# Financing Health Care in Japan: The Impact of an Aging Population*

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February 15, 2011

**Abstract**

This is a description of some work in progress aimed at providing a quantitative analysis of the impact of population aging in Japan on financing its National Health Insurance program. We construct a general equilibrium life-cycle economy that is used to study the impact of an aging population (an increased dependency ratio and increased per capita medical expenditures) on household's work and savings behavior, as well as on aggregate output and welfare. In particular, taking 2010 as an initial starting point, we calculate the transition path predicted by our model as the population structure changes and medical costs increase, using values for 2055 to construct a terminal steady state. We also evaluate various policy alternatives designed to lessen the negative impact of aging on the economy.

**Keywords:** Universal Health Insurance, Population Aging, Japan
**JEL Classification:** E21, H51, I10

*Comments Welcome.

# 1 Introduction

This paper aims to provide a quantitative analysis of the impact of population aging on the cost of maintaining a universal health care system. We focus on Japan because its National Health Insurance (NHI) program provides universal coverage and the population has been aging dramatically over the past two decades. We study the tax burden associated with financing the NHI and the impact it has on the economy as the population ages. Potential reforms of the NHI program and how it is financed will also be evaluated.

The current cost of health care in Japan is relatively low (about 6.6% of GDP or 9.0% of National Income in 2005) compared with other OECD countries. In addition, the Japanese have among the highest life expectancy and lowest infant mortality in the world. The health care system in Japan seems to be in remarkably good shape. However, as the population ages, this low-cost is probably not sustainable with the current framework and financing methods. Japan already has the world's oldest population, and it is projected that 40% will be 65 or older by 2050 (see figure 1).

The population aging affects the health care system through two channels. First, as the fraction of the population over 65 increases, the fraction that pays taxes and premiums that finance the system decreases. In particular, one quarter of the program's costs are financed by general government revenues, and the rest is paid by a payroll tax levied on employers and workers and co-payments made those seeking medical care. It is obvious that the burden of financing health care is mainly on the working-age population (age 15-64), which is projected to shrink to 51% of total population by 2050 with an old-age dependency ratio above 75% (see figures 1 and 2).[1]

Second, the elderly face higher health risks and need much more care than young people. The data show that the average per-person medical cost for those above age 65 is 241.8% as of the average of the total population, and it is about 4 times that of those under age 65. Table 1 presents medical costs per capita for different age groups. A larger elderly population implies higher per capita medical costs. Figure 3 shows the trend of medical costs in Japan. Due to population aging, if the current system is to be maintained, either the government subsidy or the insurance premium charged to workers and employers has to increase to finance the extra cost of the health care system. Either way, the financial burden on the working age population will increase.

[1] Data source: National Institute of Population and Social Security Research, Japan.

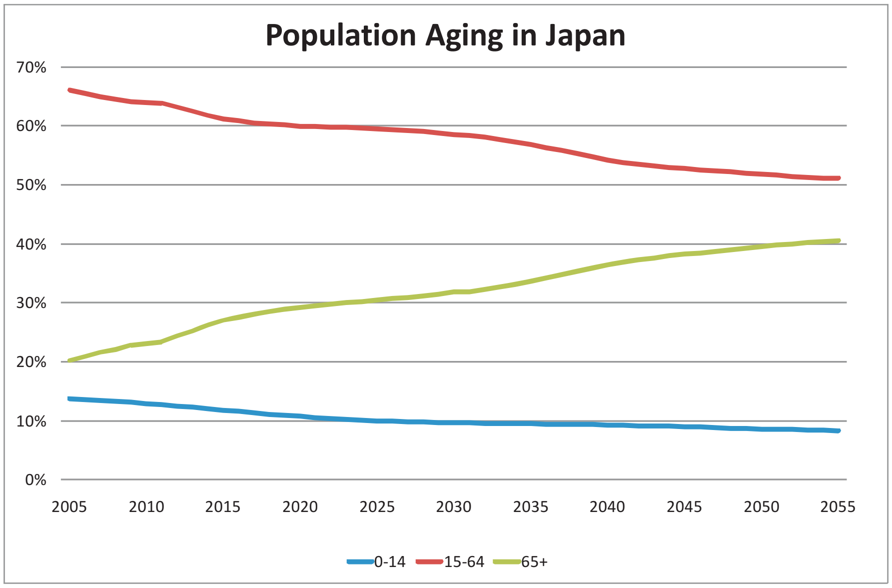


Figure 1: Japan's population structure 2005 – 2055

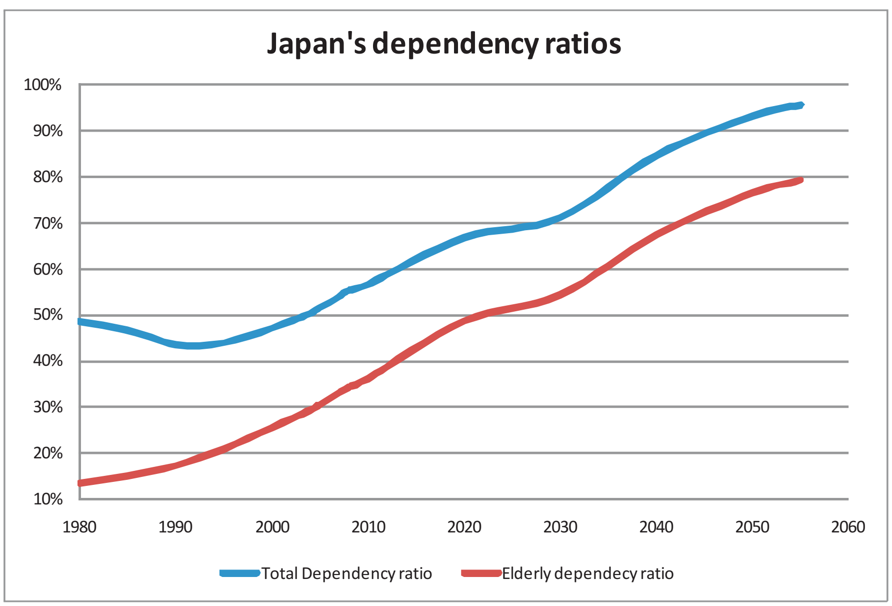


Figure 2: Japan's dependency ratios 1980 – 2055

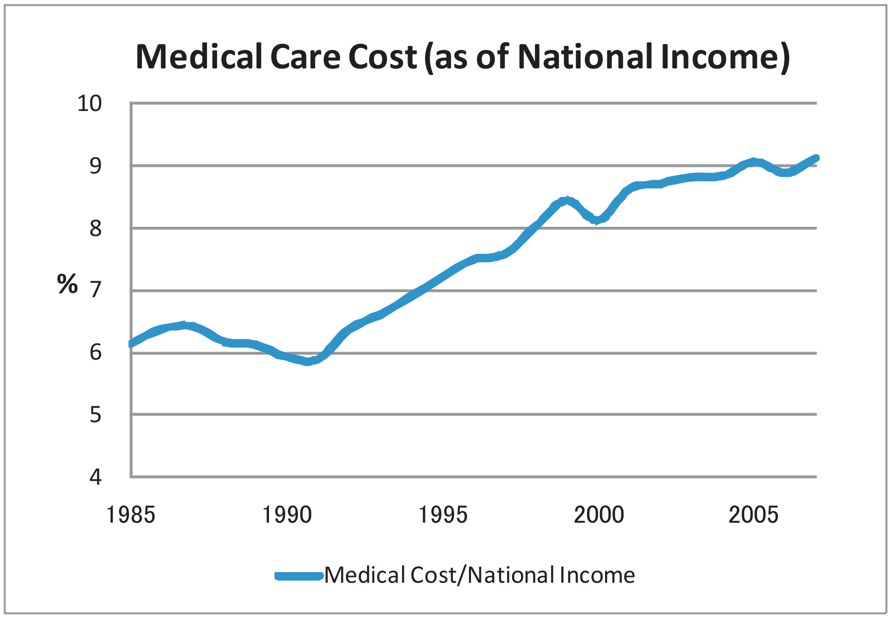


Figure 3: Trend of Japan's medical care cost 1985 – 2007

Table 1: Medical cost over age groups (2007)

| Age Group | Per person medical cost (1,000 yen) | As of total average (%) |
|---|---|---|
| Total | 267.2 | – |
| Under 65 | 163.4 | 61.15 |
| 0-14 | 134.6 | 50.37 |
| 14-44 | 103.3 | 38.66 |
| 45-64 | 261.6 | 97.90 |
| Over 65 | 646.1 | 241.80 |
| Over 70 | 722.2 | 270.28 |
| Over 75 | 794.2 | 297.23 |

Source: Estimates of National Medical Expenditure, Japan

In this paper, we construct an equilibrium life-cycle model and carry out quantitative exercises to help understand: 1) the impact of demographic change (in particular population aging) on the costs of financing the NHI; 2) the impact of the above changes on household working and saving behavior, as well as on aggregate economic performance and welfare; and 3) the effects of potential reforms of the NHI and the methods used to finance the program. 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 impact this will have on the country's health care system.

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

# 2 Model

A general equilibrium life-cycle model with national health insurance, endogenous labor supply and incomplete markets is constructed in order to carry out our analysis. We focus on the steady state and transition dynamics.

## 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 until next period with probability $\rho_j$ which depends on her/his age $j$. When individuals reach age $J$, then $\rho_J = 0$ and will leave the economy next period. The size of new cohort grows at a rate $g$. The population of age $j$ is denoted by $\mu_j$, which evolves $\mu_{j+1} = \frac{\rho_j}{1+g}\mu_j$, and the total population is normalized to one, $\sum_{j=1}^{J} \mu_j = 1$.

## 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 the time on market work for earnings or on leisure. If they decide to spend $n$ hours on the market work, their earnings are given as $(w\eta_j zn)$, where $w$ is the market wage, $\eta_j$ is the age-specific productivity, and $z$ is idiosyncratic labor productivity that evolves stochastically to characterize the income uncertainty. $\eta_j$ is zero after retirement age.

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

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

where $\gamma$ governs the degree of risk aversion.[2]

## 2.3 Health, Medical Expenditure and National Health Care

### 2.3.1 Heath Status and Medical Expenditure Uncertainty

Agents face exogenous uncertainty about their health status $h$. The health status evolves according to the Markov chain among three states of good, fair, and bad, $\{h_g, h_f, h_b\}$, with a transition matrix $\pi_j(h', h)$ that depends on age.

Individuals face an idiosyncratic medical expenditure shock $x_j(h)$ in each period.

### 2.3.2 National Health Insurance

Agents can partially insure medical expenditure risks with access to health insurance that covers a fraction $\omega(j)$ of realized medical expenditure $x$. In Japan, the National Health Insurance (NHI) is available to every resident, and financed by an income-related premium (a payroll tax) and government general revenue. The coverage rate depends on age $j$. As will be discussed later, the co-insurance rate (or co-payment rate), $1-\omega(j)$, is 30% under age 70, 20% between 70-74, and 10% over age 75.

To consider the effect of future increases in medical costs, we also estimate the growth of medical expenditures $q$, which implies that individuals pay $(1-\omega(j))qx$. In the benchmark case, $q$ is set equal to one.

[2]One can use a separable utility between consumption and leisure but it is not consistent with balanced growth path unless $\gamma$ is one:

$$u(c,n) = \frac{c^{1-\gamma}}{1-\gamma} - \varphi\frac{n^{1+1/\sigma}}{1+1/\sigma}$$

where $\varphi$ is a disutility parameter and $\sigma$ is Frisch elasticity of labor substitution

## 2.4 Public Pension

The public pension program provides the elderly with a benefit $ss$ when they reach the eligibility age of $j^{ss}$ and retire. The program is financed by the social security tax $\tau_{ss}$ imposed on labor income of the working population.

## 2.5 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

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

where $K$ and $L$ are the aggregate capital and effective labor employed by the firm's sector and $A$ is total factor productivity which we assume to be constant.[3] Capital depreciates at rate of $\delta$ every period and $\theta$ denotes the capital income share.

## 2.6 Financial Market Structure

Individuals can hold assets that are non-state contingent claims to capital. The rate of return earned from these 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. While they are allowed to insure themselves by accumulating positive asset holdings, they cannot carry debt, $a \geq 0$. This borrowing limit specially affects the asset holding decision of low-wealth households since they cannot smooth their consumption over time when their disposable incomes falls.

## 2.7 Government

In addition to the NHI and social security, the government also provides means-tested social insurance (public assistance) in this economy. The government guarantees a minimum level of consumption $\underline{c}$ by supplementing the income in case the household's disposable income plus assets (net after medical expenditure) falls below $\underline{c}$. We consider a simple transfer rule proposed by

[3] The total factor productivity $A$ is adjusted so that equilibrium wage $w^*$ equals to one in the benchmark case.

Hubbard et al. (1995). The transfer $T$ will be made if the household's disposable income plus assets (net after medical expenditure) is smaller than a minimum level of consumption. The transfer amount will be exactly equal to the difference.

Government's revenue consists of revenues from different tax instruments, labor income tax $\tau_l$, capital income tax $\tau_k$, consumption tax $\tau_c$, social security tax (pension payment) $\tau_{ss}$, and the NHI premium $p^{\text{med}}$. The government uses its revenue to finance all public programs and its own consumption $G$.

## 2.8 Household's Problem

The states for an agent is summarized by a vector $s = (j, h, a, z)$, where $j$ is age, $h$ is health status, $a$ is asset holdings brought into the period, and $z$ is the idiosyncratic shock to labor productivity. The household's problem can be expressed as:

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

subject to

$$(1+\tau_c)c + a' = W + T, \tag{1}$$

$$W \equiv y(n,j,z) + (1 + (1-\tau_k) r)(a+b) - (1-\omega(j))\, qx, \tag{2}$$

$$y(n,j,z) = (1-\tau_{ss} - p^{\text{med}}) w \eta_j z n - \underbrace{\tau_l [(1-\tau_{ss} - p^{\text{med}}) w \eta_j z n]}_{\text{tax on labor income}} + ss(j) \tag{3}$$

$$T = \max\{0, (1+\tau_c)\underline{c} - W\} \tag{4}$$

$$ss(j) = \begin{cases} ss & \text{if } j \geq j^{ss}, \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

where $T$ is the transfer made by the means-tested social insurance system, which ensures that agents will not fall into an undesired situation with negative wealth and consumption; $ss$ is the social security benefit, and $b$ is the lump sum transfer of accidental bequests. For simplicity, the public pension benefit is constant for all individuals.

Accidental bequests are redistributed by a lump-sum transfer:

$$b' = \int (1-\rho_j) a' d\Phi(s). \tag{6}$$

In the budget constraint, $\tau_l[\cdot]$ is a labor income tax function. The tax base is the labor earnings after subtracting payroll taxex and the health insurance premium. As will be discussed later, we consider both linear and progressive tax functions.

## 2.9 Government Budget Constraints

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

$$\underbrace{\int [\tau_l[\cdot] + \tau_k r(a+b) + \tau_c c] d\Phi(s)}_{\text{Tax Revenue}} = \underbrace{\psi \int (\omega(j) q x) d\Phi(s)}_{\text{NHI subsidy}} + \int T d\Phi(s) + G \quad (7)$$

$$\underbrace{\int (p^{\text{med}} w \eta_j z n) d\Phi(s)}_{\text{Premium}} = (1-\psi) \int (\omega(j) q x) d\Phi(s) \quad (8)$$

where $\Phi(s)$ is a distribution function over state variables. In the benchmark, we set the tax rates ($\tau_k$, and $\tau_c$) equal to the current rates (in 2010) and set $G$ equal to its current value as a percentage of GDP. In experiments with predicted population aging or medical care cost increases, we suppose the government will adjust the payroll tax to balance its budget and keep the values for $G$, $\tau_k$, and $\tau_c$ fixed. This allows us to investigate how large is the extra burden on individuals (measured by changes in $\tau_l$ and $p^{\text{med}}$) caused by the cost changes for the NHI.

The social security public pension system is self-financed with a Pay-As-You-Go scheme:

$$\int (\tau_{ss} w \eta_j z n) d\Phi(s) = \int ss(j) d\Phi(s). \quad (9)$$

## 2.10 Stationary Recursive Competitive Equilibrium

A stationary recursive competitive equilibrium is defined as 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 government policy of tax rates $\tau_{ss}$, $\tau_l(\cdot)$, $\tau_k$ and $\tau_c$, public pension benefits $ss$, an NHI premium $p^{med}$ and a subsidy ratio $\psi$; and a distribution of households over the state variables $\Phi(s)$, such that:

**a)** given the price system, the decision rules of $K$ and $L$ solve the firm's problem;

**b)** given the price system and the goverment policy, the decision rules $(a', n, c)$ solve the household's problem;

**c)** government policies $(\tau_{ss}, \tau_k, \tau_l, \tau_c, ss, p^{med}, \psi)$ satisfy the government's budget constraints;

**d)** $\Phi(s)$ is stationary;

**e)** all markets clear: $L = \int (\eta_j zn) d\Phi(s)$ and $K' = \int a' d\Phi(s)$ (or $K = \int ad\Phi(s) + b$);

**f)** resource feasibility condition is satisfied

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

where $C$ is the aggregate consumption, and $X$ is the aggregate medical expenditure.

# 3 Calibration

In this section, we describe calibration and parameter selection. Table 4 summarizes some key parameters.

## 3.1 Preference

We set the subjective discount factor $\beta$ equal to 0.98 so that the capital-output ratio $K/Y$ in the model matches recent values for Japan. The elasticity of intertemporal substitution $1/\gamma$ is assumed to be 0.5, i.e., $\gamma$ is set at 2, and the share of labor supply parameter $\sigma$ is set at 0.33.

## 3.2 Production Function

Parameters of the production function, capital's share $\theta$ and the depreciation rate $\delta$, are taken from İmrohoroğlu and Sudo (2010). They estimate these parameters from the SNA by extending Hayashi and Prescott (2002)'s calibration to the current Japanese economy.

## 3.3 Demographics and Survival Probability

A household enters the economy at age 20, retires at 65, and lives at most until 100. The National Institute of Population and Social Security Research (IPSR) provides future projections on Japanese demographic changes. The most recent projection was estimated in 2006, and provides forcasts of demographic changes from 2005 to 2055.. The projection consists of three variations on fertility rates, high, medium, and low, and also three variations on mortality rates. Thus, we have nine projections. We use medium variants on both fertility and mortality rates. The survival probabilities $\{\rho_j\}$ are taken from the life table for males in 2010 (*initial* stationary state) and 2055 (*final* stationary state). The population growth rate $g$ is set at 0 in both initial and final stationary state because the fraction of retired household (the ratio of household aged over 65 to that between 24 and 64) in the model (26.43%) is quite similar to the actual data (26.75%).

## 3.4 Medical expenditure

Micro-level panel data of medical expenditure are not publicly accessible in Japan. There is no database like the Medical Expenditure Panel Survey (MEPS) in the US, which is widely used to calibrate medical expenditure states and transition probabilities.[4] To do a careful calibration for Japan, our main source is the report of Kan and Suzuki (2005). Kan and Suzuki studied the concentration and the persistence of health care expenditures in Japan. They had a special permit to access the health insurance claim data from 111 Japanese health insurance societies between 1996 and 1998. The data are panel and contain 35,970 individuals with age between 0 to 70.

### 3.4.1 Transition Probabilities

Kan and Suzuki (2005) analyzed the transition of medical expenditure in 5 age groups (0-17, 18-35, 35-45, 46-55, and above 55). Within each age group, they divided the samples into 10 medical expenditure quantiles and reported the corresponding transitions from 1996 to 1998.

Our purpose is to estimate the annual transition for medical expenditures for each age (from 20 to 100). To have a clear transition patterns over age, we re-classify the 10 quantiles to 3 states of medical expenditures: 'low', 'middle' and 'high'. The category 'low' includes those in the bottom 50% of medical

[4] See, for example, Jeske and Kitao (2009) and Attanasio et al. (2010).

Table 2: Transition of medical expenditure

| | | | | |
|---|---|---|---|---|
| age: 0–17 | | low | middle | high |
| | low | 0.8280 | 0.1615 | 0.0105 |
| | middle | 0.2309 | 0.7262 | 0.0429 |
| | high | 0.0400 | 0.3914 | 0.5686 |
| age: 18–35 | | low | middle | high |
| | low | 0.7784 | 0.2040 | 0.0176 |
| | middle | 0.3087 | 0.6356 | 0.0557 |
| | high | 0.1137 | 0.3284 | 0.5579 |
| age: 36–45 | | low | middle | high |
| | low | 0.7566 | 0.2232 | 0.0202 |
| | middle | 0.2817 | 0.6523 | 0.0660 |
| | high | 0.0603 | 0.3452 | 0.5945 |
| age: 46–55 | | low | middle | high |
| | low | 0.7332 | 0.2390 | 0.0278 |
| | middle | 0.2130 | 0.6888 | 0.0982 |
| | high | 0.0399 | 0.2443 | 0.7158 |
| age: 56– | | low | middle | high |
| | low | 0.6907 | 0.2849 | 0.0244 |
| | middle | 0.1818 | 0.6850 | 0.1332 |
| | high | 0.0131 | 0.1531 | 0.8338 |

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

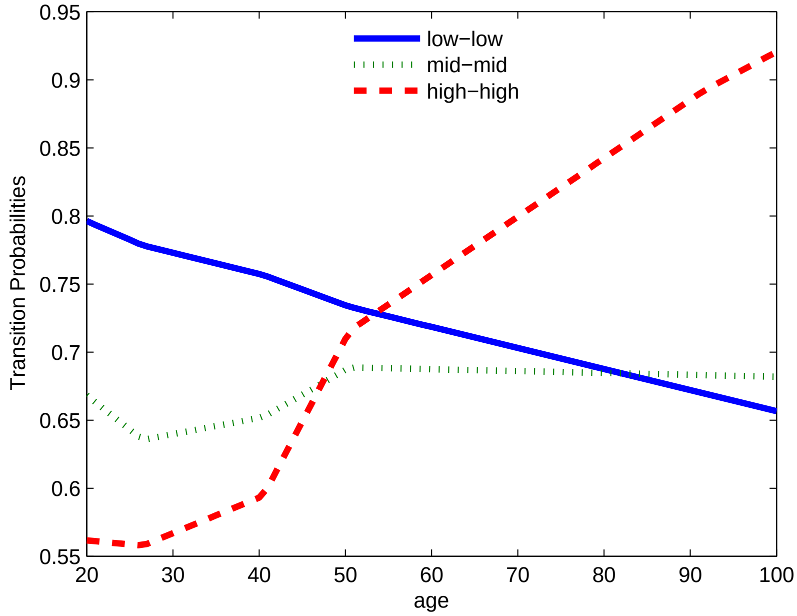


Figure 4: Transition probabilities of remaining in the same state

expenditures, the 'middle' contains the 6th quantile to the 9th quantile, and the 'high' category represents the top 10% expenders. The three states are unevenly classified such that they are able to capture the long-tail in the distribution of the medical expenditures and a small probability of incurring very large and catastrophic expenditures.

The original report in Kan and Suzuki (2005) present the transition of medical expenditure in a 2-year period. Because our model period is one year, we transform the 2-year transition matrices to a one-year transition matrices. Table 2 displays the one-year transition of the 3 states. We can observe that the probabilities of transiting to 'low' are monotonically decreasing in age. On the other hand, the probabilities of transiting to 'high' in general show an opposite pattern across age groups. In the computation, we linearly interpolate the transition probabilities so that transition matrices change smoothly over the life-cycle.

The transition probabilities of remaining in the same states over the life cycle are shown in Figure 4. The probability of staying in "low" (the line 'low-low') is monotonically decreasing in age, while the probability of remaining in "high" (the line 'high-high') is monotonically increasing after age 26. In Figure 5, we

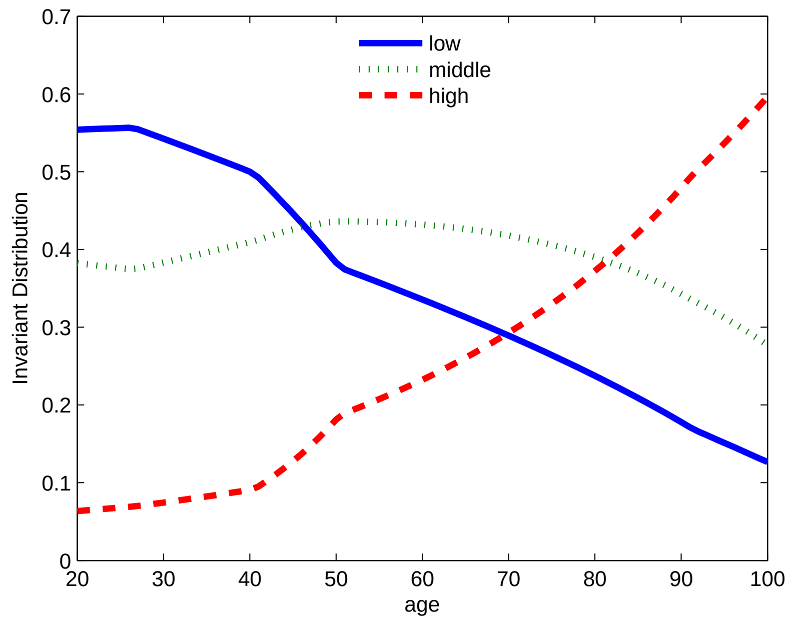


Figure 5: Invariant distribution of the medical expenditure states

display the unconditional probabilities of being in the three expenditure states over the life cycle, implied by the transition matrices.

#### 3.4.2 Medical Expenditure States

The "Estimates of National Medical Care Expenditures," which is published by the Ministry of Health, Labor, and Welfare of Japan, provides the data of average medical expenditures by age. For our calibration, we need the expenditure shares of the three states, low (bottom 50% individuals), middle (next 40%) and high (top 10%), in each age. According to Kan and Suzuki (2005), which provides the information of average expenditure shares of 10 quantiles (unconditional on age) from 1996 to 1998, we can calculate the average shares of the three expenditure states in total medical expenditure. We find that the bottom 50% in the distribution ("low") only contributes 7.1% of total medical expenditure, the next 40% of the distribution ("middle") contributes 38.1% of total medical expenditure, and the top 10% people's share of total medical expenditure is as high as 54.8%. We assume that the expenditure shares of the three states are stable across age, and then can compute the medical expenditures of the three states for each age group with the latest (2007) data from the

Table 3: Medical Care Expenditure Per Capita 2007 (Unit: 1,000 yen)

| Age | mean expenditure | low | middle | high |
|---|---|---|---|---|
| 0 - 4 | 219.0 | 31.1 | 208.4 | 1200.8 |
| 5 - 9 | 112.6 | 16.0 | 107.2 | 617.4 |
| 10 - 14 | 79.5 | 11.3 | 75.7 | 435.9 |
| 15 - 19 | 65.1 | 9.2 | 62.0 | 357.0 |
| 20 - 24 | 72.6 | 10.3 | 69.1 | 398.1 |
| 25 - 29 | 96.9 | 13.8 | 92.2 | 531.3 |
| 30 - 34 | 111.9 | 15.9 | 106.5 | 613.6 |
| 35 - 39 | 120.6 | 17.1 | 114.8 | 661.3 |
| 40 - 44 | 136.0 | 19.3 | 129.4 | 745.7 |
| 45 - 49 | 164.5 | 23.4 | 156.6 | 902.0 |
| 50 - 54 | 214.1 | 30.4 | 203.8 | 1174.0 |
| 55 - 59 | 293.4 | 41.7 | 279.2 | 1608.8 |
| 60 - 64 | 356.0 | 50.6 | 338.8 | 1952.1 |
| 65 - 69 | 455.4 | 64.7 | 433.4 | 2497.1 |
| 70 - 74 | 590.1 | 83.8 | 561.6 | 3235.7 |
| 75 - 79 | 696.1 | 98.8 | 662.5 | 3816.9 |
| 80 - 84 | 809.5 | 114.9 | 770.4 | 4438.7 |
| Over 85 | 943.0 | 133.9 | 897.5 | 5170.8 |
| average | 267.2 | 37.9 | 254.3 | 1465.1 |

Source: "Estimates of National Medical Expenditure"
and authors' calculation.

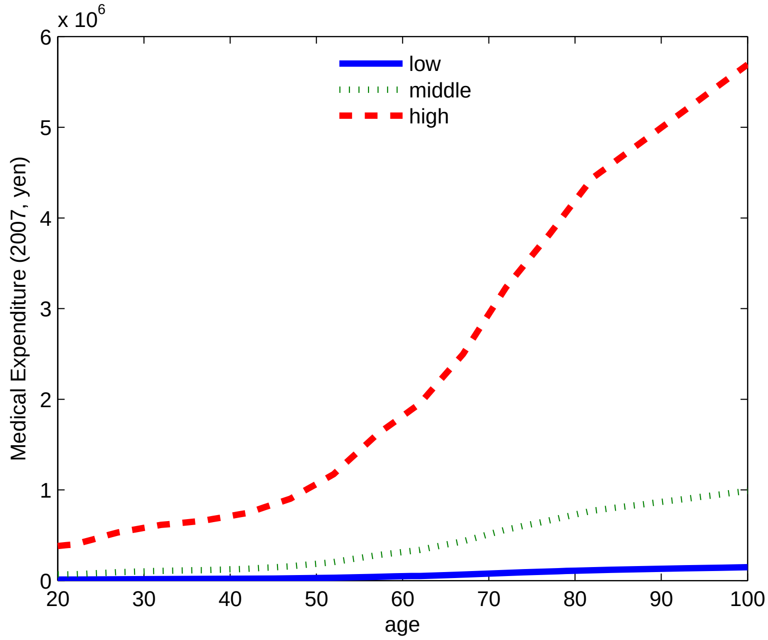


Figure 6: Medical expenditures by age in 2007

"Estimates of National Medical Care Expenditures." The estimated results are presented in Table 3.

We also linearly interpolate the medical expenditures so that the medical expenditures change smoothly over the life-cycle. Figure 6 shows the estimated medical expenditures of the three states from age 20 to 100.

### 3.5 Income shock process

We approximate the labor productivity shock $z$ by AR(1) process:

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

It is difficult to estimate stochastic hourly wage process without micro data on earnings and hours worked. It is very restricted to use such micro data of Japanese labor market. We use estimates by Abe and Yamada (2009) as a target of calibration for income risks. From the National Survey of Family Income and Expenditure, they estimate the *income* process of Japanese households. As labor supply in our model is endogenous, the corresponding income inequality is also endogenously determined. We set the skill shock parameters $\{\lambda, \sigma_\varepsilon^2\}$

to replicate Japanese income inequality from our model. We approximate the AR(1) process by finite Markov chain from Tauchen (1986)'s method.

We calibrate average labor productivity by age $\{\eta_j\}$ from the Basic Survey on Wage Structure (Chingin Kozo Kihon Tokei Tyosa), which is compiled by the Ministry of Health, Labour, and Welfare. Following Hansen (1993), we compute hourly wage of each age group.[5]

## 3.6 Health Care, Tax, and Social Security System

### 3.6.1 Price of Medical Expenditure

We focus on two issues that increase tax burden: aging population and increasing per capita costs of medical care. The medical care cost, which is captured by $q$, should change from the initial state corresponding to 2010 and is held constant after 2055. Following Attanasio, Kitao, and Violante (2008), we assume that the health care inflation rate is 0.63% per year. Then, the price of medical care increases about 32% in 45 years. Therefore, we set initial price of medical care to be one, $q_{2010} = 1$, and set final price at $q_{2055} = 1.3$. We also consider several alternative scenarios for medical expenditure inflation.

### 3.6.2 Health Care System

All citizens must contract with a health insurance society, which is based on occupation, e.g., employee, fisherman, public sector, employer, retiree, unemployed. Financial sources of medical expenditure consists of three components: (i) premium, (ii) tax, and (iii) out-of-pocket expenses. The premium covers only a half of total medical expenditure. The average out-of-pocket expense rate is about 15%. As mentioned in Section 2.3.2, the co-insurance rate, $1 - \omega(j)$, is 30% under age 70, 20% between 70 and 74, and 10% over 75. As the fraction of individuals who have bad health status increases by age, the average out-of-pocket rate is less than 30%. The remaining burden is covered by the government's general revenue.

### 3.6.3 Tax System

We consider two version of labor income tax function: linear tax and progressive tax code.

[5] For details, see also Braun et al. (2007).

- Basically, we use linear tax rate because our focus in this paper is to quantify the burden of future health care system. It is difficult to interpret the result if the tax code is nonlinear. When the labor tax rate is linear, the disposable earning in equation (3) is simply rewritten as follows:

$$y(n, j, z) = (1 - \tau_{ss} - p^{\mathrm{med}} - \tau_l)w\eta_j zn + ss(j).$$

  Notice that the labor tax rate $\tau_l$ balances the government's budget constraint in equation (7).

- Currently, the consumption tax rate $\tau_c$ in Japan is set at 5%; 4% for central government and 1% for local governments.

We calibrate exogenously determined public expenditure $G$ in the following manner. Government expenditure in 2010 is 83 trillion yen, which includes expenditures for public pension and medical care that amount 8.5 trillion yen. Thus, the government expenditure without social security related expenditure is 74.5 trillion yen. As nomical GDP in Japan is about 500 trillion yen, the target $G/Y$ is about 15%.

#### 3.6.4 Social Security System

The replacement rate of social security benefit $ss(j)$, which is estimated by Oshio and Yashiro (1997), is set at 40%. The payroll tax rate on social security system is endogenously determined. Current actual payroll tax rate for public pension is about 14%.

| Parameters | | Value |
|---|---|---|
| Discount factor | $\beta$ | 0.98 |
| Intertemporal elasticity of substitution | $\gamma$ | 2.0 |
| Share of labor supply | $\sigma$ | 0.33 |
| Capital share | $\alpha$ | 0.377 |
| Depreciation rate | $\delta$ | 0.08 |
| Persistence of labor productivity shock | $\lambda$ | 0.98 |
| Std. dev. of labor productivity shock | $\sigma_\varepsilon$ | 0.09 |
| Government share of NHI | $\psi$ | 0.25 |
| Price of medical expenditure | $q$ | $\{1, 1.36\}$ |

Table 4: Parameters of the Model

#### 3.6.5 Social Insurance

Social assistance (lower bound of consumption) $\underline{c}$ is set at 10% of average consumption.

# 4 Analysis

## 4.1 Impacts of population aging and increased medical cost

We use data from 2010 to set the initial values for the state variables. We investigate the impact of population aging and medical cost increases keeping all other things unchanged.

We first compare tax burdens in a steady state economy with the 2010 demographic structure and in economies with a population structure as projected in 2055. We assume that 2010 is the initial steady state. The benchmark model economy is calibrated to match the tax burden, the medical care cost, the capital-output ratio, population structure and some aggregate variables of Japanese economy in 2010. The government expenditure to GDP ratio is fixed at 15% as in 2010 by assumption. We also assume that the policy of government's subsidy to NHI is not changed – 25% of the total NHI cost; the policy of NHI co-insurance rate is not changed either. The remaining cost of the NHI is fully financed by the premium (a labor tax) in new steady states. The following scenarios are investigated:

**Unchanged cost of medical care**
In this case we assume that medical cost stays constant from 2010 to 2055. We assume the government would adjust labor (payroll) tax to ensure that it is able to finance the 25% share of the NHI cost. Obviously there will be an increase in the NHI cost due to the demographic change – there are more old people, who demand more medical care, but fewer tax/premium payers. The simulation result is presented in the second column of table 5. although the government's subsidy policy is not changed, the higher NHI cost requires an tax rate increase. The additional NHI cost in 2055 accounts for 2.4% labor income tax (including premium tax) increase for young people. This figure is likely to be the lower bound since we assume constant medical cost through 2055.

**Increased cost of medical care**

Table 5: The impact of population aging on NHI cost

| | Benchmark Initial SS (2010) | New SS w/ population aging (2055) Medical cost growth rate 0% | low [1] | 0.6% (Mid) | high [1] |
|---|---|---|---|---|---|
| $K/Y$ | 2.660 | 2.761 | 2.728 | 2.715 | 2.703 |
| $M/Y$ | 9.6% | 8.1% | 10.3% | 11.2% | 12.1% |
| $G/Y$ | 15% | 15% | 15% | 15% | 15% |
| **Tax burden** | | | | | |
| Social security tax | 9.6% | 12.1% | 12.1% | 12.1% | 12.1% |
| Labor tax | 11.2% | 12.3% | 13.0% | 13.3% | 13.5% |
| Premium | 6.8% | 8.1% | 10.3% | 11.1% | 12.0% |
| Consumption tax | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% |
| Capital tax | 39.8% | 39.8% | 39.8% | 39.8% | 39.8% |
| Increased NHI burden (as of labor income) | | 2.4% | 5.2% | 6.4% | 7.5% |

Note: $K/Y$ – capital output ratio; $M/Y$ – medical care cost - output ratio; $G/Y$ – government expenditure-output ratio.
[1] low – growth rate 0.4% per year; high – 0.75% per year.

If we assume the price growth of medical care is similar to the US, 0.6% annual growth rate, the medical care in 2055 will be about 30% more expensive than in 2010. Taking into account this medical price inflation, the NHI in the 2055 will increase the labor/premium tax rate by 6.4%. The result is shown in the 4th column of table 5.

Alternative growth rates are also investigated – in particular, a low growth rate, 0.4% per year (i.e. 20% price increase in 2055), and high growth rate, 0.75% per year (i.e. 40% price increase in 2055). The additional tax burdens caused by higher NHI costs are equivalent to 5.2% and 7.5% labor income tax, respectively. Table 5 presents the results.

## 4.2 Reform of NHI policy

To reduce the tax burden on the working age population with the aged population in 2055, we consider the following NHI policy reforms:
a) Having old people's (those above 70) co-payment (out-of-pocket) rate ad-

Table 6: Alternative NHI policies in 2055– steady state comparison

| | Current system | NHI policy reform Co-payment rate | | | | |
|---|---|---|---|---|---|---|
| | | 30% | 35% | 40% | 45% | 50% |
| $K/Y$ | 2.715 | 2.861 | 2.912 | 2.964 | 3.018 | 3.071 |
| $M/Y$ | 11.2% | 10.7% | 10.6% | 10.4% | 10.2% | 10.1% |
| $G/Y$ | 15.0% | 15.0% | 15.0% | 15.0% | 15.0% | 15.0% |
| **Tax burden** | | | | | | |
| Social security tax | 12.1% | 12.1% | 12.1% | 12.1% | 12.1% | 12.1% |
| Labor tax | 13.3% | 13.4% | 13.4% | 13.4% | 13.5% | 13.5% |
| Premium | 11.1% | 9.0% | 8.3% | 7.5% | 6.8% | 6.1% |
| Consumption tax | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% |
| Capital tax | 39.8% | 39.8% | 39.8% | 39.8% | 39.8% | 39.8% |
| **Welfare comparison** | | | | | | |
| CEV(new-born, $h$ =good) | 0.00% | 4.89% | 6.48% | 7.99% | 9.48% | 10.86% |
| CEV(new-born, $h$ =fair) | 0.00% | 4.90% | 6.48% | 7.98% | 9.45% | 10.82% |
| CEV(new-born, $h$ =bad) | 0.00% | 4.93% | 6.46% | 7.91% | 9.34% | 10.66% |
| CEV(all population) | 0.00% | -0.07% | 0.07% | 0.17% | 0.22% | 0.23% |

Note: CEV=CEQ-1

justed to 30% as young people's;
b) Increasing the co-payment rate to 35%, 40%, 45%, and 50% instead of the current 30%, and having old people's co-payment rate the same as young people's.

Welfare is measured by expected life time value with equilibrium distribution of all population or of the new-born. Welfare deviation is calculated by using the certainty equivalent consumption (CEQ) measure: given the utility function, $CEQ = (V_{\text{new}}/V_{\text{original}})^{1/[\sigma(1-\gamma)]}$, where $V_{\text{new}}$ is the welfare in the economy with a new policy and $V_{\text{original}}$ is the welfare in the original economy.

The results of the policy experiments are presented in table 6. We can see that the K/Y ratio increases as the NHI co-payment rate is raised because agents have to accumulate more precautionary savings to guard against the medical expenditure risk by themselves, especially for their old periods.

Table 7: Financing policies in 2055– steady state comparison

| | Current system | Financing policy reform Consumption tax rate $\tau_c$ | |
|---|---|---|---|
| | $\tau_c = 5\%$ | 10% | 15% |
| $K/Y$ | 2.715 | 2.775 | 2.834 |
| $M/Y$ | 11.2% | 11.0% | 10.8% |
| $G/Y$ | 15.0% | 15.0% | 15.0% |
| **Tax burden** | | | |
| Social security tax | 12.1% | 12.1% | 12.1% |
| Labor tax | 13.3% | 9.3% | 5.5% |
| Premium | 11.1% | 10.9% | 10.7% |
| Consumption tax | 5.0% | 10.0% | 15.0% |
| Capital tax | 39.8% | 39.8% | 39.8% |
| **Welfare comparison** | | | |
| CEV(new-born, $h$ =good) | 0.00% | 1.99% | 3.78% |
| CEV(new-born, $h$ =fair) | 0.00% | 2.00% | 3.79% |
| CEV(new-born, $h$ =bad) | 0.00% | 2.03% | 3.84% |
| CEV(all population) | 0.00% | 0.26% | 0.41% |

Note: CEV=CEQ-1

In addition, the policy reform of increasing co-payment forces old people to share more the medical care cost and lowers down the tax burden of young people. Therefore, we observe significant welfare improvement of the policy reform for the new-born (see CEV for the new-born in table 6). Moreover, the reduction of labor tax burden will less distort labor supply and improve the welfare. However, the higher co-payment hurts old people who face higher medical expenditure shocks. The average welfare of all population would be ambiguous. We find the CEV of all population is much smaller and even becomes negative (see CEV(all population) in table 6).

## 4.3 Reform of financing policy

Here we investigate various financing policies for the NHI with the aged population. We particulary focus on consumption tax ($\tau_c$) as a substitute of labor tax (as well as the premium). We investigate two cases: $\tau_c$ increased to 10% and to 15% in 2055. The results of the policy experiments are presented in table 7.

Imposing a higher consumption tax to substitute the labor tax also has a redistribution effect across generations: it forces old people to share more tax burden through the consumption tax since they do not pay any kind of labor taxes, and reduces young people's tax burden. The decrease in labor tax burden reduces labor distortion and improves welfare. Another effect is that people need to save more for their old ages to finance the pricier consumption. So we find higher K/Y ratios in the simulation results with the policy experiments.

In general, the welfare effect of this financing policy reform is similar to it with the NHI co-payment increase. The new-born enjoy the reform but the old do ont although the overall CEV is positive.

## 4.4 Transition

In the above we compare welfare in different steady states. The cost along with the transition is not considered.

Now we take into account the transitional cost for better understanding the welfare implications of the alternative polices. We assume that from the steady state in 2010, the economy will reach the second steady state in 2200, and we compute the transitional path between the steady states. The approach that we use here is similar to Nishiyama and Smetters (2005). Please see the computational details in the appendix.

We perform the transition analysis for two potential policy reforms: 1) changing old people's NHI co-payment rate to 30% as young people's; 2) increasing consumption to 10%. The results are presented by figures 7-9. Our finding suggests that older people would encounter a large loss under the reforms.

# 5 Robustness Analysis

To be written.

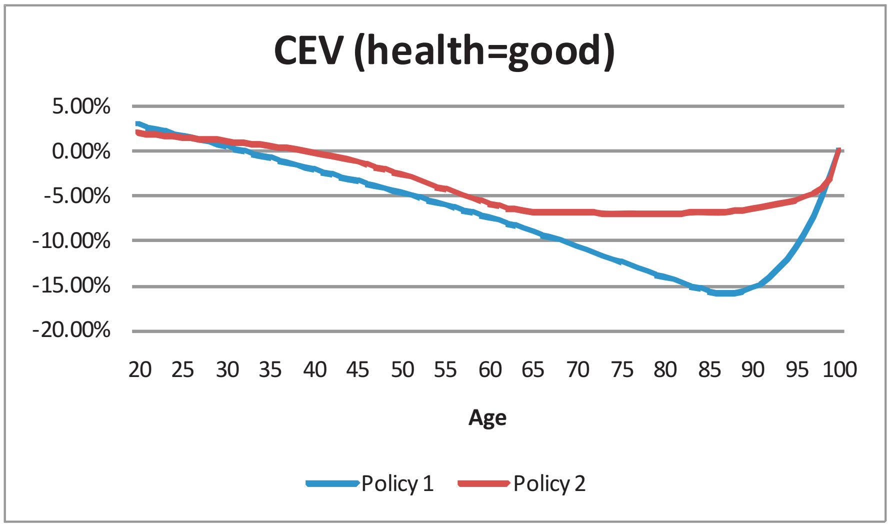


Figure 7: Policy reform – CEV by age (transition), good health

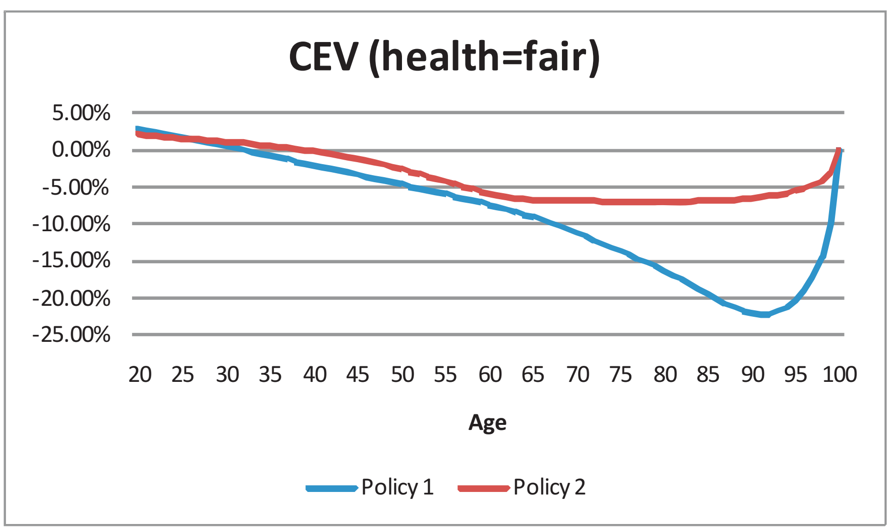


Figure 8: Policy reform – CEV by age (transition), fair health

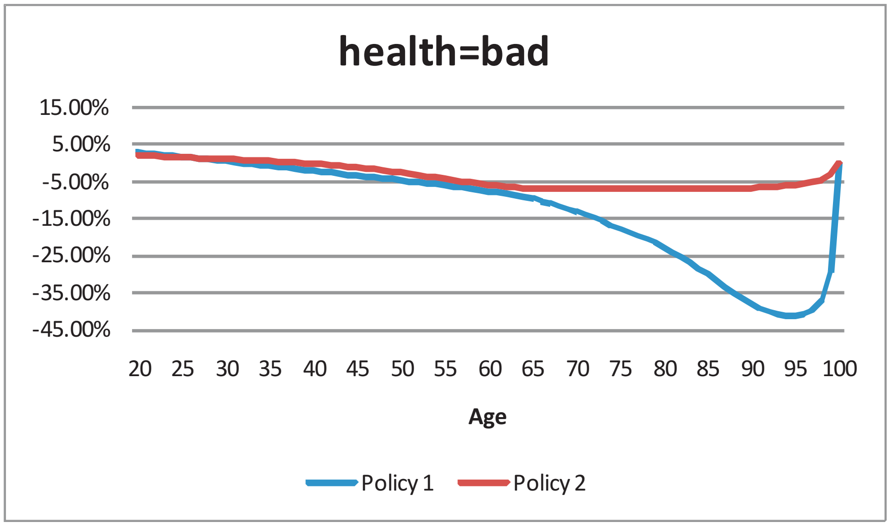


Figure 9: Policy reform – CEV by age (transition), bad health

# 6 Concluding Remarks

To be written.

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# A Health Insurance System in Japan

To be written.

# B Computational Details

To be written.