Macroeconomic and Fiscal Implications of Changes in the Labor Share under Population Aging in Japan*

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Abstract

This study examines how declining labor share affects macroeconomic outcomes and fiscal sustainability in Japan —the country with the most advanced population aging globally. While previous research has documented the global trend of declining labor share, its implications for fiscal policy in aging societies remain underexplored. Using a life-cycle general equilibrium model in the Auerbach-Kotlikoff tradition, we calibrate parameters to match Japan's economic and demographic characteristics, incorporating country-specific institutions such as public pension, health insurance, and long-term care systems. Our analysis reveals that when capital share increases by 3 percentage points between 2025-2060, it generates fiscal relief equivalent to approximately 3 percentage points in consumption tax by 2070 through enhanced capital accumulation. More significantly, this declining labor share amplifies the efficacy of pension reforms, potentially yielding savings equivalent to over 12 percentage points in consumption tax. Our findings suggest that declining labor share, when coupled with appropriate policy reforms, may benefit fiscal sustainability in rapidly aging societies with high public debt.

Keywords: Population aging, labor share, social security reform, overlapping generations model, Japanese economy.

JEL Classification: E22, E25, J11, H55, H60

1 Introduction

In recent years, there has been growing concern about the declining trend of labor share in various countries around the world. Piketty (2014), using French tax data, pointed out that historically the return on capital (r) exceeds the economic growth rate (g), resulting in an expansion of capital's share over time. Subsequently, empirical studies on the increasing trend of capital share (i.e., the decline in labor share) have been conducted in various countries While the research findings are in fact diverse, there are numerous results indicating a downward trend. However, in the context of macroeconomics, it is not clear what impact the decline in labor share has on the macroeconomy.

Since Kaldor (1961)'s stylized facts, various studies have been conducted under the assumption that capital share remains constant in various macroeconomic models. However, in many countries, labor share has not necessarily been stable, even when not declining. Elsby et al. (2013) and Karabarbounis and Neiman (2014) have studied the decline in labor share in the United States, emphasizing the importance of technological progress. With technological advancement, some labor has been substituted by capital. As the relative price of physical investment declined and ICT capital became more affordable, some of the simple labor tasks previously performed began to be replaced by capital. Moreover, with globalization, labor-intensive industries have become central industries in developing countries, while developed countries have specialized in capital-intensive industries, increasingly importing labor-intensive goods. These technological advances have increased returns to capital in developed countries, driving labor share downward.

Labor share is defined as the ratio of employee compensation to GDP or national income. Compensation of employees is the total value of labor income for all workers in a country. In other words, the compensation of employees is the sum of labor income of people with various backgrounds in terms of age and skills (human capital, or educational attainment). It may not be surprising that in many countries, labor share has not necessarily been constant over the decades. This is because labor markets are aging in various developed countries, including Europe and East Asia. Additionally, in many countries, college enrollment rates have increased, leading to a more educated workforce. As a result, labor input is influenced by the population distribution. If all workers were perfectly substitutable, the labor share would remain unchanged as long as the total labor input hours remained constant. However, in reality, some labor inputs may be more easily substituted with capital than others. Consequently, demographic changes may affect the labor share. Indeed, as shown in Figure 1, although labor share in Japan is stable, it exhibits a gradual declining trend.[1] However, in the previous macroeconomic literature, there is insufficient accumulation of quantitative research on the distributional impact of differences in labor share.

This paper focuses on the Japanese economy. As shown in Figure 2, Japan is the country with the most advanced aging population and declining birthrate in the world, with the old-dependency ratio –the proportion of those aged 65 and over to the working population– being exceptionally high among developed countries (Figure 2 (a)). Moreover, the fertility rate remains significantly below the replacement rate of 2.06, making the prospects for improvement in the aging population and declining birthrate challenging. Meanwhile, the progression of Japan's aging population and declining birthrate is also causing deterioration in the fiscal situation. Social security systems such as public pension systems, health insurance systems, and long-term care insurance systems are strongly affected by demographic trends. Generally, as healthcare expenditures and long-term care insurance expenditures are concentrated on the elderly, an aging population with a declining birthrate accelerates fiscal deterioration. Due to prolonged stagnation and the progression of an aging population with a declining birthrate, Japan's public debt to GDP ratio GDP is exceptionally high among developed countries. Under these circumstances, what macroeconomic implications does the decline in labor share bring? Furthermore, how is fiscal reform affected by the decline in labor share?

In this paper, we conduct a quantitative analysis of the impact of declining labor share on macroeconomic variables and social security system reforms using a quantitative

[1] In the calculation of labor share in Figure 1, following Hayashi and Prescott (2002), a portion of mixed income from "operating surplus and mixed income" has been added to compensation of employees. Also, this labor share is after removing the foreign sector (exports and imports) to ensure consistency with the subsequent model analysis.

life-cycle general equilibrium model. The basis is an Auerbach and Kotlikoff (1987) type large-scale overlapping generations model, with model parameters adjusted to the current Japanese economy, modeling various Japan-specific institutions such as health insurance and long-term care insurance, and conducting fiscal simulations.

The analysis results are as follows. Based on numerical results, if the labor share remains unchanged, fiscal conditions will deteriorate with the progression of the aging population and declining birthrate, indicating that a tax increase equivalent to more than 20% in consumption tax would be necessary to maintain fiscal sustainability. However, compared to this baseline scenario, it was revealed that if the labor share decreases (i.e., the capital share increases), a tax-saving effect equivalent to more than 3% in consumption tax would occur. Furthermore, the increase in capital share has an effect of enhancing the impact of partial reductions in public pensions, revealing an expected tax-saving effect equivalent to more than 12% in consumption tax. This is considered to be strongly influenced by the increase in income and consumption among the elderly associated with the rise in capital share. From the above, we point out that the decline in labor share is not only negative but also has the potential to create greater effects when combined with certain policies.

This paper builds upon two streams of prior research. The first concerns quantitative analysis using large-scale overlapping generations models. Since the seminal work by Auerbach and Kotlikoff (1987), numerous studies analyzing population aging and social security reforms through large-scale overlapping generations models have been published, including those by De Nardi (2004), Nishiyama and Smetters (2005, 2007), and Kotlikoff et al. (2007). Regarding the Japanese economy specifically, notable contributions include works by Braun and Joines (2015), Kitao (2015a,b, 2018). İmrohoroğlu et al. (2016, 2017, 2019) conducted quantitative analysis of Japan's fiscal sustainability challenges using a partial equilibrium model with more detailed modeling of Japan's fiscal aspects. These studies collectively demonstrate that, despite some numerical variations depending on assumptions about the Japanese economy, a consumption tax rate equivalent of over 30% would be necessary to sustain Japan's fiscal position. While the present study employs a similar methodological approach, its examination of declining labor share represents an academic contribution not addressed in previous research.

The second research stream concerns recent studies on the trends of labor share. Even before Piketty (2014)'s observations on long-term labor share decline, the possibility of decreasing labor share had been identified based on U.S. data. For instance, Elsby et al. (2013) explain factors contributing to labor share decline through capital substitution in manufacturing and trade sectors, offshoring of labor-intensive industries, and declining unionization rates. Karabarbounis and Neiman (2014) similarly note that the decline in the relative price of investment goods has induced firms to substitute capital for labor, contributing to labor share decline. The emergence of superstar firms has been proposed as another explanation for labor share dynamics. Autor et al. (2017) and Autor et al. (2020) document how firms with lower labor shares have gained market share, contributing to the aggregate decline in labor share. Meanwhile, Koh et al. (2020) focus on the role of intellectual property products (IPP), proposing an adjustment methodology to appropriately incorporate IPP into capital and labor contributions. While this study does not aim to endogenously explain labor share trends, it offers a novel analysis of how changes in labor share, taken as given, affect macroeconomic outcomes and policy effectiveness.

This paper is structured as follows. First, in Section 2, we illustrate how changes in population balance can affect labor share using a simple model. Here, rather than providing exact figures, we limit ourselves to showing the potential impact of population distribution on labor share. Section 3 explains the life-cycle general equilibrium model used in the actual analysis. Section 4 explains how to set the model parameters, comparing them with the real Japanese economy. Section 5 discusses the numerical calculation results of the model. Section 6 summarizes the entire paper.

2 Endogenous Determination of Labor Share: An Example

In a Cobb-Douglas production function, by assumption, the labor share is determined by exogenous parameters. However, this property is not necessarily true in all production functions. For example, in production functions that incorporate capital-skill complementarity as proposed by Griliches (1969), the labor share can vary endogenously via the effects of demographic changes. We will illustrate this point using a simple example of a production function that incorporates capital-skill complementarity. Let us assume that production is generated from three types of inputs: capital K, skilled labor L_s, and unskilled labor L_u.

The production function is expressed as:

$$Y = (K + L_u)^{\theta} L_s^{1-\theta}$$

where capital K and unskilled labor L_u are perfect substitutes, and their sum affects production.

Due to the homogeneity of the production function, output is the sum of the marginal products of each input:

$$\begin{aligned} Y &= rK + w_s L_s + w_u L_u, \\ &= \frac{\theta}{K + L_u} YK + \frac{\theta}{K + L_u} YL_u + \frac{1-\theta}{L_s} YL_s, \end{aligned}$$

where r is the rental rate of capital, w_s is the wage of skilled labor, and w_u is the wage of unskilled labor. Sum of the second and third term, $\frac{\theta}{K+L_u} YL_u + \frac{1-\theta}{L_s} YL_s$, constitutes the compensation of employees in the System of National Account, and when divided by Y, it yields the labor share. Consequently, the labor share becomes $1 - \theta \left(1 - \frac{L_u}{K+L_u}\right)$. Since $0 \leq \frac{L_u}{K+L_u} \leq 1$, as this term approaches 0, the labor share approaches $1 - \theta$. [2]

[2] The capital-skill complementarity model proposed by Griliches (1969) is frequently employed to explain the mechanism of skill premiums. It is well-documented that in the United States, despite an

Under the capital-skill complementarity model, for a given capital K, as the proportion of unskilled labor decreases, the labor share also decreases. Thus, the possible range of the labor share is $[1-\theta, 1]$.

The proportions of unskilled labor, skilled labor, and capital can naturally change over time. Research measuring skill premium often approximates skilled and unskilled labor as college-graduates and high school-graduates workers, respectively. In Japan, the college enrollment rate for individuals born in 1950 was approximately 14%, 22% for males and about 6% for females, whereas in recent years, over 50% of the same cohort individuals attend university. In addition, as shown in Figure 3 (a), Japan's population distribution is not flat, but has several peaks due to factors such as the baby boom. Therefore, the total labor supply is determined by the aggregate number of skilled and unskilled workers across age groups, thus it is influenced by demographic distribution.

While the labor share may change endogenously due to population distribution, however, it is difficult to fully explain this movement using a Griliches-type production function numerically. Therefore, in the following, we will exogenously vary the parameter representing the capital share in the Cobb-Douglas-type production function. Additionally, based on microdata, we will set exogenous wage profiles to account for differences in productivity between skilled and unskilled labor. While this approach cannot endogenously explain the impact of population distribution on the labor share, the objective of this paper is to examine the macroeconomic and fiscal implications of changes in the labor share.

3 Model

In this section, we present a theoretical framework to analyze the relationship among demographic changes, labor share and fiscal burdens. There are two types of economic

increase in skilled labor L_s, the skill premium has risen, which contradicts the intuition of conventional demand-supply and price mechanisms. However, in the capital-skill complementarity model, an increase in capital stock has the effect of enhancing the marginal productivity of skilled labor, thereby potentially increasing the skill premium even as L_s increases. In contrast, Japan's skill premium is known to be more stable compared to the United States. This may be attributable to the counterbalancing effect of increases in both skilled labor and capital K.

agents in the model. One type consists of individuals who graduate from high school and start working at the age of 18, and the other type consists of individuals who graduate from university and start working at the age of 22. In our model, whether or not to attend university is determined by an exogenous parameter, and we assume that they start economic activity at the age of 18 or 22. Based on their educational attainment, individuals are classified into high-skilled (h) or low-skilled (ℓ) workers, where $s \in \{h, \ell\}$. In Japan, the proportion of college graduates has increased over the past few decades, resulting in significant differences in the distribution of skills across cohorts.

3.1 Demographic Transition

Time is discrete with calendar time denoted by t. The demographic structure is characterized by the population size $\mu_{j,t}$ for each age j at time t, with the total population at time t given by $\sum_j \mu_{j,t}$, where the population size is the sum of two types of individuals, i.e., $\mu_{j,t} \equiv \mu_{j,h,t} + \mu_{j,\ell,t}$.

The life-cycle structure of the model assumes that individuals begin their working life at age 18 or 22, depending on their educational attainment, and retire after reaching age $jr + 1$. In our calibration, the retirement age, $jr + 1$, is set at 65, and individuals can live up to a maximum age of $J = 105$. It should be noted that individuals between ages 0 and 17 are considered dependents and do not participate in the labor market.

Survival risk is incorporated through age- and time-dependent survival probabilities $\zeta_{j,t} \in [0, 1)$. The evolution of cohort sizes follows the relationship $\mu_{j+1,t+1} = \zeta_{j+1,t+1}\mu_{j,t}$. The model takes the population distribution of 2019 (the year immediately preceding the COVID-19 pandemic), $\{\mu_{j,2019}\}_{j=0}^{J}$, as the target year for calibration. Population dynamics are governed by fertility rates $\psi_{j,t}$ for women aged 15-49, with new cohorts entering the economy according to $\mu_{0,t+1} = \sum_{j=15}^{49} \psi_{j,t}\mu_{j,t}^{\text{female}}$, where $\sum_{j=15}^{49} \psi_{j,t}$ represents the total fertility rate.

3.2 Household

We assume exogenous labor supply during working age. Labor income is determined by macroeconomic wages w_t and individual productivity levels by skill type $\eta_{j,s}$, which are time- and age-dependent, i.e., $y_{j,s,t} = w_t \eta_{j,s}$. After retirement, individuals' productivity becomes zero and they receive a public pension benefit $ss(\hat{y})$ based on their average past earnings $\hat{y}$. The average past earnings $\hat{y}'$ of age j at time t evolve according to $\hat{y}' = \frac{(j-1)\hat{y}+\min(y_{j,s,t},y^{\max})}{j}$ for working-age individuals ($j < jr$) and remain constant after retirement. There is un upper limit on the earnings recorded in the past earnings history based on the current Japanese publis pension system, denoted as $y^{\max}$. The public pension benefit, $ss(\hat{y})$, consists of two components: a basic pension (*kiso nenkin*) represented by ρ_0, and an earnings-related part (*kosei nenkin*) calculated as $\rho_1\hat{y}$: $ss(\hat{y} = \rho_0 + \rho_1\hat{y}$.

Households face the following budget constraints:

$$(1+\tau_t^c)c_{j,t} + a_{j+1,t+1} = (1-\tau_j^y)y_{j,s,t} + R_t(a_{j,t}+b_t) - m_j - \xi_t^* \text{ if } j < jr, \quad (1)$$

$$(1+\tau_t^c)c_{j,t} + a_{j+1,t+1} = (1-\tau^{lc})ss(\hat{y}) + R_t(a_{j,t}+b_t) - m_j - \xi_t^*, \text{ if } j \geq jr. \quad (2)$$

where c is consumption, a is asset holdings, R_t is the after-tax gross rate of return on assets, m_j represents mandatory medical expenditures that do not yield utility, and ξ_t^* is a lump-sum tax/transfer used to adjust the government's budget balance in the initial steady state. τ_j^y represents the combined rate of labor income tax (τ^l), social security payroll tax (τ^p), premium for public health insurance (τ^h), and long-term care insurance (τ_j^{lc}). The premium for the long-term care insurance is age-dependent as the government imposes the premium on only individuals aged 40 and older, and $\tau_j^{lc} = 0$ for those under 40 in Japan.

Following Braun and Joines (2015) and Kitao (2015a,b), individusl savings are exogenously allocated to productive capital and public debt. The government determines the portfolio allocation parameter ϕ_t to match the empirical debt-to-capital ratio. Therefore, the gross rate of return on assets is a mix of the return on capital, r^k, and the return on exogenously determined government bonds, r^d. The after-tax gross rate of return on assets, R_t, is given by $R_t \equiv 1 + (1 - \tau^k) r_t^k (1 - \phi_t) + (1 - \tau^d) r^d \phi_t$, where capital income is taxed at rate τ^k, while government bonds are subject to tax rate τ^d. The government also impose consumption tax τ_t^c to balance the government budget.

Additionally, households face mandatory medical expenditures m_j that do not yield utility, and are subject to a borrowing constraint $a' \geq 0$. The term ξ_t^* represents a lump-sum tax/transfer used to adjust the government's budget balance in the initial steady state and transition paths in the periods of fixed consumption tax rate.

Households are characterized by their state variables: age (j), asset holdings (a), skill level (s), and average past earnings ($\hat{y}$). The household's objective function is represented by the following value function:

$$V_{j,t}(a, s, \hat{y}) = \max_{c,a'} \{u(c_{j,t}) + \zeta_{j+1,t+1} \beta V_{j+1,t+1}(a', s, \hat{y}')\} \tag{3}$$

3.3 Technology

Production function is the standard Cobb-Douglas type:

$$Y_t = Z_t K_t^{\alpha_t} L_t^{1-\alpha_t}$$

where Y_t is the output, K_t is the capital stock, L_t is the labor input, and Z_t is the technology level. $\left(\frac{Z_{t+1}}{Z_t}\right)^{1/(1-\alpha)} \equiv 1 + g_t$ is the TFP factor growth rate.[3] As we emphasized in Section 2, the labor share parameter α_t may vary over time.

Production sector is competitive and the factor prices are determined from the first order condition.

$$r_t^k = \alpha_t Z_t K_t^{\alpha_t - 1} L_t^{1-\alpha_t} - \delta, \tag{4}$$

$$w_t = (1 - \alpha_t) Z_t K_t^{\alpha_t} L_t^{-\alpha_t}, \tag{5}$$

[3] In the numerical calculation, all variables are detrended by dividing $Z_t^{1/(1-\alpha)}$. For details, see Braun et al. (2009) and Hansen and İmrohoroğlu (2016).

where δ is the depreciation rate of capital. The aggregate asset, $A_t = \sum_s \sum_j \mu_{j,t}(a_{j,s,t} + b_t)$, is distributed into production sector and public debt depending on ϕ_t:

$$A_t = (1 - \phi_t)A_t + \phi_t A_t = K_t + D_t.$$

3.4 Medical Expenditure and Long-term Care Expenditure

In Japan, individuals pay only a portion of the cost of medical treatment or long-term care, and the remaining portion is covered by the public health insurance, with the co-payment rate depending on age. Each of the co-payment rate are denoted as λ_j^h and λ_j^l respectively. The out-of-pocket medical and long-term care expenses that appear in the individual's budget constraint are as follows:

$$m_j = \lambda_j^h m_j^h + \lambda_j^l m_j^l.$$

where m_j^h and m_j^l are the expenses for medical care treatment and the long-term care respectively.

The sum of the medical and long-term care expenses by the government is as follow:

$$M_t = \sum_j \mu_{j,t} \left[(1 - \lambda_j^h) m_j^h + (1 - \lambda_j^l) m_j^l \right].$$

3.5 Government

We consider a unified budget constraint that includes the public pension system, the public health insurance system, and the long-term care system following İmrohoroğlu et al. (2016, 2017, 2019). General government revenue consists of tax revenue from labor income T_t^y, tax revenue from capital income T_t^a, revenue from consumption taxes T_t^c, newly issued government debt D_t, and lump-sum taxes ξ_t^*. From the total revenue, the government pays for public pension benefits S_t, medical and long-term expenditures M_t, government expenditure G_t, and the gross interest payment on government debt

$(1 + r^d)D_{t-1}$:

$$G_t + (1 + r^d)D_{t-1} + S_t + M_t = T_t^y + T_t^a + T_t^c + D_t + \xi^*. \tag{6}$$

$T_t^y = \tau_j^y \sum_s \sum_j y_{j,t}\mu_{j,s,t}$ is the sum of tax revenue from labor income. Tax revenue from capital income and the government debt is given by: $T_t^a = \sum_s \sum_j [\tau^k r_t^k (1 - \phi_t) + \tau^d r^d \phi_t](a_{j,t} + b_t)\mu_{j,t} = \tau^k r_t^k K_t + \tau^d r^d D_t$. The government also collect consumption tax revenue, $T_t^c = \tau_t^c \sum_j c_{j,t}\mu_{j,t} = \tau_t^c C_t$, where C_t is the aggregate consumption. Consumption tax rate τ_t^c is determined endogenlusly to balance the budget under transition paths.

The public pension payments consist of the basic pension, which is a fixed amount for each individuals, and the earnings-related pension, which is based on the average past earnings $\hat{y}$: $S_t = \sum ss(\hat{y})\mu_{j,t} = \sum_{j=jr+1}^{J} (\rho_0 + \rho_1 \hat{y}_{j,t})\mu_{j,t}$. ξ_t^* is the lump-sum tax (transfer) that adjust the budget balance in the initial steady state, in which the consumption tax rate is fixed at the current level. ξ_t^* may also be used to adjust the budget balance in the transition path in the periods of fixed consumption tax rate.

3.6 Definition of Competitive Equilibrium

Given a set of exogenous demographic parameters $\{\mu_{j,t}\}, \{\zeta_{j,t}\}, \{\phi_{j,t}\}$, and a set of exogenous government policy variables $\{G_t, D_t, \tau_t^k, \tau_d, \tau_j^y, \xi^*\}$, a competitive equilibrium consists of individuals' decision rules, $\{V_{j,t}(a, s, \hat{y})g_{j,t}(a, s, \hat{y})\}$ a sequence of factor prices $\{r_t^k, w_t\}$, accidental bequests $\{b_t\}$, a sequence of consumption $\{c_{j,t}\}$ for each time $t = 0, 1, ...,$ such that:

1. Individuals' solve the Bellman equation (3) under the budget constraints (1) and (2) with the policy functions $g_{j,t}(a, s, \hat{y})$.

2. Factor prices are determined in competitive markets: (4) and (5).

3. Accidental bequests are distributed to the individuals in the lump-sum manner:

$$b_t = \sum_s \sum_{j=1}^{J} \mu_{j,t}\zeta_{j,t}a_{j,t}.$$

4. The government budget constraint (6) is satisfied.

5. The capital and labor markets clear:

$$K_t = (1-\phi_t)\sum_{s}\sum_{j=1}^{J}\mu_{j,s,t}(a_{j,t}+b_t),$$

$$L_t = \sum_{s\in\{h,\ell\}}\sum_{j=1}^{jr}\mu_{j,s,t}\eta_{j,s}.$$

6. The goods market clearing condition is satisfies:

$$C_t + K_{t+1} + G_t + M_t = Y_t + (1-\delta)K_t.$$

4 Calibration

This section explains how the model parameters are calibrated to the Japanese economy. Although macroeconomic parameters would be available after 2020, since they may have deviated from their steady state due to the impact of the COVID-19 pandemic in 2020, we will set parameters based on the data from 2019. While the parameter targets are based on 2019 data, the transition path is calculated for the period 2004-2400. This is because neither 2019 nor 2025, the year in which the policy changes in the policy simulation, can be considered a steady state, and to express the point that the current year is in the middle of the transition path.[4]

4.1 Population

We use the official population projection provided by the National Institute of Population and Social Security Research (IPSS) in Japan released in 2023. The institute provide three variants of future fertility and mortality rate projections: low, medium and high. We use the medium variant for both parameters. The IPSS estimates future population

[4]For more details on the calculation of transition paths, see Hsu and Yamada (2017).

path between 2020 and 2070. We assume that the total fertility rate, which is calculated from $\{\psi_{j,t}\}$, converges to the steady state level (i.e., TFR is 2.06) from 2070 to 2120, and set the final steady state in 2400.[5]

Figure 3 (a) shows the population distribution in 2020. As the figure shows, the population distribution is bimodal, with a large number of individuals in their late 40s and 70s. Since the baby boomer Jr. generation in their 40s, the number of young people has been steadiliy decreasing. Figure 3 (b) plots the fertility rate by age. The fertlity rate itself declines and the peak age of the fertility is shifting to the right. As a result, as Figure 3 (c) and (d) show, the number of worker is expected to decline and the old dependency ratio is expected to increased from 0.54 in 2020 to almost 0.8 in 2070.

4.2 Labor Productivity and College Enrollment Rate

Earnings profiles by skill type, $\{\eta_{s,j}\}$, are estimated from the Basic Survey on Wage Structure, which is compiled by the Ministry of Health, labor and Welfare in Japan. We use the wages of college graduates for high-skilled workers. On the other hand, the wage data on high school graduates are used for the wage profiles of low-skilled workers. In Figure 4, we plot the average earnings between 2000 and 2019 for college graduates and high school graduates by age. As Figure 4 shows, both high-skilled and low-skilled workers' wages are hump-shapedd with age, although the level of high-skilled workers' wages is higher than that of low-skilled workers.

As for the ratio of skill types, we use the four year college advancement rate by year. In Figure 5, we calculate the advancement rate of four year college/university by age from the Basic School Survey in 2019. In 1980s, the advancement rate was less than 30%, but it has been increasing steadily since then. Recently, more than 50% of high school graduates are entering four-year colleges/universities.

[5] Braun and Joines (2015) assume that the TFR converges to the steady state level for 100 years.

4.3 Medical and Long-term Care Expenditure

Regarding the medical expenditures $\{m_j^h\}$ and expenditures for the long-term care expenditures $\{m_j^l\}$, we update the data used in İmrohoroğlu et al. (2019). Figure 6 (a) plots the exogenous medical expenditure by age. In their working age, the medical expenditures remains low, but it starts to increase after the age of 60. In Japan, the 70% of the medical expenditures are coverd by public health insurance, and the remaining 30% are paid by individuals before the age of 70: $\lambda_j^h = 0.3$. The co-payment rate is set at 20% between 70 and 74, and it is set at 10% for those aged 75 and older. Figure 6 (b) plots the long term care expenditures in 2018. Spending on nursing care is more concentrated among the elderly than spending on medical care. Regarding the co-payment rate, the long-term care insurance system was introduced in 2000, and the co-payment rate is set at 10%.

4.4 Government

Public Pension: In the benchmark model, the public pension system has two components. The first-tier, called *kokumin nenkin* in Japanese, pays a fixed amount of Basic pension for each personk. The second tier (*kosei nenkin*) depends on the past average earnings $\hat{y}$. We set the basic pension payment at 55,800 yen per month, which is then annualized: : $\rho_0 = 55,800 \times 12$. The parameter ρ_1 determines the earnings-related component of the public pension (*kosei nenkin*). We set ρ_1 to 0.25 in order to match the average replacement rate of the earnings-related pension in Japan.

Tax: According to İmrohoroğlu et al. (2016), we set the interest rate on government bonds, r^d, to 0.01, and the tax rate τ^d to 20% respectively. We set the marginal labor income tax rate τ^l at 6.15% to match the tax revenue from labor income in the model with the actual data. The health insurance rate and long-term care insurance rate are also set so that the total amounts in the model would match the data. Details will be discussed in Section 5.1. The social security payroll tax τ^s is set at 0.183, reflecting the post-2018 rate of 18.3%. For capital income tax, we follow İmrohoroğlu et al. (2017)

and set τ^k at 0.1. Consumption tax rate τ^c is set the actual number in the data before 2025, and determined endogenously after 2026 to balance the government budget.

4.5 Other Parameters

The calibration of our tax system involves several key parameters. The discount factor β is chosen to match the capital-output ratio (K/Y) of 2.413 in the model.

Parameters were calibrated to ensure that all values pertaining to the steady state and transition paths align with empirical data. With respect to government expenditure G_t, we set the ratio of G_t such that the G_t/Y_t ratio in the model corresponds to the empirical data. It should be noted that G excludes expenditures on public pensions and medical and long-term care insurance. For instance, the ratio of government expenditure to GDP in 2019 was 0.126. Similarly, the parameter Φ is calibrated to match the historical public debt ratio (D_t/Y_t). As of 2019, the D_{2019}/Y_{2019} was 1.6489.[6] For future transition paths, we assumed an extrapolation of the 2025 ratios.

All the calibration parameters are summarized in Table 1.

5 Results

5.1 Model Economy in 2019

Let us first verify that the parameters in our model accurately replicate the Japanese economy. Our target is the Japanese economy immediately prior to COVID-19, specifically in 2019.

The figure in the top left of Table 2 represents values derived from actual SNA (System of National Accounts) data in Japan. The units are in trillion yen; for instance, Japan's GDP in 2019 was 556.8 trillion yen, with total private consumption at 303.93 trillion yen and gross fixed capital formation at 142.21 trillion yen. Government final

[6] The public debt includes public pension funds, and these government funds have been netted out. For details on the methodology of constructing public debt and government expenditure data, refer to İmrohoroğlu et al. (2016).

consumption expenditure (67.7 trillion yen) excludes expenditures on public pensions, public health insurance, and long-term care insurance to maintain consistency with our model, and includes provisions for public goods. It should be noted that our model assumes no utility derived from public goods. The two columns on the right compare macroeconomic variables when normalizing GDP to 1, for both empirical data and model projections. Compared to the data, our model estimates consumption approximately 6% higher, while fixed capital depreciation is approximately 20% lower.

Table 3 illustrate expenditure and revenue sides, respectively, showing both absolute values and ratios relative to GDP (normalized to 1). The basic pension and the earnings-related part of public pension amounted to 23.97 trillion yen and 31.65 trillion yen, respectively, in 2019. Meanwhile, expenditures on health insurance totaled 44.39 trillion yen, and long-term care insurance benefits reached 10.78 trillion yen. The middle and right columns display these values normalized to GDP equal to 1. The discrepancies between the model and actual data show approximately 10% error for national health insurance, while other categories exhibit errors of less than 10%. The revenue side, conversely, presents the scale of various funding sources. Based on the Japanese central government's budget, income tax revenue in 2024 was 19.53 trillion yen, corporate tax revenue was 12.07 trillion yen, and consumption tax yielded 21.72 trillion yen. The values normalized to macroeconomic output equal to 1 are summarized in the middle and right columns. Again, the values in the model are not far from the actual values of the Japanese economy.

5.2 Transition Dynamics: Baseline Scenario

Figure 7 plots the equilibrium consumption tax rates $\{\tau_t^c\}$ from 2004 to 2070, which balance the government budget constraint (6), and the endogenously determined return on capital $\{r_t^k\}$ in the transition path. As discussed in Section 4.4, our model closes the government budget constraint using the consumption tax. More precisely, we fixed tax rates and insurance premium rates other than the consumption tax, and adjusted either the consumption tax rate or lump-sum tax ξ_t^* to ensure that the government budget constraint is satisfied in each period. As plotted in Figure 7 (a), we used the actual consumption tax rates from 2004 to 2025; the ump-sum tax ξ_t^* is adjusted to balance the budget. Until 2013, Japan's consumption tax rate was 5%. It increased to 8% from April 2014, and to 10% from October 2019. For the transition years of 2014 and 2019 when the tax rate changed mid-year, we used the weighted average of the respective periods as the consumption tax rate for that year.

From 2026 onward, the consumption tax rate in our model changes endogenously to ensure the government budget constraint is satisfied. Consequently, there is a jump in 2026. If we were to balance the government budget constraint solely through consumption tax, the consumption tax rate would need to increase to approximately 14% in 2026. Subsequently, the equilibrium consumption tax rate continues to increase almost monotonically. This is due to the progress of population aging in Japan. In our baseline model, only the population distribution changes along the transition path. As the proportion of elderly increases, the total expenditure on medical care and long-term care insurance rises, as indicated in Figure 6, which shows that medical and long-term care expenditures increase for the elderly. Meanwhile, as the working population decreases, labor income tax revenue declines. To cover these costs, the consumption tax rate must inevitably increase. It continues to rise beyond 2070, reaching approximately 40% around 2120 according to our simulation results. However, it should be noted that the simulation results for this period are strongly dependent on predictions and assumptions regarding population distribution, and may change significantly in accordance with future forecast revisions.

Conversely, the return on capital r_t is projected to decline by approximately 1.4 percentage points over the 45-year period from 2025 to 2070. This phenomenon stems from the declining birthrate and aging population. As postulated by the life cycle income hypothesis, middle-aged and elderly individuals tend to accumulate greater savings than their younger counterparts. As the population distribution increasingly concentrates toward the elderly, aggregate capital will temporarily increase. Consequently, the capital-output ratio (K/Y) will rise, advancing capital deepening. Given these factors, the marginal productivity of capital will decrease, and it is anticipated that, based on our model, returns on capital will fall by approximately 1.4% from current levels by around 2070. The potential decline in returns on capital accompanying the aging demographic has been noted by researches such as Blanchard (2023), suggesting that resource distribution between capital holders and wage-dependent workers will be significantly affected.

It is important to note that we are by no means advocating that all future revenue shortfalls *should* be covered by consumption tax. We are merely calculating the potential increase in fiscal burden when converted to consumption tax terms. Naturally, the tax system, including consumption tax, should be designed considering various efficiency factors. Consumption tax has advantages compared to income tax, notably that it can generate revenue from the elderly population as well. While progressive labor income tax has the benefit of reducing ex-post income inequality, it has the drawback of being unable to collect taxes from the elderly. In contrast, consumption tax has the advantage of being able to collect taxes from the elderly population, which is expected to increase in the future. Additionally, since wealthier individuals tend to consume more, consumption tax can ensure a certain degree of fairness.[7]

5.3 Decline in Labor Share

Next, let us examine how fiscal burden and macroeconomic variables change when the labor share decreases. In the baseline scenario, we assumed that the capital share remained constant at 0.4254. Let us now assume that the capital share increases linearly from 2025, reaching 0.4554 by 2060. Table 4 summarizes how the interest rate, total assets, output, and equilibrium consumption tax rate change in comparison to the baseline for the years 2040, 2050, and 2060.

As the capital share increases, total assets A_t rise due to the promotion of capital accumulation. At the point of 2040, the increase is merely 0.574% compared to the

[7] Although it has been pointed out that in Japan, consumption tax applies to almost all consumption expenditures, which may exacerbate inequality since necessities like food items and luxury goods are taxed at the same rate.

baseline, but by 2070, it leads to more than a 10% increase in total capital Although we assume that the capital share begins to increase from 2025, the effects of this gradual rise in capital share become prominent only after several decades, due to both the modest pace of increase and the time required for capital accumulation. However, a mere 0.03 point increase in capital share (with other parameters held constant) promotes a 10% accumulation of capital in the future. In our model, since the total labor supply is exogenous, the increase in capital stock directly translates to an increase in output.

Despite the increase in total capital, the interest rate also rises slightly compared to the baseline scenario. This is due to the effect of the increase in the value of the capital share α_t itself. As the capital share increases, the consumption tax rate required to balance the government budget decreases. The effect is minimal at the point of 2040, but by 2070, it results in more than 3% reduction in consumption tax. This is because the increase in capital share promotes capital accumulation, which leads to an increase in output.

5.4 Policy Experiments

Finally, let us analyze how the decline in labor's share of income might potentially alter the effects of policies. In this policy experiment, we measure the effects of policies under two scenarios: one where the capital share remains constant, and another where the capital share increases by 0.03 percentage points as in the previous section.

Let us consider two policies: (i) The first policy is to increase not only the consumption tax but also the labor income tax τ_t^l. Specifically, following İmrohoroğlu et al. (2019), we increase the labor income tax rate by 5 percentage points in 2026, from 6.15% to 11.15%. (ii) The second policy is to partially cut public pensions. Specifically, we reduce ρ_2, which was 0.25 in the baseline scenario, to 0.15. In other words, we reduce the earnings-related part of public pensions by 10% relative to past average income. Both policies contribute to improving the fiscal balance; however, while one policy places the burden on the working population, the other places it on the elderly population, resulting in contrasting effects.

Table 5 summarizes the effects of two policies in the baseline scenario. The left column presents values for the years 2040, 2050, 2060, and 2070 in the baseline scenario, with assets normalized to 1 in 2040 for clarity. The two rightmost columns illustrate the differences generated by each policy when compared to the baseline. Both the increase in labor income tax τ^l and the reduction in public pension ρ_2 diminish the fiscal burden as measured by consumption tax τ_t^c. Notably, a policy that reduces the earnings-related component of public pension by 10% yields a tax-saving effect exceeding 8% in terms of consumption tax. However, these two policies have different effects on capital accumulation. Cutting public pensions encourages savings to secure future living expenses, while raising labor taxes reduces the source of savings and thus hinders capital accumulation. Therefore, their effects on the real rate of return are also opposite.

Table 6 compares the effects of these same two policies under economic conditions where the capital share increases. As in Table 5, the two columns on the right calculate deviations from the baseline scenario values. The column labeled "no policy change" represents cases where there was no policy change and only the capital share increased. Again, the effect of reducing public pension is particularly substantial, with an anticipated tax reduction effect of approximately 12% when the capital share increases. This phenomenon can be attributed to two factors: the strengthened saving motive resulting from decreased post-retirement income, and the increased capital income of the elderly population due to the higher capital share, which leads to increased expenditure among this demographically significant group. Conversely, while taxing labor income also produces a consumption tax reduction effect, its impact is less pronounced than that of reducing public pensions. The increase in labor income tax constitutes taxation on the source of savings for younger generations, thereby reducing disposable income and negatively affecting capital accumulation. Nevertheless, since the rise in capital share encourages capital accumulation, the aggregate effect ultimately contributes positively to capital accumulation in the long term.

6 Conclusion

In this paper, we have conducted a quantitative analysis of how the decline in labor share affects macroeconomic conditions and policy efficacy utilizing a lifecycle general equilibrium model. By calibrating parameters specifically for Japan –a country experiencing population aging and declining birth rates– we examined how fiscal consolidation policies in Japan are influenced by variations in labor share.

The findings demonstrate that an increase in labor share can stimulate capital accumulation, promote capital deepening, and potentially alleviate fiscal burden. This is attributable to the possibility that, in an aging Japan, it may foster increased capital income among middle-aged and elderly demographics who constitute the high-asset class. Furthermore, the results indicate that policies encouraging savings by partially reducing public pensions for the elderly may make a greater fiscal contribution compared to policies that tax labor income earned by workers.

Our findings suggest several critical implications for deliberations on the future trajectory of the Japanese economy. First, the decline in labor share is not necessarily entirely detrimental, as it may promote additional savings through enhanced returns on capital, thereby potentially contributing to the amelioration of fiscal challenges. Additionally, substituting a portion of public pensions with savings predicated on self-reliance efforts could potentially enable a further reduction in the equilibrium consumption tax rate.

Nevertheless, several preconditions must be satisfied for these outcomes to materialize. Primarily, nominal interest rates from Japanese banks remain considerably low, with the nation currently in the process of gradually transitioning away from its zero interest rate policy. Unless a capital market structure that adequately secures returns on savings can be guaranteed, the anticipated effect of stimulating savings cannot be realized. Moreover, if firms allocate substantial portions of their profits to internal reserves rather than returning them as capital yields, the incentive for savings may similarly be diminished. In recent years, Japan has witnessed a growing momentum toward accumulating personal savings in preparation for old age. Further reinforcement of this trend is likely to contribute significantly to Japan's future fiscal consolidation efforts.

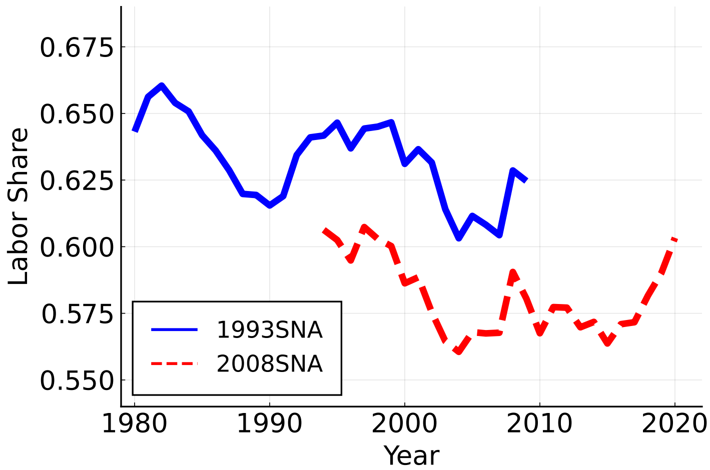
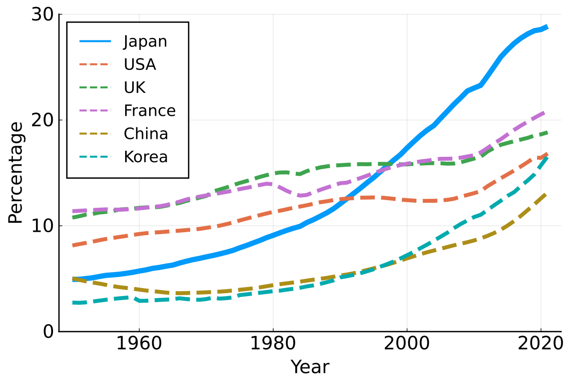
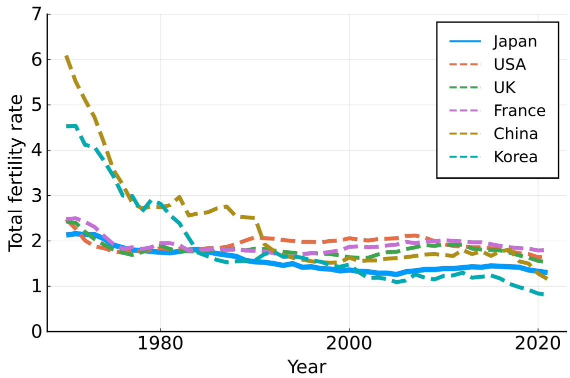


Figure 1: Labor Share

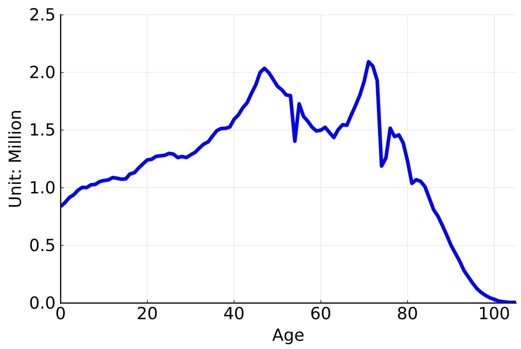


(a) Percentage of Elderly

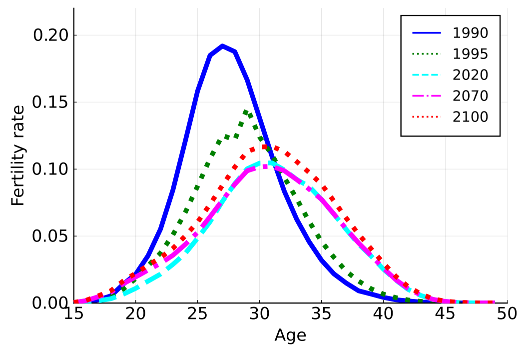


(b) Total Fertility Rate

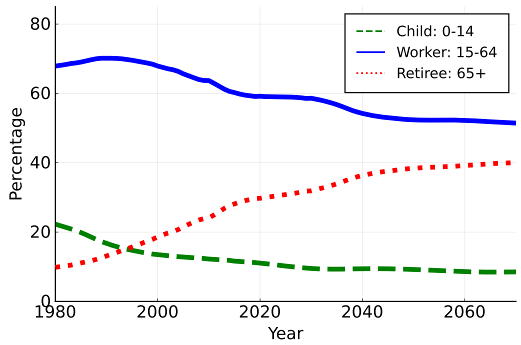
Figure 2: Population Aging and Fertility Rate in OECD Countries



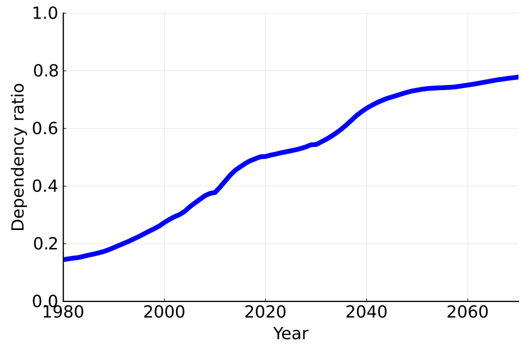
(a) Population distribution in 2020



(b) Fertility rate by age



(c) Population by category



(d) Old dependency ratio

Figure 3: Population Projection in Japan: 2020-2070

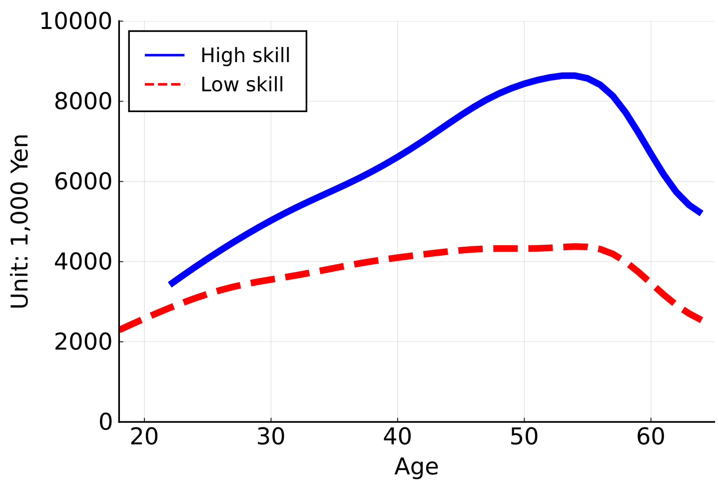


Figure 4: Wage Profile by Skill: Basic Survey on Wage Structure

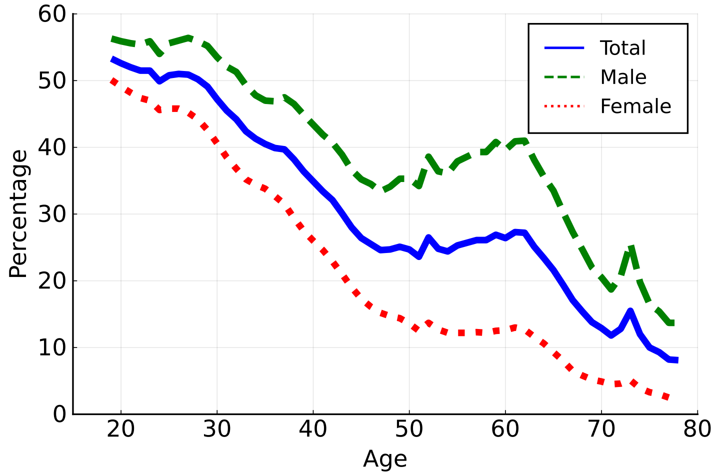
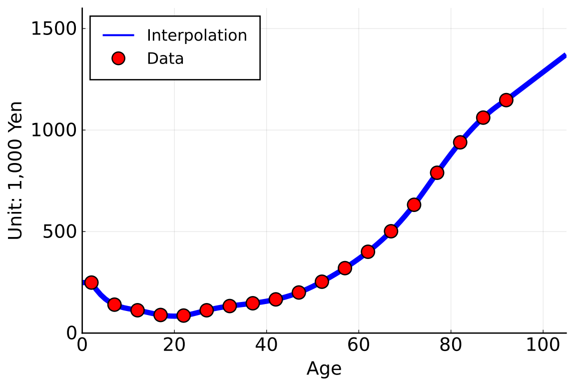
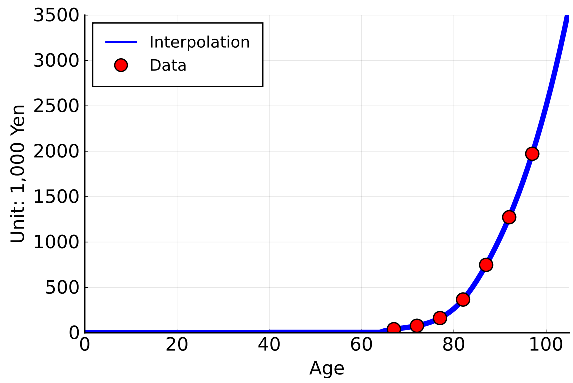


Figure 5: Advancement Rate by Age in 2019

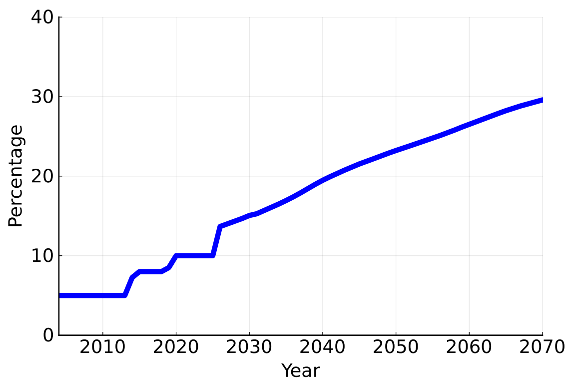


(a) Medical expenditure by age

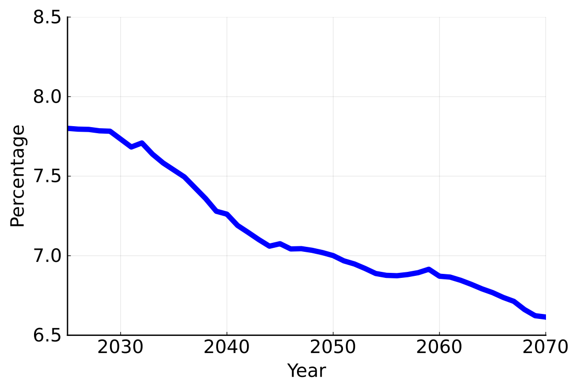


(b) Nursing care expenditure by age

Figure 6: Medical and Nursing Care Expenditures by Age



(a) Consumption tax rate



(b) Real rate of return from capital

Figure 7: Transitional Path of Consumption Tax Rate and Real Rate of Return from Capital from 2004 to 2070

Table 1: Parameters of the Model (Steady State in 2019)

Parameter	Description	Values/source
Demographics		
$\{\zeta_{j,t}\}$	survival probabilities	IPSS (2023)
$\{\psi_{j,t}\}$	fertility rate	IPSS (2023)
$\{\mu_{j,t}\}$	population distribution	Census survey and IPSS
Preferences		
β	subjective discount factor	1.003 ($K/Y \approx 2.413$)
γ	risk aversion	2.0
Labor market		
$\{\eta_{j,s}\}_{j=18(22)}^{64}$	labor productivity	BSWS
Technology		
g	TFP factor growth rate	1.0%
α	capital share	0.4254 (2019)
δ	capital depreciation rate	0.0829
Government		
τ^l	labor income tax	6.15%
τ^p	payroll tax	18.3% (2019)
τ^h	health insurance premium	6.91%
τ^{lc}	long-term insurance premium	0.75%
τ^k	capital income tax	10%
τ^d	tax on gov. bond return	20%: İmrohoroğlu et al. (2017)
ξ^*	lump-sum tax/transfers	see text
$y^{\max}$	upper limit of pension contribution	10.44 million JPY
$\{m_j^h\}$	medical expenditures	Figure 6 (a)
$\{m_j^l\}$	long-term nursing care expenditures	Figure 6 (b)
D_t/Y_t	net debt to GDP ratio	1.6489 (2019)
G_t/Y_t	government expenditure to GDP ratio	0.1260 (2019)
r^d	interest rate on government bond	1.0%

Table 2: SNA and Steady State in 2019

Description	Data (trillion JPY)	Normalized Data	Normalized Model
GDP	556.80	1.000	1.000
Expenditure			
Private consumption (excl. M and LT)	303.93	0.546	0.580
Govt consumption (excl. M and LT)	67.74	0.122	0.126
Gross capital formation	142.21	0.255	0.200
Income			
Compensation of employees	317.40	0.570	0.575
Consumption of fixed capital	140.56	0.252	0.200

Table 3: Government Budget: Data and Model

Description	Data (trillion JPY)	Normalized Data	Normalized Model
Expenditure			
Public pension: 1st tier	23.97	0.043	0.046
Public pension: 2nd tier	31.65	0.057	0.057
Medical expenditure	44.39	0.080	0.088
Long-term care expenditure	10.78	0.019	0.020
Interest payment for govt debt	8.42	0.015	0.015
Revenue			
Labor income tax	19.53	0.035	0.035
Capital income tax (corporate tax)	12.07	0.022	0.026
Consumption tax	21.72	0.039	0.049
Public pension	51.96	0.093	0.105
Public health insurance	21.94	0.039	0.040
Long-term care insurance	2.38	0.004	0.004

Table 4: Impact of Declining Labor Share on Key Variables

Year	Diff. in r_t	Diff. in A_t	Diff. in Y	Diff. in τ_t^c
2040	0.753%	0.574%	1.990%	-0.232%
2050	1.050%	3.299%	4.732%	-1.138%
2060	1.265%	7.179%	8.351%	-2.474%
2070	0.969%	10.776%	11.693%	-3.906%

Table 5: Policy Experiments without Declining Labor Share

Year	Baseline	High τ^l	Low ρ_2
Interest rate			
2040	7.283%	0.206%	-0.506%
2050	7.009%	0.312%	-0.580%
2060	6.871%	0.398%	-0.649%
2070	6.610%	0.457%	-0.703%
Asset			
2040	1.000	-2.272%	5.857%
2050	1.031	-3.506%	6.946%
2060	1.048	-4.484%	7.926%
2070	1.058	-5.210%	8.787%
Consumption tax rate			
2040	19.586%	-4.986%	-6.060%
2050	23.315%	-4.773%	-7.065%
2060	26.644%	-4.583%	-7.885%
2070	29.765%	-4.399%	-8.762%

Table 6: Policy Experiments with Declining Labor Share

		No policy	High α +	
Year	Baseline	change	High τ^l	Low ρ_2
Interest rate				
2040	7.283%	0.753%	0.966%	0.280%
2050	7.009%	1.050%	1.376%	0.517%
2060	6.871%	1.265%	1.680%	0.674%
2070	6.610%	0.969%	1.435%	0.336%
Asset				
2040	1.000	0.574%	-1.722%	5.926%
2050	1.031	3.299%	-0.353%	9.690%
2060	1.048	7.179%	2.332%	14.691%
2070	1.058	10.776%	4.983%	19.437%
Consumption tax rate				
2040	19.586%	-0.232%	-5.111%	-6.149%
2050	23.315%	-1.138%	-5.830%	-7.950%
2060	26.644%	-2.474%	-7.050%	-9.995%
2070	29.765%	-3.906%	-8.435%	-12.209%

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