortality rates. We

\textsuperscript{5}In the benchmark model, we fix a set of policy variables (τ_{ss}, τ_k, τ_c, ω_j, ψ_j, \psi, \xi, \varphi, G), and τ_l, ss, and \( p^{med} \) are determined endogenously to satisfy the equilibrium conditions.
use the medium variants for both fertility and mortality rates. For a stationary state comparison, the survival probabilities \( \{ \rho_j \} \) are obtained from the life table for males in 2010 (initial stationary state) and 2050 (final stationary state). The population growth rate \( g \) is set at zero in the initial stationary state and at \(-1.5\%\) in the final stationary state. Figure 4 plots the actual and simulated population distributions in 2010 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 (26.43%) is quite close to the actual data (26.75%) for 2010. Under the assumption of a negative population growth rate, the fraction of retired households in the model (45.0%) is also close to the data (44.12%) for 2050.

3.3 Health and 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 data from 111 Japanese health insurance societies (insurers) between 1996 and 1998. The data are panel data and include observations on 35,970 individuals between the ages of 0 and 70.

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). Within each age group, they divide the samples into 10 medical expenditure quantiles and report the corresponding transitions from 1996 to 1998.

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: “good” (low expenditures), “fair” (medium expenditures), and “bad” (high expenditures). The “good” category includes those in the bottom 50% of medical expenditures, the “fair” category includes those in the sixth to ninth quantiles, and the “bad” category includes 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.

6To 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.
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 probabilities of transitioning to a “good” health status are monotonically decreasing in age. By contrast, the probabilities of transitioning to a “bad” health status generally show the opposite pattern across age groups. We linearly interpolate the transition probabilities, such that that transition matrices change smoothly over the life cycle.

The transition probabilities of remaining in the same state over the life cycle are shown in Figure 5. The probability of maintaining “good” health status (line “g-g”) is monotonically decreasing with age, whereas the probability of remaining in a “bad” health status (line “b-b”) is monotonically increasing after age 26. In Figure 6, we display the unconditional probabilities of being in the three health (expenditure) states over the life cycle implied by the transition matrices.

3.3.2 Medical Expenditures

There is a gap in medical expenditures between the aggregate data and the micro data from Kan and Suzuki (2005). To ensure that the medical costs in the model match the aggregate medical costs, we first compute the expenditure shares of the three categories, good (bottom 50% individuals), fair (next 40%), and bad (top 10%), in each age group from the micro data. Based on the report of Kan and Suzuki (2005), we find that 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. To compute the medical expenditures of the three health categories for each age group, we use the medical expenditure shares and aggregate data from the “Estimates of National Medical Care Expenditures (2007),” published by the Ministry of Health, Labor, and Welfare of Japan, which provides data on average medical expenditures by age. The estimated results are presented in Table 3.

We also linearly interpolate medical expenditures over age, such that medical expenditures change smoothly over the life cycle. Figure 7 shows the estimated medical expenditures of the three health states from age 20 through 100. The aggregate medical expenditure-output ratio $X/Y$ in our benchmark model is 7.1, which matches the data for 2008.
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 is employed as estimated in Abe and Yamada (2009), who 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 $\{\lambda, \sigma^2\}$ are chosen such that Japanese income inequality can be replicated in our model. We then approximate the AR(1) process by 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 5.\(^7\)

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 0.6% per year above TFP growth.\(^8\) We use a parameter $q$ to capture health care inflation and normalize it to one in the benchmark year (2010). The price of medical care is thus expected to increase by approximately 27% relative to consumption goods in the next 40 years (i.e., $q_{2050} = 1.27$).

\(^7\)For details, see also Braun et al. (2007).

\(^8\)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 0.6% 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 (Imrohoroğlu and Sudo, 2010). Therefore, the estimated health care inflation rate in the US may not differ significantly from that in Japan.
3.5.2 Health Care System

All residents are covered by UHI. The co-insurance rate $\omega_j$ (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. Because medical expenditures increase with age, the average out-of-pocket ratio is approximately 15%. The current UHI premium cannot fully sustain the UHI system, and we observe that 25% of the total UHI cost is financed by general government revenue (i.e., $\psi = 25\%$).

3.5.3 Social Security

The payroll tax rate for the social security system in 2010 was 16.054%. Thus, we set the payroll tax rate $\tau_{ss}$ in the initial steady state at 16.054%. As a part of 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 $\phi$ is endogenously determined in the model according to the social security tax.\(^9\)

3.5.4 Social Insurance

The social insurance system (safety net) is represented by a consumption floor $\zeta$, 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

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. Note that the labor tax rate $\tau_l$ balances the government’s budget constraint in equation (1). Currently, the consumption tax rate $\tau_c$ in Japan is set at 5%.\(^10\) In our model, capital tax $\tau_k$ is set at 39.8%, following İmrohoroglu and Sudo (2010).

\(^9\)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.

\(^10\)Although the consumption tax is scheduled to rise to 8% in 2014 and to 10% in 2015, we maintain the tax at 5% of consumption in the policy experiment below.
We set government expenditures $G$ according to the ratio of government expenditures to output $G/Y$ in the data. Japanese government expenditures in 2008 were 84.7 trillion yen, including expenditures of 23.6 trillion yen for social security and medical care. Thus, government expenditures without social security/health insurance related expenditures are 62.1 trillion yen. As nominal GDP in Japan was 492 trillion yen in 2008, $G/Y$ was 12.43%. We use the average value of $G/Y$ during the period from 2000 to 2008, 12.5%, in our analysis.

4 Analysis

4.1 Effects of Population Aging and Increased Medical Cost

We first compare the tax burden in a steady-state economy, given the 2010 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 2010-2050 period.\textsuperscript{11} We assume that the 2010 economy is in the initial steady state. The benchmark model economy is calibrated to match the tax burden, the cost of medical care, the capital-output ratio, the population structure, and some aggregate variables of the Japanese economy in 2010 (the first column of Table 6). The social security tax is assumed to increase to 18.3% (from 16.05%) following the government’s plan, and social security is self-financing. The ratio of government expenditure to GDP ($G/Y$) is assumed to be fixed at 12.5%, as in 2010, in future steady states; thus, we can isolate the additional burden of financing the UHI. We also assume that the government’s subsidy to UHI is fixed at 25% of total UHI costs ($\psi = 0.25$). 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 (i.e., the rate of increase of medical prices is equal to aggregate economic growth along the balanced growth path). 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. 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.

\textsuperscript{11}For details on the numerical procedures, see Appendix B.
structure and the above assumptions. The simulation results are presented in the third column of Table 6. The numerical exercise shows that the aging of the population and the associated additional UHI costs in 2050 correspond to an 8.9% labor tax burden (including both payroll taxes and premium taxes) for young people. The total labor tax burden increases from the current 29.1% to 40.3%, of which 2.3% consists of the scheduled increase in the social security tax. 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 0.6% annual rate of growth above productivity growth, then medical care in 2050 will be approximately 27% more expensive than in 2010 (i.e., \( q = 1.27 \)). Given this growth in health care prices, an additional 13.6% tax burden on labor will be needed, and the total labor tax burden will reach 45.1%. The results are shown in the fourth column of Table 6.

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 finding is noted partly because of a smaller aggregate labor supply, which declines by 16-17% relative to the 2010 benchmark. 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 \( \frac{X}{Y} \) increases to 12% from 7% in 2010 and may rise as high as 16% with rapid health care inflation.

A counterfactual simulation employing only health care inflation without population aging is also performed. The results are presented in the second column of Table 6. We observe that in this scenario, the effect is much smaller, with an additional labor tax burden of 2.5%.

### 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 6.

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. Setting the co-payment rate for the elderly (those above 70) to 30% to match that of the young

2. Raising the general co-payment rate from its current level of 30% for all ages to 35% or 40%

We continue to assume that the ratio of government subsidy to total UHI costs is fixed at 25%, 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 \(\frac{G}{Y}\) is fixed at 12.5% and that the government will adjust the labor income tax rate to balance its budget. We assume that \(q = 1.27\) in the new steady state and thus that health care inflation is 0.6% per year between 2010 and 2050.

In addition to the tax burden, the welfare effects of the alternative UHI policies are also evaluated. Welfare is measured by expected lifetime utility aggregated over the equilibrium distribution of the population or of the new-born. Welfare deviations from the steady state under the original policy are calculated using the certainty equivalent consumption variation (CEV) measure. Given the utility function, CEV for a representative agent can be expressed as follows:

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

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

\[\text{See Conesa et al. (2009).}\]
We adopt two measures of (social) welfare: one for the overall population and one for the new-born. The CEV for the overall population (i.e., based on the social average of individuals’ expected remaining lifetime utilities) is defined as follows:

\[
CEV_{\text{all}} = \left( \frac{\int V_{\text{new}}(j, h, a, z) d\Phi_{\text{new}}(j, h, a, z)}{\int V_{\text{original}}(j, h, a, z) d\Phi_{\text{original}}(j, h, a, z)} \right)^{\frac{1}{\gamma(1-\gamma)}} - 1,
\]

where \( \Phi_{\text{new}} \) is the stationary distribution of the population over the state variables under a new policy and \( \Phi_{\text{original}} \) is the distribution under the original policy. The CEV for new-born agents (i.e., based on the ex ante expected lifetime utility) is defined as follows:

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

Because the time discount factor in our model is 0.98, which is significantly less than 1, alternative policies that benefit the young more but hurt the elderly tend to have higher values of \( CEV_{\text{nb}} \) than the corresponding values of \( CEV_{\text{all}} \).

The results of the UHI policy experiments are presented in Table 7. For the sake of comparison, the baseline economy is also shown in the first column of Table 7. 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 encourages increased labor supply. In equilibrium, output rises while the \( X/Y \) ratio falls, and aggregate medical expenditures \( X \) are the same as in the baseline economy without reform. As a result, we observe a significant welfare improvement for the new-born as a result of this type of policy reform (see \( CEV_{\text{nb}} \) in Table 7). 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. However, the higher co-payment harms the elderly, who confront greater medical expenditure uncertainties. Therefore, the CEV for the population as a whole is lower than that for the new-born under this policy reform scenario. The social average welfare gain (\( CEV_{\text{all}} \)) is 1.3% of lifetime consumption under a reform that equalizes co-payment rates for the young and the old to 30%. In all cases, the welfare measure \( CEV_{\text{all}} \) remains positive (see \( CEV_{\text{all}} \) in Table 7).
4.2.2 Reform of Financing Policy

We also investigate alternative financing policies for the UHI and government spending, given an aging population. The current consumption tax in Japan is 5%, 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 has decided to increase the consumption tax gradually to 8% in 2014 and to 10% in 2015, although this policy remains controversial. Therefore, we particularly focus on the consumption tax ($\tau_c$), which can be a substitute for the labor tax and is less distoritive of the labor supply, as it spreads the tax burden over the full population. We investigate two potential reforms: increasing the consumption tax rate $\tau_c$ to 10% and increasing the rate to 15%. The corresponding changes in steady states given the expected population structure in 2050 are examined. The results of this policy experiment are presented in Table 8.

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 labor supply/output, and improves welfare, as in 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 8.

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 the new-born 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. Therefore, we observe that the CEV$_{all}$ is 1.1% under a 10% consumption tax (the second column of Table 8), similar to that of a UHI reform that institutes a 30% co-payment, as shown in the second column of Table 7, although its CEV value CEV$_{nb}$ is much smaller than that resulting from the UHI reform (3.7% vs. 9.7%, respectively).

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 gain a better understanding of the welfare changes that result from these reforms, we decompose the change in CEV (for the new-born) into two components: that arising from distributional changes and that arising from aggregate-level changes. Our approach to welfare decomposition is similar to that of Benabou (2002) 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 (without reform), but the average level becomes that of the economy with reform. The distributional component captures the reverse situation. Table 9 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_{nb}.

4.3 Transition: Welfare Implications for Current Residents

Above, we study the welfare implications of reforms based on steady-state comparisons. We find significant welfare gains for future generations, especially under the reform involving an increase the UHI co-payment rate. However, 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.

We now consider the transitional cost to gain a better understanding of the welfare effects of the alternative polices on current generations. We assume that the starting point for the economy is 2010, that a new policy is unexpectedly
implemented in 2011, and that the economy transitions to a new steady state in 2200. Between 2010 and 2050, the survival probabilities and population growth rates as well as the population age structure evolve according to the population forecast. After 2050, the demographic factors stop changing, and the economy converges to a new steady state in 2200. We compute the equilibrium transitional path between the two steady states. The approach that we use here is similar to that employed by Nishiyama and Smetters (2005).\footnote{See Appendix D.}

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 2010 to understand the effects of potential policy reforms on current residents. The CEV of individuals of age $j = j_x$ in 2010 is defined as follows:

$$CEV_{j_x, 2010} = \left( \frac{\int V_{\text{new}}(s|j = j_x, t = 2010) d\Phi_{\text{new}}(s|j = j_x, t = 2010)}{\int V_{\text{original}}(s|j = j_x, t = 2010) d\Phi_{\text{original}}(s|j = j_x, t = 2010)} \right)^{\frac{1}{\sigma(1-\gamma)}} - 1.$$

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

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 2011
2. a gradual UHI policy change-beginning in 2011, increasing the co-payment rate of the elderly by 1% per year until it reaches 30%, as in Policy 1
3. a sudden financing policy reform-increasing the consumption tax to 10% from its current level of 5% in 2011
4. a gradual financing policy reform-beginning in 2011, increasing the consumption tax to 10% from its current level of 5% by 1% per year

The welfare changes by age and health status of individuals living in 2010 are represented as “Policy 1,” “Policy 2,” “Policy 3,” and “Policy 4” in Figures 8 through 11, respectively. Figure 8 presents welfare changes by age and by health status for each policy separately. Figures 9 – 11 compare welfare changes by age under the four policies, separately for each health status.

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 individuals would experience greater losses under the reform, whereas...
younger individuals, especially those under 35, may experience welfare gains (the three lines in Figure 8(a) are above zero only for the 20-35 age range). 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 8% of their lifetime consumption and could even be much worse for those in poor health, except those who are very old and close to the terminal age. The large loss arises first because the elderly confront higher medical shocks and thus incur greater harm from increased co-payments. Second, most importantly, because the new policy is implemented unexpectedly, immediately after 2010, 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. The welfare loss is particularly severe for those in poor health whose medical care costs may even rise above the average income (see Figures 8(a) and 11). In this case, the unexpected 10-20% increase in co-payments would largely reduce the consumption of people who are unprepared, retired, or at high medical risk. Indeed, the new UHI co-payment rates force the unhealthy and elderly to assume a greater share of medical costs than healthy people.

To avoid the disadvantages associated with a sudden UHI policy reform, as discussed above for Policy 1, we now consider a gradual reform of the UHI policy (Policy 2): the elderly’s co-payment rates increased 1. 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 health 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 has less immediate effects and allows more time for people to prepare for the policy change.

Regarding the reform of financing policy, we find that Policy 3, a consumption tax increase that can reduce the labor tax rate by a similar proportion in the steady state, as in Policy 1, has a much milder effect on those who are currently elderly (Figure 8(c)), although they will still experience welfare losses. The average 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 health statuses are not significantly different. We also find that a gradual reform of the consumption tax (Policy 4) has a welfare effect that is similar to that of Policy 3 (Figure 8(c)), but the negative effect on the elderly is
slightly smaller for the same reason as for Policy 2. 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 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.

4.4 Policy Implication and Political Dilemma

4.4.1 Rate of support

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

To more fully understand levels of support for the reforms among the current generation, following Conesa and Krueger (1999), we calculate agreement rates by age for each of the reform policies discussed in the transition analysis. We assume that if an individual expects a welfare improvement to result from a transition to a reform policy, then the individual will agree with the reform. Figure 12 presents the agreement rates by age for each reform policy for the current generations (who are alive in 2010).

We find that for Policy 1, which involves an increase in the UHI co-payments of the elderly, young individuals age 31 and under are rather supportive; however, individuals above 40 do not support the reform. The agreement rate for Policy 2, which increases the UHI co-payments of the elderly gradually, 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 40, must pay higher UHI co-payments in any case, even with the gradual reform, but under an immediate reform scenario, they can enjoy a lower tax burden relatively sooner than under a gradual reform scenario.

Support for Policy 3 is the highest among the four potential reforms. Most individuals below the age of 40 would agree with this reform. Support for Policy 4 is similar to that for Policy 3, but Policy 4 loses some support from younger individuals for reasons that are similar to those discussed above for Policy 2.

15Following the same method, Yamada (2011) proposes politically feasible social security reforms in Japan.
4.4.2 Compensation

We also investigate how much the government must compensate current residents (who are alive in 2010) under the reform scenario to ensure that their welfare can be maintained at its original level. Suppose that $V_{\text{original}}(j, h, a, z, t = 2010)$ is the level of welfare of a household alive in 2010, with state variables $(j, h, a, z)$ 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 welfare $V_{\text{new}}$ is equal to the pre-reform value:

$$V_{\text{new}}(j, h, a + \tilde{a}, z, t = 2010) = V_{\text{original}}(j, h, a, z, t = 2010).$$

For households with welfare gains under the reform, $\tilde{a}$ will be negative.

Total compensation $T_c$ is defined as follows:

$$T_c = \int \tilde{a} d\Phi_{\text{new}}(j, h, a, z, t = 2010).$$

We calculate the amount of compensation for each policy reform. Compared with GDP in 2010 (479.2 trillion yen), the total compensation is equal to 41.32%, 37.83%, 25.45%, and 25.01% of 2010 GDP for Policies 1 through 4, respectively. Table 10 summarizes the results.

We assume that the government can borrow to pay for the compensation. Similar to 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 (lump-sum) tax (negative transfer) on a future new-born household at time $t > 2010$, where $a_f$ is defined by the following:

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

Because the policy reforms improve welfare for most future generations, $a_f$ is typically negative. We can calculate the maximum debt $T_f$ that the government can raise in 2010 for the needed compensation under each reform policy from the following:

$$T_f = \sum_{t=2011}^{2200} \left( \frac{1}{1 + \bar{r}_t} \right)^{t-2010} \int -a_f d\Phi_{\text{new}}(j = 20, h, a = 0, z, t),$$

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

17 As negative assets are outside of the state space in the benchmark value function, we use linear interpolation to compute this value.
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 2010 GDP are 40.68\%, 40.09\%, 17.27\%, and 17.19\% for Policies 1 through 4, respectively. The results indicate that it would not be difficult for the government to provide sufficient compensation $T_c$ for Policies 1 and 2 because these policies improve the welfare of future generations more than Policies 3 and 4, although Policies 3 and 4 have less negative effects on the current elderly population. However, if we assume that the government must pay interest rates as high as the model equilibrium interest rates, which are above 5\% over the next 20 years, then the affordable debt levels $T_f$ are much smaller: 12.44\%, 11.99\%, 4.91\%, and 4.85\% in terms of 2010 GDP for Policies 1 through 4, respectively. The above results are summarized in the second and third rows of Table 10.

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 9-14\% in labor income taxes 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 relies primarily 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 arise primarily 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 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 following 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 further 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 interest rate on government debt is low.
References


Appendix (not for publication)

A Health Insurance System in Japan

As in many OECD countries, Japan provides a public universal health insurance system, which covers all of the residents including employee, self-employed, unemployed, children and retirees.\footnote{For a brief history and the development of universal public health insurance system in Japan, see Kondo and Shigeoka (2013).} There were already some independent health insurance programs based on jobs and occupations before World War II. The Japanese government re-organized those health insurance programs, and achieved the universal health insurance coverage in 1961.\footnote{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 universal public health insurance system in Japan, which is achieved in 1961.}

There are hundreds of insurers, which are managed by societies organized by big firms or central/local governments, providing health insurance coverage and collecting premiums. Although there exist many different insurers, an individual cannot choose the insurer freely. The insurer assigned to a specific individual is determined according to some individual characteristics: job/occupation, employment status, age and so on.

For example, employees of a big firm are covered by the union-based health insurance. Moreover, all the insurance benefits are set by the government regardless the insurer.

The calculation of UHI premium is slightly different for each insurer but is based mainly on salary, and therefore it is equivalently a labor income tax. Insurers also receive government subsidies for the insurance payment. The general coverage of the UHI 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 those with income higher than a threshold. An additional benefit for the elderly aged 75 and above was introduced in 1983. The co-payment rate is further reduced to 10% except those with income higher than a threshold.

Insurance Organizations

The current public health insurance can be divided into three categories: (a) employment-based health insurance, (b) residential-based health insurance (Kokumin Kenkou Hoken or National Health Insurance) and (c) health insurance for the elderly.
Most employees are included in the employment-based health insurance system. There are several health insurance schemes based on occupation:

- Most employees who work in private sector are covered by *Kenko Hoken*. Depending on the size of firms they work, there are two types: union-based health insurance and government-administered health insurance. Employees of big firms are covered by the union-based health insurance, and those of small firms are covered by 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 cover approximately 30 million individuals including dependent family members. 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 a society-managed health insurance. There were 76 societies under this scheme in 2009, and it covers 9 million individuals.

The residential-based insurance, *Kokumin Kenkou Hoken*, covers people who are not included in the category (a), e.g., the self-employed, the unemployed, irregular employees and retired people. 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.

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20 Dependent children and spouses are covered by household heads’ health insurance.
B Computational Procedures

In this section, we explain details of numerical procedures for computing steady states and transition paths. The household’s problem is expressed as follows:

\[ V_t(s) = \max_{c,n,a'} \{ u(c_{j,t}, n_{j,t}) + \rho_{j,t} \beta E [V_{t+1}(s')] \}, \]

subject to

\[ (1 + \tau_{c,t})c_{j,t} + a'_{j+1,t+1} = W + T, \]

\[ W \equiv y_t(n, j, z) + (1 + (1 - \tau_{ss,t})r_t)(a_{j,t} + b_t) - (1 - \omega_{j,t})q_t x, \]

\[ y_t(n, j, z) = (1 - \tau_{ss,t} - \tau_{l,t} - p_{t,med}^m)w_t \eta_j zn_{j,t} + T_{ss,t} \]

\[ T_{ss,j} = \max\{0, (1 + \tau_{c,t})\xi_j - W\} \]

\[ ss_j = \begin{cases} ss & \text{if } j \geq j^{ss} \\ 0 & \text{otherwise.} \end{cases} \]

Note that aggregate variables \( \{K_t, L_t, Y_t, C_t, b_t\} \), factor prices \( \{r_t, w_t\} \) and survival probabilities \( \{\{\rho_{j,t}\}_{j=20}^{100}\}_{t=2010} \) depend on calendar time \( t \) when computing transition paths. As a result, government expenditure \( G_t \) and minimum consumption level for social assistance \( \xi \) are also time-dependent since these variables are determined as a fixed fraction of aggregate output and consumption: \( G_t/Y_t \approx 12.5\% \) and \( \xi/C_t = 10\% \). Labor income tax rate \( \tau_{l,t} \) and premium \( p_{t,med}^m \) are determined from government budget constraints which are also time-dependent. We use co-payment rate \( \omega_{j,t} \) and consumption tax rate \( \tau_{c,t} \) as policy variables. We assume that households have perfect foresight about future prices.

Computing Policy Functions Our model is a standard life cycle model with medical expenditure shocks. Although there are potentially many kinks, we can solve the model by backward induction. We use the endogenous gridpoint method (EGM) to compute policy functions. Basic idea is from Carroll (2006) and, in particular, Appendix in Krueger and Ludwig (2006). The trick of their approach is changing the timing of state variables.

Invariant Distribution We use Young’s (2010) approximation method to compute an invariant distribution.\(^{21}\) We resort to a simulation method when we decompose the welfare change.

\(^{21}\)See also Heer and Maussner (2009).
Find a Steady State  Computation of the steady state is the same as in Huggett (1996). We omit time subscript $t$ when computing the steady state. There are three markets in the model, goods, labor, and capital. However the factor prices $(r, w)$ are determined from the capital–labor ratio $K/L$. By the Walras law, we concentrate on $K/L$.

We compute triple-nested loop: In the inner loop, given $G/Y, X/Y, \zeta/C$, and $\{\tau_l, p^{med}\}$, we find a set of factor prices as in Huggett (1996). In the middle loop, we find the labor income tax rate and the premium, $\{\tau_l, p^{med}\}$, that balance the budget constraints. In the outer loop, we adjust $G/Y, X/Y, \zeta/C$ to match the calibration targets.

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: $\{(c_{ij}), i=1, 100, n_{ij}, j=1, 20\}$. First, we compute the benchmark profiles using equilibrium prices and policy functions; denote them as $\{c, n\}$. Second, we compute consumption and hours profiles of the households with a policy change: $\{c^*, n^*\}$.

Using the simulated profiles, we can compute the expected lifetime value $W(\{c, n\})$ and $W(\{c^*, n^*\})$. 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.
2. Compute the adjusted value, $W(\left\{\frac{c^*}{(1+\alpha_c)}, \frac{n^*}{(1+\alpha_n)}\right\})$.
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:

$$CEV_{Level} = \left(\frac{W(\{c^*, n^*\})}{W(\{\bar{c}^*/(1+\alpha_c), \bar{n}^*/(1+\alpha_n)\})}\right)^{\frac{1}{\gamma}} - 1.$$
There still remains a difference, its shape. Some policy change affects allocation of consumption and leisure over life cycle through risk sharing opportunities and liquidity constraints. After adjusting the effect, we compute the welfare change as follows:

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

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 either hours worked or consumption is fixed at the benchmark case, and do the same procedures explained above.

\section*{D Transition Paths}

After the computation of the steady states in 2010 and 2200, we compute the transitional path between the steady states. The basic idea here is the same as Nishiyama and Smetters (2005).

1. Set survival probabilities \( \{\rho_{j,t}\} \), age-efficiency profile \( \{\eta_j\} \), and medical expenditure shocks \( x \) from external data. Approximate a labor productivity process (AR1) by a finite Markov chain using Tauchen’s (1986) method. Discretize next period’s asset by \( a_{j+1,t+1} \in [a_{\min}, a_{\max}] \). Find an equilibrium payroll tax rate path for social security system \( \{\tau_{ss,t}\} \). Set the price of medical expenditure path \( \{q_t\} \) as \( q_{2010} = 1 \) and it increases 0.7% per year.

2. Compute an initial and final steady state. The algorithms are stated above.

3. Given an exogenous path of \( \{\{\rho_{j,t}, \omega_j\}_{j=20}^{100}, \tau_{c,t}, \tau_{k,t}, q_t\}_{t=2010}^{2200} \) and guess an equilibrium sequence of \( \{r_t, w_t, \tau_{c,t}, \tau_{k,t}, q_t, L_t, b_t, q_t\}_{t=2010}^{2200} \), which are required to solve a household’s problem.\footnote{For simplicity, we start a linear case.}

4. Because we have the policy function of the final steady state in 2200, we compute a sequence of policy functions using the EGM backwardly from 2200 to 2010.

5. Given the policy functions, compute the distribution function \( \{\Phi_{j,t}\} \) from 2010 onwards and compute aggregate variables, \( \{K_t, L_t, Y_t, C_t, r_t, w_t\}_{t=2010}^{2200} \).
Set the government expenditure \( \{G_t\} \) as \( G_t / Y_t \) is close to a target value, and adjust minimum consumption to satisfy \( c_t / C_t = 10\% \).

6. Check whether each market clearing conditions and government budget constraints are satisfied. If these are not in equilibrium, update the price sequences and repeat steps 3 – 5.\(^{23}\)

7. If all markets clear and government budget constrains satisfied in all periods, then stop computation. Compute value for each age and time by value function iteration.

\(^{23}\)There are many efficient methods for update the price sequence. For example, Krueger and Ludwig (2007) and Ludwig (2007) uses a modified version of Gauss-Zeidel method for computing the transition path.
Tables and Figures

Table 1: Medical cost over age groups (2010)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Per person medical cost (1,000 yen)</th>
<th>Percentage of total average (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>292.2</td>
<td>–</td>
</tr>
<tr>
<td>Under 65</td>
<td>169.4</td>
<td>57.97</td>
</tr>
<tr>
<td>0-14</td>
<td>143.6</td>
<td>49.14</td>
</tr>
<tr>
<td>14-44</td>
<td>106.1</td>
<td>36.31</td>
</tr>
<tr>
<td>45-64</td>
<td>268.2</td>
<td>91.79</td>
</tr>
<tr>
<td>Over 65</td>
<td>702.7</td>
<td>240.49</td>
</tr>
<tr>
<td>Over 70</td>
<td>794.9</td>
<td>272.04</td>
</tr>
<tr>
<td>Over 75</td>
<td>878.5</td>
<td>300.65</td>
</tr>
</tbody>
</table>

Source: Estimates of National Medical Expenditure, Japan
Table 2: Transition of health (medical expenditures) status

<table>
<thead>
<tr>
<th>Age</th>
<th>Good</th>
<th>Fair</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 0–17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>0.8280</td>
<td>0.1615</td>
<td>0.0105</td>
</tr>
<tr>
<td>Fair</td>
<td>0.2309</td>
<td>0.7262</td>
<td>0.0429</td>
</tr>
<tr>
<td>Bad</td>
<td>0.0400</td>
<td>0.3914</td>
<td>0.5686</td>
</tr>
<tr>
<td>Age: 18–35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>0.7784</td>
<td>0.2040</td>
<td>0.0176</td>
</tr>
<tr>
<td>Fair</td>
<td>0.3087</td>
<td>0.6356</td>
<td>0.0557</td>
</tr>
<tr>
<td>Bad</td>
<td>0.1137</td>
<td>0.3284</td>
<td>0.5579</td>
</tr>
<tr>
<td>Age: 36–45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>0.7566</td>
<td>0.2232</td>
<td>0.0202</td>
</tr>
<tr>
<td>Fair</td>
<td>0.2817</td>
<td>0.6523</td>
<td>0.0660</td>
</tr>
<tr>
<td>Bad</td>
<td>0.0603</td>
<td>0.3452</td>
<td>0.5945</td>
</tr>
<tr>
<td>Age: 46–55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>0.7332</td>
<td>0.2390</td>
<td>0.0278</td>
</tr>
<tr>
<td>Fair</td>
<td>0.2130</td>
<td>0.6888</td>
<td>0.0982</td>
</tr>
<tr>
<td>Bad</td>
<td>0.0399</td>
<td>0.2443</td>
<td>0.7158</td>
</tr>
<tr>
<td>Age: 56–</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>0.6907</td>
<td>0.2849</td>
<td>0.0244</td>
</tr>
<tr>
<td>Fair</td>
<td>0.1818</td>
<td>0.6850</td>
<td>0.1332</td>
</tr>
<tr>
<td>Bad</td>
<td>0.0131</td>
<td>0.1531</td>
<td>0.8338</td>
</tr>
</tbody>
</table>

Note: Calculation based on Kan and Suzuki (2005).
Table 3: Per Capita Medical Expenditures (Unit: 1,000 yen)

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean expenditure</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>219.0</td>
<td>31.1</td>
<td>208.4</td>
<td>1200.8</td>
</tr>
<tr>
<td>5 - 9</td>
<td>112.6</td>
<td>16.0</td>
<td>107.2</td>
<td>617.4</td>
</tr>
<tr>
<td>10 - 14</td>
<td>79.5</td>
<td>11.3</td>
<td>75.7</td>
<td>435.9</td>
</tr>
<tr>
<td>15 - 19</td>
<td>65.1</td>
<td>9.2</td>
<td>62.0</td>
<td>357.0</td>
</tr>
<tr>
<td>20 - 24</td>
<td>72.6</td>
<td>10.3</td>
<td>69.1</td>
<td>398.1</td>
</tr>
<tr>
<td>25 - 29</td>
<td>96.9</td>
<td>13.8</td>
<td>92.2</td>
<td>531.3</td>
</tr>
<tr>
<td>30 - 34</td>
<td>111.9</td>
<td>15.9</td>
<td>106.5</td>
<td>613.6</td>
</tr>
<tr>
<td>35 - 39</td>
<td>120.6</td>
<td>17.1</td>
<td>114.8</td>
<td>661.3</td>
</tr>
<tr>
<td>40 - 44</td>
<td>136.0</td>
<td>19.3</td>
<td>129.4</td>
<td>745.7</td>
</tr>
<tr>
<td>45 - 49</td>
<td>164.5</td>
<td>23.4</td>
<td>156.6</td>
<td>902.0</td>
</tr>
<tr>
<td>50 - 54</td>
<td>214.1</td>
<td>30.4</td>
<td>203.8</td>
<td>1174.0</td>
</tr>
<tr>
<td>55 - 59</td>
<td>293.4</td>
<td>41.7</td>
<td>279.2</td>
<td>1608.8</td>
</tr>
<tr>
<td>60 - 64</td>
<td>356.0</td>
<td>50.6</td>
<td>338.8</td>
<td>1952.1</td>
</tr>
<tr>
<td>65 - 69</td>
<td>455.4</td>
<td>64.7</td>
<td>433.4</td>
<td>2497.1</td>
</tr>
<tr>
<td>70 - 74</td>
<td>590.1</td>
<td>83.8</td>
<td>561.6</td>
<td>3235.7</td>
</tr>
<tr>
<td>75 - 79</td>
<td>696.1</td>
<td>98.8</td>
<td>662.5</td>
<td>3816.9</td>
</tr>
<tr>
<td>80 - 84</td>
<td>809.5</td>
<td>114.9</td>
<td>770.4</td>
<td>4438.7</td>
</tr>
<tr>
<td>Over 85</td>
<td>943.0</td>
<td>133.9</td>
<td>897.5</td>
<td>5170.8</td>
</tr>
</tbody>
</table>

average 267.2 37.9 254.3 1465.1

Table 4: Parameters of the Model

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta$ 0.98</td>
</tr>
<tr>
<td>Intertemporal elasticity of substitution</td>
<td>$\gamma$ 2.0</td>
</tr>
<tr>
<td>Share of labor supply</td>
<td>$\sigma$ 0.33</td>
</tr>
<tr>
<td>Capital share</td>
<td>$\alpha$ 0.377</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta$ 0.08</td>
</tr>
<tr>
<td>Persistence of labor productivity shock</td>
<td>$\lambda$ 0.98</td>
</tr>
<tr>
<td>Std. dev. of labor productivity shock</td>
<td>$\sigma_\epsilon$ 0.09</td>
</tr>
<tr>
<td>Government share of UHI</td>
<td>$\psi$ 0.25</td>
</tr>
<tr>
<td>Price of medical expenditure</td>
<td>$q$ {1, 1.27}</td>
</tr>
</tbody>
</table>

Table 5: Age-Efficiency Profile

<table>
<thead>
<tr>
<th>Age</th>
<th>$\eta_j$</th>
<th>Age</th>
<th>$\eta_j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–24</td>
<td>0.545</td>
<td>45–49</td>
<td>1.243</td>
</tr>
<tr>
<td>25–29</td>
<td>0.718</td>
<td>50–54</td>
<td>1.271</td>
</tr>
<tr>
<td>30–34</td>
<td>0.884</td>
<td>55–59</td>
<td>1.130</td>
</tr>
<tr>
<td>35–39</td>
<td>1.030</td>
<td>60–64</td>
<td>0.770</td>
</tr>
<tr>
<td>40–44</td>
<td>1.149</td>
<td>60–64</td>
<td>0.654</td>
</tr>
</tbody>
</table>
Table 6: Effects of population aging/medical cost inflation on UHI

<table>
<thead>
<tr>
<th>Demographic structure</th>
<th>Benchmark 2010</th>
<th>Only Price 2010</th>
<th>Only Aging 2050</th>
<th>Aging &amp; Price 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medical price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( q = 1 )</td>
<td>1.00%</td>
<td>-1.47%</td>
<td>-0.52%</td>
<td>-4.67%</td>
</tr>
<tr>
<td>( q = 1.27 )</td>
<td>1.27</td>
<td>1.27</td>
<td>1.27</td>
<td>1.27</td>
</tr>
<tr>
<td>Change in ( K )</td>
<td>0.00%</td>
<td>-1.47%</td>
<td>-0.52%</td>
<td>-4.67%</td>
</tr>
<tr>
<td>Change in ( L )</td>
<td>0.00%</td>
<td>-0.18%</td>
<td>-16.63%</td>
<td>-17.23%</td>
</tr>
<tr>
<td>( K/Y )</td>
<td>2.52</td>
<td>2.50</td>
<td>2.82</td>
<td>2.75</td>
</tr>
<tr>
<td>( X/Y )</td>
<td>7.1%</td>
<td>9.1%</td>
<td>12.1%</td>
<td>15.7%</td>
</tr>
<tr>
<td>( G/Y )</td>
<td>12.5%</td>
<td>12.5%</td>
<td>12.5%</td>
<td>12.5%</td>
</tr>
<tr>
<td><strong>Tax burden</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption tax</td>
<td>5.0%</td>
<td>5.0%</td>
<td>5.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Capital tax</td>
<td>39.8%</td>
<td>39.8%</td>
<td>39.8%</td>
<td>39.8%</td>
</tr>
<tr>
<td>Payroll tax (A)</td>
<td>7.58%</td>
<td>8.63%</td>
<td>12.22%</td>
<td>14.08%</td>
</tr>
<tr>
<td>Premium tax (B)</td>
<td>5.54%</td>
<td>7.08%</td>
<td>9.81%</td>
<td>12.72%</td>
</tr>
<tr>
<td>(A)+(B)</td>
<td>13.12%</td>
<td>15.72%</td>
<td>22.03%</td>
<td>26.80%</td>
</tr>
<tr>
<td>Social security tax (C)</td>
<td>16.06%</td>
<td>16.06%</td>
<td>18.30%</td>
<td>18.30%</td>
</tr>
<tr>
<td>Total labor burden</td>
<td>29.17%</td>
<td>31.77%</td>
<td>40.33%</td>
<td>45.10%</td>
</tr>
<tr>
<td>(A)+(B)+(C)</td>
<td>29.17%</td>
<td>31.77%</td>
<td>40.33%</td>
<td>45.10%</td>
</tr>
<tr>
<td>Increased UHI burden</td>
<td>-</td>
<td>2.6%</td>
<td>8.9%</td>
<td>13.7%</td>
</tr>
</tbody>
</table>

Note: \( K/Y \) – capital output ratio; \( X/Y \) – medical cost output ratio; \( G/Y \) – government expenditure-output ratio.
Table 7: Alternative UHI policies – steady state comparison (with 2050 demographic structure)

<table>
<thead>
<tr>
<th></th>
<th>Current system</th>
<th>UHI policy reform</th>
<th>Co-payment rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$q = 1.27$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in $K$</td>
<td>0.0%</td>
<td>14.0%</td>
<td>19.1%</td>
</tr>
<tr>
<td>Change in $L$</td>
<td>0.0%</td>
<td>1.9%</td>
<td>2.7%</td>
</tr>
<tr>
<td>$K/Y$</td>
<td>2.75</td>
<td>2.95</td>
<td>3.02</td>
</tr>
<tr>
<td>$X/Y$</td>
<td>15.7%</td>
<td>14.8%</td>
<td>14.5%</td>
</tr>
<tr>
<td><strong>Tax burden</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption tax</td>
<td>5.0%</td>
<td>5.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Capital tax</td>
<td>39.8%</td>
<td>39.8%</td>
<td>39.8%</td>
</tr>
<tr>
<td>Payroll tax (A)</td>
<td>14.1%</td>
<td>13.3%</td>
<td>13.0%</td>
</tr>
<tr>
<td>Premium tax (B)</td>
<td>12.7%</td>
<td>10.0%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Social security tax (C)</td>
<td>18.3%</td>
<td>18.3%</td>
<td>18.3%</td>
</tr>
<tr>
<td>Total labor burden (A)+(B)+(C)</td>
<td>45.1%</td>
<td>41.5%</td>
<td>40.4%</td>
</tr>
<tr>
<td><strong>Welfare comparison</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$CEV_{nb}$</td>
<td>0.0%</td>
<td>9.7%</td>
<td>12.6%</td>
</tr>
<tr>
<td>$CEV_{all}$</td>
<td>0.0%</td>
<td>1.3%</td>
<td>2.0%</td>
</tr>
</tbody>
</table>
Table 8: Alternative financing policies – steady state comparison (2050 demographic structure)

<table>
<thead>
<tr>
<th></th>
<th>Current system τc = 5%</th>
<th>Financing policy reform Consumption tax rate τc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>Change in K</td>
<td>0.0%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Change in L</td>
<td>0.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td>K/Y</td>
<td>2.75</td>
<td>2.82</td>
</tr>
<tr>
<td>X/Y</td>
<td>15.7%</td>
<td>15.3%</td>
</tr>
<tr>
<td><strong>Tax burden</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption tax</td>
<td>5.0%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Capital tax</td>
<td>39.8%</td>
<td>39.8%</td>
</tr>
<tr>
<td>Payroll tax (A)</td>
<td>14.1%</td>
<td>9.9%</td>
</tr>
<tr>
<td>Premium tax (B)</td>
<td>12.7%</td>
<td>12.4%</td>
</tr>
<tr>
<td>Social security tax (C)</td>
<td>18.3%</td>
<td>18.3%</td>
</tr>
<tr>
<td>Total labor burden (A)+(B)+(C)</td>
<td>45.1%</td>
<td>40.6%</td>
</tr>
<tr>
<td><strong>Welfare comparison</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEV_{nb}</td>
<td>0.0%</td>
<td>3.7%</td>
</tr>
<tr>
<td>CEV_{all}</td>
<td>0.0%</td>
<td>1.1%</td>
</tr>
</tbody>
</table>
Table 9: Decomposition of welfare change

<table>
<thead>
<tr>
<th></th>
<th>UHI policy reform</th>
<th>Financing policy $\tau_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Co-payment rate for all</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>30%</td>
<td>35%</td>
</tr>
<tr>
<td>CEV$_{nb}$</td>
<td>9.66%</td>
<td>12.63%</td>
</tr>
<tr>
<td>Level change</td>
<td>4.93%</td>
<td>6.75%</td>
</tr>
<tr>
<td>Only $c$</td>
<td>5.90%</td>
<td>8.23%</td>
</tr>
<tr>
<td>Only $n$</td>
<td>-0.92%</td>
<td>-1.37%</td>
</tr>
<tr>
<td>Distribution change</td>
<td>4.86%</td>
<td>5.97%</td>
</tr>
<tr>
<td>Only $c$</td>
<td>3.41%</td>
<td>4.10%</td>
</tr>
<tr>
<td>Only $n$</td>
<td>1.44%</td>
<td>1.84%</td>
</tr>
</tbody>
</table>

Table 10: Compensations and affordable debt (in terms of 2010 GDP)

<table>
<thead>
<tr>
<th></th>
<th>Policy 1</th>
<th>Policy 2</th>
<th>Policy 3</th>
<th>Policy 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Compensation ($T_c$)</td>
<td>41.32%</td>
<td>37.83%</td>
<td>25.45%</td>
<td>25.01%</td>
</tr>
<tr>
<td>$T_f$ ($\bar{r} = 1%$)</td>
<td>40.68%</td>
<td>40.09%</td>
<td>17.27%</td>
<td>17.19%</td>
</tr>
<tr>
<td>$T_f$ (model rates $\bar{r} &gt; 5%$)</td>
<td>12.44%</td>
<td>11.99%</td>
<td>4.91%</td>
<td>4.85%</td>
</tr>
</tbody>
</table>
Figure 1: Japan’s population structure 1980 – 2050
Figure 2: Japan’s dependency ratios 1980 – 2050

Figure 3: Trend of Japan’s medical care cost 1980 – 2010
Figure 4: Actual and Simulated Population Distribution
Figure 5: Transition probabilities of remaining in the same state
Figure 6: Distribution of the health (expenditure) states over life-cycle

Figure 7: Medical expenditures by age in 2007
Figure 8: CEV by age and health status
Figure 9: Comparison – CEV by age, good health

Figure 10: Comparison – CEV by age, fair health
Figure 11: Comparison – CEV by age, bad health

Figure 12: Agreement rates of the reform policies