Demography, Fiscal Sustainability, and Social Security System in Japan

Sagiri Kitao* Minamo Mikoshiba†

July 15, 2024

Abstract

This chapter presents a survey of recent developments in the study of Japan's demographic transition and fiscal sustainability from a macroeconomic perspective. We begin by reviewing growth models that use aggregate data, followed by various overlapping generations models that focus on issues related to fiscal sustainability, social security, fertility and foreign workers within the context of demographic aging in Japan. Next, we build a quantitative general equilibrium model populated by overlapping generations to analyze the impact of demographic aging on Japanese households, macroeconomy and fiscal situation. The model incorporates heterogeneity in gender, marital status, earnings and assets to quantify how demographic conditions affect the behavior of different households and influence the transition path of the aggregate economy. Additionally, the model details the social security system in Japan, encompassing public pension, healthcare, and long-term care insurance programs. We quantitatively assess how demographic aging affects the government budget balance through changes in the financing of these programs and the tax burden on future generations. We also explore which factors are critical in mitigating the fiscal burden and labor shortage over the coming decades.

Keywords: Demographic aging, social security, public pension, health insurance, long-term care, gender, family, fertility, foreign workers.
JEL Classification: E00, E20, H55, J11

*National Graduate Institute for Policy Studies: sagiri.kitao@gmail.com
†Nagoya University: minamo.mikoshiba@gmail.com

1 Introduction

The recent demographic trends in Japan, characterized by a secular decline in fertility and increased longevity, have significantly altered the age distribution and the composition of government expenditures. The age pyramid now peaks in the early 50s, representing the second baby boom generation, and again in the mid 70s, representing those born after the World War II. For the past five decades, fertility rates have remained well below the replacement level needed to maintain a stable population, leading to a chronic decline in the working-age population.

Understanding the macroeconomic and fiscal consequences of ongoing demographic aging in Japan necessitates a quantitative analysis using a large-scale model that incorporates households from different generations and interactions between the public and private sectors to account for rising government expenditures. There are several approaches to analyzing the economic impacts of demographic aging. One approach is to use generational accounting models that describe the relationship between individual variables at the micro level and changes in macroeconomic variables for each cohort. Accounting models can handle multiple dimensions of heterogeneity across households and one can also compare the economic conditions of different generations as a simple outcome of the model.

However, these models are limited in their ability to investigate potential household responses to changes in economic environments, such as movements of wages and interest rates, increased longevity, and time-varying tax burdens and social security policy. As a partial equilibrium model, they do not consider the feedback effects from actions of households to macroeconomic variables.

Endogenous growth models of infinitely-lived individuals, which approximate the movement of aggregate variables, address some shortcomings of accounting models. The models, however, require strong assumptions to analyze the effects of demographic aging, since age in not a factor that explicitly affects decisions of households or impacts the government budget. Overlapping generations models, on the other hand, capture age and cohort heterogeneity across households and provide a tractable framework for considering demographic shifts and the impact of policy changes on different generations of households. In the survey section of this chapter, we review recent developments of the literature focused on demographic aging and its macroeconomic impact using different approaches.

We then present a quantitative model of overlapping generations calibrated to the Japanese economy. The model incorporates heterogeneity in gender, marital status, age, earnings, and assets of households. The model economy consists of both public and private sectors, with the government managing social security systems such as public pensions, healthcare, and long-term care insurance programs. We quantify how the demographic aging over the coming decades will influence government spending in each component and generate the tax burden on future cohorts. Additionally, we explore how alternative scenarios regarding demographic variables and women's labor supply conditions could impact these transition paths.

In Section 2, we present a survey of macroeconomic literature on demographic aging and fiscal sustainability. Section 3 presents our quantitative model, calibration of the model to the Japanese data, and numerical results, and Section 4 concludes.

2 Models of Demographic Aging and Fiscal Policy

Over the past few decades, various types of quantitative macroeconomic models have been developed to analyze the impact of the demographic transition on macroeconomy and fiscal sustainability. In this section, we review recent developments in the literature since the late 2000s, with a particular emphasis on models that are specifically applied to the Japanese economy. Section 2.1 surveys models that use aggregate data, and Section 2.2 reviews studies incorporating heterogeneous households that belong to overlapping generations, focusing on the roles of fiscal policies in the context of aging economy.

2.1 Aggregate Data and Neoclassical Growth Model

We start by reviewing quantitative analyses that use aggregate data and neoclassical growth models. Broda and Weinstein (2005) provided an early analysis of fiscal sustainability from an accounting approach, arguing that Japan's government debt does not have a major impact on medium- to long-term fiscal sustainability. In contrast, Doi et al. (2011) showed that a substantial increase in tax rates is necessary to maintain fiscal sustainability and stabilize the size of government debt relative to GDP. Hoshi and Ito (2014) also employed an accounting method to estimate the future fiscal imbalance and concluded that large-scale tax increases and spending cuts are necessary.

There are also papers that develop general equilibrium models of infinitely lived agents to analyze the impact of demographic changes and associated tax increases on macroeconomic variables. Imrohoroglu and Sudo (2011) built a neoclassical growth model to examine changes in the fiscal balance and government debt under various scenarios. They argued that increasing revenues through consumption taxes and productivity growth is essential to maintaining fiscal sustainability under population aging. However, they found that even if the consumption tax is raised to 15% and the GDP growth rate reaches 3%, achieving fiscal surplus would still be challenging. Hansen and İmrohoroğlu (2016) also used a neoclassical growth model to assess the additional taxation required to prevent the expansion of government debt. They calculated the necessary tax rate when the government debt reaches 250% of GDP, which they assume would trigger a tax increase to reduce the debt level to 60% of GDP in the long-run. Without spending cuts, the budget balancing tax would reach 30-40% of total consumption.

These recent papers using aggregate models demonstrate the magnitude of fiscal challenges faced by the Japanese economy undergoing rapid and extensive demographic aging. However, as models of infinitely-lived agents, they are not suitable to study how future tax increases or shifts in factor prices and macroeconomic conditions affect households that belong to different cohorts. Investigating these age and cohort-specific effects requires a model with overlapping generations, which explicitly incorporates the demographic structure of the economy. In the next section, we present a survey of papers that use overlapping generations models to explore wide-ranging issues related to demographic aging.

2.2 Overlapping Generations Models and Demographic Aging

The history of overlapping generations models is extensive, and dates back to classic contributions of Samuelson (1958) and Diamond (1965), which use two-period overlapping generations models. The theoretical models allow for the derivation of analytical solutions and theorems that provide intuitions and differ from those derived in infinite-period models. However, analytical models often fall short in explaining individual behavior over the life-cycle as observed in data and in deriving practical and quantitative policy implications.

The workhorse model of overlapping generations was developed by Auerbach and Kotlikoff (1987), establishing the foundation of quantitative analysis of household behavior over the life-cycle. In their full-blown life-cycle model, individuals enter the economy at age 20 and live up to a maximum age of 74, making consumption, saving, and labor supply decisions at each age to maximize lifetime utility. The model assumes no uncertainty, with households taking wages, interest rates, and fiscal policies as given. In competitive markets, firms rent capital and labor supplied by households to maximize profits. The market wage and interest rate are determined competitively, balancing supply and demand in their respective factor markets. The government finances public consumption and expenditures, including pensions, by taxing household income and consumption.

Starting with the Auerbach and Kotlikoff (1987) model, quantitative analysis using large-scale overlapping generations models has advanced considerably, building on the model elements described above. These overlapping generations models capture incentives of individuals of different ages and intergenerational resource allocations, serving as powerful tools for quantitatively analyzing the impact of demographic shifts on macroeconomy and fiscal sustainability. By integrating various crucial factors, these models have achieved better alignment and consistency with microdata.

By including idiosyncratic risks individuals face over the life-cycle, the model can also account for intra-generational heterogeneity, allowing for the evaluation of policies from redistributional perspectives. The development of so-called Bewley models, pioneered by Bewley (1986), İmrohoroğlu (1989) and Aiyagari (1994), as well as Huggett (1996), which incorporated uninsured idiosyncratic risks and incomplete markets in a life-cycle model, greatly advanced the scope of quantitative analysis. Various models were developed to study life-cycle aspects of economic issues, such as the macroeconomic analysis of social security reforms, life expectancy uncertainty, bequest motives, and the intergenerational linkage of inequality. For the analysis of demographic and fiscal issues facing Japan, large-scale overlapping generations models have been extensively used since the 2000s. Next, we review studies about the Japanese economy on topics about fiscal sustainability, the social security system including public pensions, health and long-term care insurance programs, fertility and foreign workers.

Fiscal Sustainability: Recent literature analyzing the impact of population aging on fiscal sustainability in Japan demonstrates that significant tax increases or spending cuts are inevitable to maintain the current social security and tax system. In an early quantitative analysis, Ihori et al. (2006) built a model of endogenous saving and consumption to study the macroeconomic and welfare impacts of demographic aging. Using a general equilibrium model, they showed that the tax burden would rise to 36% of GDP by 2050 due to increasing expenditures and accumulated government debt. Braun and Joines (2015) endogenized labor supply in a general equilibrium model and analyzed the medium- to long-term impact of aging on government debt. They argued for the urgent need to implement pension and health insurance reforms, showing that without such reforms, the debt will continue to grow, leading to a default by 2040. Kitao (2015) built a model endogenizing labor supply in both intensive and extensive margins to account for the retirement behavior of the elderly. By incorporating pension, healthcare, and long-term care insurance systems into the model, the paper showed that a substantial tax increase is necessary to maintain the current generosity of the social security systems, with the required tax revenue amounting to about 50% of total consumption at its peak.[1] McGrattan et al. (2019) constructed a dynamic general equilibrium model of overlapping generations to study various policy options to finance the demographic transition in Japan. They found that financing through gradual increases in the consumption tax rate is a better option for macroeconomic performance and welfare than alternatives such as raising the insurance premium or issuing debt.

There are papers that demonstrate the importance of considering individuals' heterogeneity within a cohort when analyzing fiscal sustainability. İmrohoroğlu et al. (2016) constructed a generational accounting model that incorporates heterogeneity in gender, employment status, earnings, and assets. They showed that one of the most important factors for the success of fiscal consolidation would be an increase in the labor supply of women. Kitao and Mikoshiba (2020) analyzed how changes in labor force participation and productivity of men and women affect the macroeconomy and fiscal sustainability, under a general equilibrium framework. The study pointed out that while maintaining and increasing labor force participation is essential, a rise in participation rates alone, without an increase in productivity, cannot have a significant effect. The key is to promote employment of women and the elderly, with a particular emphasis on improving the productivity of women.

Other studies analyzed the impact of tax and social security systems on women's labor. Yamada (2011a) constructed a life-cycle model with endogenous labor supply decisions of married women and studied the impact of tax reform in Japan during the 1990s. He found that tax cuts increased the hours worked by married women and estimated their elasticity of hours to be 0.8. Kitao and Mikoshiba (2024) analyzed the effects of tax and social security regulations on women's labor supply and human capital accumulation. They showed that eliminating tax and social security provisions, such as the spousal deduction and exemption from the social security premium payment for low-income dependents, would not only increase labor force participation of women but also encourage the accumulation of human capital. More women would choose regular employment throughout their life-cycle and their life-time earnings would be significantly higher.

[1] See also Chen et al. (2007) and Braun et al. (2009) that build overlapping generations models and study factors that account for the historical path of saving rates in Japan.

Social Security System: As demonstrated in the papers discussed above, one of the main factors contributing to a rise in government expenditures over the coming decades is the social security system: rising costs of public pensions, health, and long-term care insurance programs. This implies that if government spending on these social security programs can be curbed, the tax burden will be significantly mitigated.

Early quantitative analyses of social security reforms using an overlapping generations model include Yamada (2011b) and Okamoto (2013). These papers constructed a general equilibrium model populated by many generations, taking into account the income uncertainty faced by households and the two-tiered pension system in Japan. They analyzed the impact of pension reform on the welfare of current and future generations. Yamada (2011b) showed that reforms to eliminate the earnings-related part of the pension system and to raise the basic pension benefits would improve the welfare of future generations. He also demonstrated that the reform can be implemented without worsening the welfare of the working-age population by appropriately adjusting the benefit structure during the transition. Okamoto (2013) found that reforms to eliminate the earnings-related part and to fund the basic pension with a consumption tax would raise saving and output, but have a limited impact on welfare. Additionally, the results indicated that the reform would bring relatively more benefits to higher-income households.

Most papers study the effects of social security reforms assuming specific implementation timings and details, although there exists much uncertainty about when and how the reforms will be implemented in the future. Kitao (2018) considered uncertainty of future pension systems in Japan, by explicitly modeling households' expectations about the timing and content of the reforms. The study showed that policy uncertainty significantly impacts the transition paths of macroeconomic variables and household welfare. Postponing and scaling back reforms would benefit current middle-aged and older adults, but result in additional fiscal burdens and lower welfare for young and future generations, posing a trade-off across generations.

Several studies have built overlapping generations models that incorporate medical expenditure risks to study the roles of the public health insurance system in Japan. Hsu and Yamada (2019) developed a general equilibrium model with medical expenditure risk to evaluate the impact of public health insurance reform. They found that reforms to raise co-payment rates would significantly enhance the welfare of future generations. However, these reforms would also lead to higher out-of-pocket expenditures, thereby reducing the welfare of the working-age population, and highlighting political challenges associated with implementing such changes. Similarly, Hagiwara (2022) analyzed reforms to increase co-payment rates of health insurance, while considering elastic demand for medical care. Compared to models with inelastic demand, these reforms would result in greater welfare gains for future generations and mitigate welfare losses for current generations. These improvements stem from lower insurance premiums, driven by reduced household demand for medical care in response to higher co-payments, and from higher wages due to increased capital accumulation from additional precautionary savings.

The extent to which income and savings can mitigate the risk of medical costs over the life-cycle varies with individual characteristics. Therefore health insurance reforms would lead to different responses of households. Fukai et al. (2024) constructed an overlapping generations model that includes heterogeneity in gender, education, marital status, and health status. They showed that when co-payment rates are raised, high-income households increase their savings to prepare for higher expenditures, while low-income households reduce savings and consumption when faced with large medical expenditure shocks. While benefit cuts would reduce healthcare spending, the reform results in a rise in the number of welfare recipients.

The public long-term care insurance system has gained policy importance along with the aging population. Mikoshiba (2023) developed an overlapping generations model incorporating two-sided altruism between parents and children. The study demonstrated that the long-term care insurance system mitigates disability risks in old age, and eliminating the system would significantly harm household welfare due to higher financial costs of long-term care and reduced labor income from informal care. The impact on household welfare is shown to depend on the labor productivity of potential family caregivers, underscoring the need for system design to consider impacts on family members from the medium- to long-term perspectives.

Fertility: It has been long recognized that family decisions, including those related to fertility, children's education, family members' time allocation, marriage, and divorce, influence not only the economic decisions of households but also the movement of macroeconomic variables. The literature on family and macroeconomics has grown rapidly, investigating various issues specific to families.[2] Driven by concerns over population decline and labor shortage, overlapping generations models that endogenize fertility decisions of households have been used to evaluate the impacts of family-related policies on childbirth, education and men and women's labor supply in Japan.

[2]See Doepke and Tertilt (2016) and Doepke et al. (2023) for comprehensive surveys of the literature on topics of family macroeconomics and fertility.

Oguro et al. (2011) analyzed how fiscal reforms and child-related policies financed by consumption taxes would affect the macroeconomy, fiscal situation, and household welfare. They showed that increasing child allowance would improve the welfare of the current and future generations. Furthermore, Oguro et al. (2013) examined household welfare when the increase of child allowance benefits was financed by alternative taxes and debt. Okamoto (2020) considered long-run macroeconomic and welfare impacts of changes in child benefits, findingthat while the improvement in fertility is limited, the reform enhances welfare in the long run by increasing the working-age population.

Recent papers consider the interaction of family formation decisions and heterogeneity within households, such as differences in productivity and labor market opportunities between men and women, and the division of labor by household members. Yamaguchi (2019) constructed a dynamic discrete choice model that explicitly describes household decisions about women's employment and fertility over the life-cycle. The study found that introducing one-year parental leave would significantly increase the employment rate of women with children. However, extending the duration of parental leave further or providing cash benefits has little additional impact.

Hagiwara (2024) constructed a general equilibrium overlapping generations model that endogenizes both the quantity and quality of children. He found that while cash childcare benefits have a limited effect on fertility, they promote investment in children already born. In contrast, in-kind childcare support is more effective in raising fertility. Nakakuni (2024) developed a model incorporating fertility choices and household heterogeneity in marital status, number of children, and their education. He demonstrated that raising childcare benefits would improve the welfare of households without children through positive externalities. Despite an increased tax burden on households, the net gain is achieved due to the reduced cost of the public pension system through improved fertility.[3]

Guest Workers and Immigrants: Another approach to mitigate labor shortages and to address macroeconomic and fiscal challenges is to accept more foreign workers and/or immigrants. İmrohoroğlu et al. (2017) analyzed the impact of a policy that accepts a certain number of foreign guest workers each year. Assuming that 200,000 foreign workers with the same productivity level as Japanese workers arrive annually and stay for 10 years, their study showed a fiscal effect equivalent to a maximum of about 5%

[3]See also Kitao and Nakakuni (2024) for a study that investigates the trend of family formation and time allocation of families, extending a model of Greenwood et al. (2023) by incorporating gender differences in household decisions and production.

of total consumption due to increased tax revenues. In contrast, Shimasawa and Oguro (2010) argued that immigration policy alone could not significantly reduce the debt, even though there would be fiscal effects, assuming the acceptance of 150,000 people each year. A possible reason for differing results is that accepting immigrants rather than foreign guest workers increases government spending due to the need to provide the same social security benefits as those given to Japanese citizens.

3 Quantitative Analysis of the Japanese Economy and Demographic Aging

In this section, we present a quantitative general equilibrium model of overlapping generations to study the effects of demographic aging on the macroeconomy and fiscal situations in Japan. As discussed in Section 2, most of the previous studies on the effects of demographic aging do not explicitly consider the heterogeneity of family structure. The model presented in this section incorporates heterogeneity in genders and marital status of individuals and the household structure.

Studies such as Fukai et al. (2024) and Kitao and Mikoshiba (2024) incorporate marital heterogeneity into overlapping generations models for Japan, and we build on their modeling strategy.[4] They focus, however, on different issues: the roles of medical expenditures and insurance, and tax policies and female labor supply, respectively. Moreover, these papers are steady-state analyses assuming partial equilibrium and do not analyze the effects of general equilibrium or the long-term transition process, which are important factors in the present analysis focused on demographic aging.

In evaluating the long-term outlook for the Japanese economy, the decline in the labor force due to the low birthrate and aging population is one of the most critical factors to consider. Given the already high participation rates of men with little room to grow further, the evolution of women's labor force participation and productivity over the coming decades is crucial. Data show that women's employment and earnings tend to fluctuate more than men's over their lifetimes, and these patterns are highly dependent on marital status. Considering the heterogeneity of marital status, alongside age and gender, is essential for a more accurate understanding of the future outlook for the Japanese economy.

Moreover, a number of recent studies suggested the importance of explicitly incor-

[4]The baseline model used in this section is Kitao et al. (2023).

porating differences in family structure, such as marital status and number of children, into macroeconomic models, as also discussed in Section 2. This study can be considered as an attempt to bring new insights to the literature of macroeconomic analysis and demographic aging by building on the findings from the literature on family and macroeconomics.

3.1 Model

This section describes the macroeconomic model used for our analysis of demographic aging and fiscal sustainability. In our model, individuals are heterogeneous in four dimensions: age, gender, marital status, and assets. We denote age as $j = \{1, ..., J\}$, gender as $g = \{m, f\}$, marital status as $q = \{S, M\}$, single or married, and assets as a. Singles include both never-married and widowed individuals. t denotes the time period. The vector of state variables is defined as $x = (j, g, q, a)$, and the number of individuals in state x in period t is denoted by $\mu_{x,t}$. Also, we denote the total number of individuals in a particular state by μ with a subscript, for example, as $\mu_{g,t}$.

Demographics: An individual enters the economy at age $j = 1$ and survives up to a maximum age of J. The life span is uncertain, and the conditional probability of survival until the next period for an individual of age $j-1$ and gender g at time $t-1$ is denoted by $\Phi_{j,g,t}$. The probability of survival from birth to age j is denoted as $\Phi_{j,g,t} = \prod_{k=1}^{j} \phi_{k,g,t+(k-j)}$. Note that $\Phi_{1,g,t} = \phi_{1,g,t} = 1$ and $\Phi_{J+1,g,t} = \phi_{J+1,g,t} = 0$. Denote the growth rate of the new cohort size as $n_{g,t}$. Assume that when an individual begins economic activity at age $j = 1$, a certain fraction of them are single and never married, and the rest are married. In period t, singles of age j marry with probability $\xi_{j,t}$. In this model, we assume that married couples are of the same age and we abstract from divorce and remarriage.

Preference, Endowment and Bequest: The utility function of a single individual aged j consuming $c_{j,t}$ is given as $u^S(c_{j,t}/\eta) = (c_{j,t}/\eta)^{1-\sigma}/(1-\sigma)$, where η denotes the equivalence scale that varies by the size of the household. For single households, $\eta = 1$. σ represents the relative risk aversion. The utility function of a couple from household consumption $c_{j,t}$ is given as $u^M(c_{j,t}/\eta) = 2(c_{j,t}/\eta)^{1-\sigma}/(1-\sigma)$.

The life-time utility of an individual alive in period t is defined as

$$U_{g,t} = \mathbb{E} \sum_{j=1}^{J} \Phi_{j,g,t+j-1} \beta^{j-1} u^q \left(\frac{c_{j,t+j-1}}{\eta} \right) \tag{1}$$

where β denotes the subjective discount factor, and the expectation $\mathbb{E}$ is with respect to uncertainty about marital status. We assume that each individual has no assets when entering the economy at age $j = 1$. Individuals face a borrowing constraint and assets must be non-negative.

In period t, an individual of age j, gender g, and marital status q supplies $\varepsilon_{j,g,q,t}$ efficiency units of labor and receives a market wage w_t per efficiency unit. An individual's gross earnings is given by $\varepsilon_{j,g,q,t} w_t$.

Individuals save and earn the market interest rate r_t. Assets left upon death of an individual are collected as accidental bequests and distributed as a lump-sum transfer to all surviving individuals, denoted as b_t.

Medical and Long-term Care Expenditures: An individual of age j and gender g faces gross medical expenditures $med_{j,g,t}$ and long-term care expenditures $ltc_{j,g,t}$. Each individual pays a fraction $\lambda_{j,t}^{med}$ and $\lambda_{j,t}^{ltc}$ as out-of-pocket expenditures and the rest is paid by the public health and long-term care insurance programs. Total out-of-pocket expenditures for an individual of age j and gender g in period t are given as $o_{j,g,t} = \lambda_{j,t}^{med} med_{j,g,t} + \lambda_{j,t}^{ltc} ltc_{j,g,t}$.

Firms and Production: Firms are competitive and a representative firm produces output according to the Cobb-Douglas production function $Y_t = F(Z_t, K_t, L_t) = Z_t K_t^{\alpha} L_t^{1-\alpha}$, using aggregate capital K_t and labor L_t as production inputs. Z_t represents the total factor productivity and grows at rate γ_t. α and $(1-\alpha)$ represent shares of capital and labor, respectively. Capital depreciates at rate δ. In equilibrium, K_t is the sum of capital rent from households and L_t equals total labor supply. The market interest rate r_t^k and wage w_t are determined competitively.

Government: The government revenues in our model consist of the payment of tax and social security premiums from households and proceeds from debt issuance. Expenditures consist of payment of public pension benefits, health insurance and long-term care, government transfers, other government consumption and service of the government debt.

We denote the government debt at the beginning of the period by B_t and government consumption expenditures by G_t. The government pays the bond interest rate r_t^b on its debt. Proportional taxes are imposed on consumption, capital income, labor income, and government bond interest income, at rate τ_t^c, τ_t^k, τ_t^l, and τ_t^b, respectively. Note that pension, health, and long-term care insurance premiums are included in the tax τ_t^l imposed on labor income.

Household savings are rent to the government and to firms, and firms use the proceeds as capital in production. The after-tax gross interest rate per unit of savings is denoted as $R_t = 1 + p_t^b(1 - \tau_t^b)r_t^b + (1 - p_t^b)(1 - \tau_t^k)r_t^k$, and the net interest rate after tax is $r_t = R_t - 1$. p_t^b represents the share of government bond purchases in households' total savings. We assume that households do not make portfolio choices, and a constant share of their savings p_t^b is allocated exogenously to government bonds, while the remaining share $(1 - p_t^b)$ is directed to corporate lending, earning a constant rate of r_t net interest on their total savings.

Individuals who have reached the pension eligibility age j^R start to receive a public pension each period. The level of pension $p_{j,g,t}$ received by an individual of age $j \geq j^R$ and gender g is given by the following equation based on the average earnings up to the eligibility age for each cohort and given as $p_{j,g,t} = \rho W_{j,g,t}/(j^R - 1)$, where ρ denotes the pension replacement rate, relative to the average annual income $W_{j,g,t}$, which is the sum of the individual's earnings up to a year before the retirement age. Household co-payment rates of health and long-term care insurance are denoted as $\lambda_{j,t}^{med}$ and $\lambda_{j,t}^{ltc}$.

We assume that the government provides a transfer tr_t to guarantee minimum consumption $\underline{c}_q$, which depends on marital status q. This conditional government transfer prevents zero/negative consumption of households in the model. The transfer benefit amount is given as $tr_t = \max\left\{0, (1 + \tau_t^c)\underline{c}_q - \underline{a}_{q,t}\right\}$, where $\underline{a}_{q,t}$ represents disposable income for households of marital status q.[5]

In the government budget constraint, we include a lump-sum tax τ_t^{ls} collected from each individual (or a lump-sum transfer if negative). The lump-sum tax τ_t^{ls} is introduced in the model not for the purpose of approximating the actual tax system, but it is used as an adjustment variable to satisfy the government budget constraint each period. Its

[5]Disposable income is defined as follows for single and married households, respectively.

$$\begin{aligned} \underline{a}_{S,t}(x) &= R_t(a_t + b_t) + (1 - \tau_t^l)\varepsilon_{j,g,q,t}w_t + p_{j,g,t} - o_{j,g,t} - \tau_t^{ls} \\ \underline{a}_{M,t}(x) &= R_t(a_t + 2b_t) + \sum_g [(1 - \tau_t^l)\varepsilon_{j,g,q,t}w_t + p_{j,g,t} - o_{j,g,t}] - 2\tau_t^{ls} \end{aligned}$$

movement represents the time-varying fiscal cost of demographic aging during the transition.

Household Problem: Households choose the paths of consumption and savings to maximize life-time utility as defined in (1). Since the utility function and budget constraint differ in the model between the working-age group under 65 and the older age group aged 65 and above, as well as between singles and married couples, the optimization problem is classified into four groups, and the problem is solved recursively using value functions. Appendix A provides more details of the optimization problems of the four groups. The definition of competitive equilibrium is provided in Appendix B.

3.2 Calibration

In this section, we describe the calibration of the model presented in the previous section. The model period is annual.

Demographics: For population statistics, we use the 2023 population projections by the National Institute of Population and Social Security Research (IPSS) and the 2020 Census Data. In computing the transition dynamics, we start the simulation in 2020, and follows the population dynamics based on the IPSS projections. The 2020 Census data is used for the population distribution in 2020.

The model assumes that individuals enter the economy at age 25, start receiving public pensions at age 65, and survive up to a maximum age of 100. For the growth rate of the new cohort, we use the rate of change in the population aged 25 in each year. In the simulations, we assume that the mortality rate is zero for ages 25-64 and survival rates for those aged 65 and above follow the estimates of the IPSS.[6]

We compute the marriage rates by age using data from the 2020 Census. Since the model assumes that men and women have the same marriage rates, we compute the average proportion of married individuals by age. The marriage rates are then derived from the difference in these proportions across subsequent age groups. Note that the model abstracts from divorce and remarriage, and we calculate the proportion of married individuals based on the number of never-married and married people at each age. We assume that the probabilities of marriage by age remain constant after 2020.

[6]This assumption about zero mortality risks below age 65 is for simplicity and tractability of the model, but would not affect quantitative results since the death probability is very small.

Preference and Endowment: The consumption equivalence scale η is set to 1 for singles and 1.5 for married couples based on the OECD's modified equivalence scale. The value of the parameter σ, which indicates the degree of risk aversion is set to 3. The subjective discount rate β is set to 1.023 so that the ratio of total capital to GDP in 2020 is 2.7 (Hansen and İmrohoroğlu 2016).

For individual labor productivity, we use data from the Employment Status Survey (ESS) in 2017. Average annual earnings by gender, age and marital status is calculated by multiplying employment rate and average earnings of working individuals.

Medical and Long-Term Care Expenditures For medical expenses by age and gender, we use the Estimates of National Medical Care Expenditure of the Ministry of Health, Labour and Welfare (MHLW). For long-term care expenses, we use data from the Statistics of Long-term Care Benefit Expenditures of the MHLW to calculate the average cost for each age and gender. Gross expenditures are allocated to individuals and the government based on the co-payment rates of the medical and long-term care insurance programs, as explained below.

Firms and Technology We assume the Cobb-Douglas production function and set the capital share $\alpha = 0.36$ and capital depreciation rate $\delta = 0.089$ as in Kitao (2015). For the level of total factor productivity, the initial value of Z_0 is set to 0.932 so that wage rate is normalized to 1.0 in the initial economy of 2020. The growth rate of TFP is set to 0.7%.[7]

Government Government spending including medical and long-term care spending was 21% of GDP in 2020 and net government debt was 162% of GDP. We set government consumption G_t and net debt B_t in the initial economy to these values.[8] As a result, G_t is 7.9% of GDP. The ratios of government consumption and net debt to GDP are held constant during the transition.

The consumption tax rate τ_t^c is 10% and the capital income tax rate τ_t^a is set to 35% based on the estimates of the effective tax rate by Hansen and İmrohoroğlu (2016). The tax rate on government bond interest τ_t^b is set to 20%. The tax on labor income τ_t^l, which includes social security premiums, is set at 35% based on the estimates of Gunji

[7]This value lies in the middle of the total factor productivity growth rate of 0.6 to 0.8 percent assumed in the FY2019 Financial Verification of the Ministry of Health, Labour and Welfare (MHLW).

[8]Government spending rose in 2020 due to additional expenditures related to the COVID-19, but government spending in 2015-2019 was about 20% of GDP, and 22% in 2021-2022, close to the level in 2020.

and Miyazaki (2011). The lump-sum tax τ_t^{ls} is determined endogenously in equilibrium to satisfy the government budget constraint in each period.

The eligibility age for public pension benefits is 65, and the parameter ρ, which determines the replacement rate, is set to 0.332 so that the ratio of total pension benefits to GDP in 2020 is 10%, as in the data. The co-payment rates for health insurance are 30% for those under age 70, 20% for 70-74, and 10% for 75 and older. The co-payment rate for long-term care insurance is set to 10%. The consumption floor, $\underline{c}_q$, guaranteed by transfer payments is assumed to be 870,000 yen for a single person and 1,320,000 yen for a married couple, as in Kitao and Mikoshiba (2024).

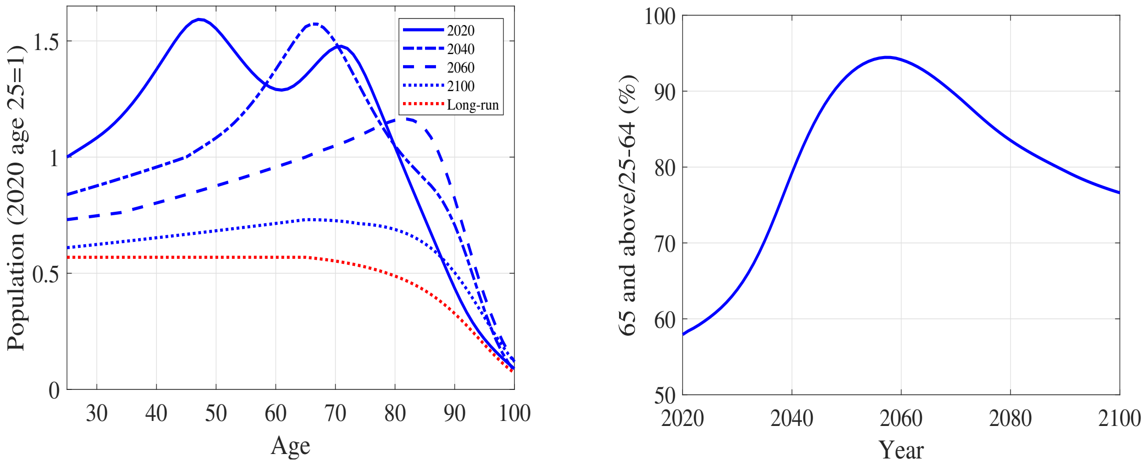
3.3 Numerical Analysis

This section describes the results of numerical calculations. First, we present the results from the baseline model, including an overview of the initial economy and the transition dynamics, followed by analysis of the transition process under alternative scenarios about labor market and demographic parameters.

3.3.1 Baseline Model

The simulation begins in 2020 and we change the population structure according to the long-term population projections of the IPSS. Survival probabilities by age and gender follow the IPSS estimates up to 2120 and they stay constant thereafter. For changes in new cohort size, we assume that the growth rate, which is negative in 2100, converges to 0% over 30 years thereafter. We assume that population growth will be zero and the age distribution will stay constant in the long run.

Figure 1a shows the trends in age-specific population distribution. The levels are normalized so that the population at age 25 in 2020 is set to 1. The peak of the second baby boom generation, who are in their late 40s in 2020, shifts to the right over time until the profile converges to a steady-state population distribution. At the same time, the total population continues to fall due to the low birth rates that stay below the population replacement level. Furthermore, as shown in Figure 1b, the ratio of the population aged 65 and over to those aged 25-64 rises rapidly from 2020 to 2060 and gradually decreases after late 2050.



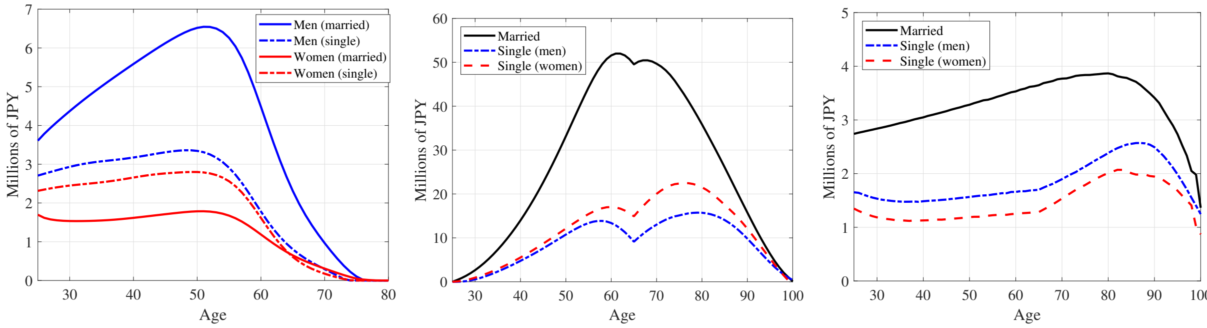
(a) Age Distribution

(b) Old-Age Dependency Ratio

Figure 1: Trends of Age Distribution and Old-Age Dependency Ratio (65 up/25-64) (Source: IPSS Projections and Model)

Initial Economy: The age profile of average annual earnings in the initial economy is shown in Figure 2a, which is calculated by multiplying the labor participation rate and average annual earnings of workers for each age and gender. For men, the average earnings of married workers are much higher than those of singles, while for women the pattern is the opposite. As discussed in Kitao and Mikoshiba (2024), this is partly due to the fact that many women move from regular employment to contingent employment or to non-employment upon marriage or birth of children, and experience a significant decline in earnings, which lasts for the remaining working-age periods.

Figures 2b and 2c show the age profiles of assets and consumption by marital status and gender of singles in the initial economy. The average assets of married couples significantly exceed those of singles, reflecting the higher earnings of married men. Although the average earnings of single men and women do not differ as much as those of married men and women do, single women's savings slightly exceed those of single men, partly due to women's longer average life expectancy and their stronger incentives to save for longer retirement. After age 65, single women's assets continue to surpass those of single men, and this gap widens. The group of singles includes not only never-married individuals but also widowed individuals. In addition to women's incentive to save for a longer lifespan, the higher likelihood of inheriting the couple's assets also contributes to consistently higher assets of single women compared to single men.



(a) Earnings (b) Assets (c) Consumption

Figure 2: Age Profiles of Variables by Marital Status and Gender: Initial Economy

The peak of assets for married couples is in their early 60s, at approximately 50 million yen. According to the National Survey of Family Income and Expenditure (NSFIE) of the Ministry of Internal Affairs and Communications (MIC), the peak assets for households with two or more people are reported to be around 48 million yen in their 60s, and our figure aligns with that.[9]

The consumption profile for married couples shows a monotonic increase until around their 80s. Consumption of single households is lower and grows slowly until their mid 60s. The consumption for single individuals represents the average consumption of never-married and widowed individuals at each age. In old age, especially after age 65, they start to receive pension benefits and the group starts to include more widowed individuals, who have higher assets, contributing to higher consumption growth.

Transition Dynamics: Next, we examine the evolution of macro variables during the transition. First, we compute the equilibrium of the final steady state in the long run corresponding to the economy of 2300. We then calculate the path connecting the initial and final economies. We show figures of the transition from 2020 to 2100.[10]

As shown in Figure 3a, aggregate labor monotonically declines due to the sharp decline in the working-age population. Figure 3b shows that aggregate capital increases until the mid 2030s and then falls thereafter. While a rise in life expectancy increases incentives to save for retirement, the number of savers decreases, making the overall change in total

[9]https://www.stat.go.jp/data/zensho/2014/pdf/gaiyo4.pdf (Figure II-1)
In the model, assets decline until age 65 and slightly increase thereafter, resulting in an M-shaped curve. This is because in our model households decumulate assets to maintain consumption levels until they start receiving pension benefits at 65.

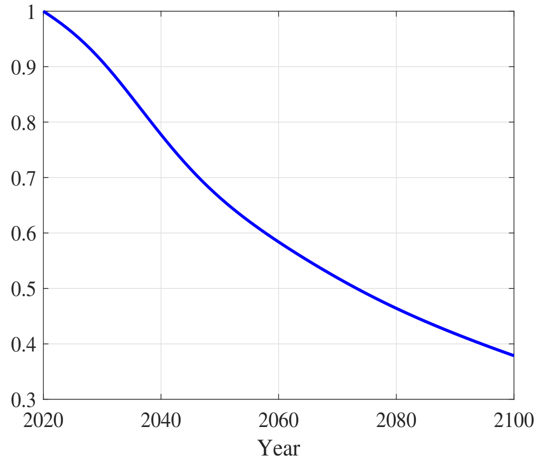
[10]For variables such as capital and consumption that grow with total factor productivity, we show the levels that are adjusted to remove the effect of growth in total factor productivity.

savings ambiguous. In this model, the effect of increased savings outweighs the effect of the shrinking pool of savers initially, but the net effect reverses after the mid 2030s.[11]

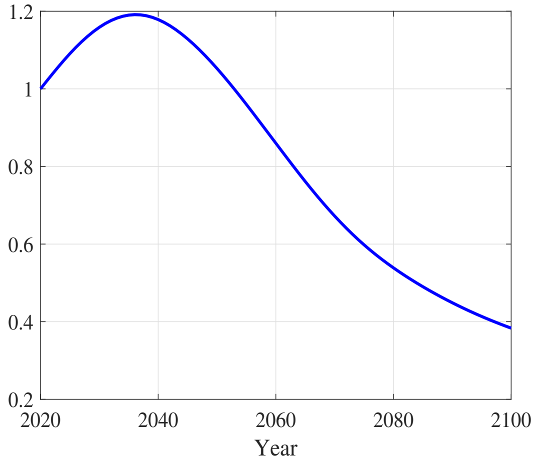
As a result of the movements in aggregate capital and labor, the capital-labor ratio increases until the late 2040s, but then decreases as the decline in aggregate capital accelerates. In equilibrium, interest rates and wages are determined competitively, and relative scarcity of capital and labor determine the movements in factor prices. As shown in Figure 3c, the interest rate decreases until the late 2040s while labor is more scarce relative to capital, and increases thereafter as capital becomes more scarce. Over the next 20 years, the decline in the working-age population will keep the labor market tight, and a rise in longevity will keep saving growth high. These lead to an increase in the capital-labor ratio and a decline in the interest rate, while the wage continues to rise.

From a fiscal perspective, as the population ages, expenditures on public pension, health and long-term care insurance programs will increase, while the tax base supporting these expenditures will shrink with a declining number of births and workers. Figure 3d shows the path of the lump-sum tax in equilibrium that is necessary to satisfy the government budget constraint each period. The fiscal burden is expected to increase monotonically until around 2070 and the lump-sum tax will reach almost 700,000 yen at the peak.

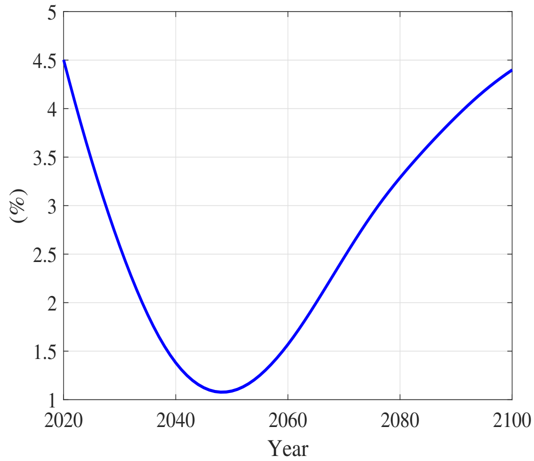
[11]Furthermore, the rising tax burden reduces disposable income, giving further downward pressure on savings. We confirmed, however, that even if there was no change in the tax burden and the lump-sum tax was fixed at the 2020 level, the pattern of aggregate capital rising initially and then declining remains unchanged.



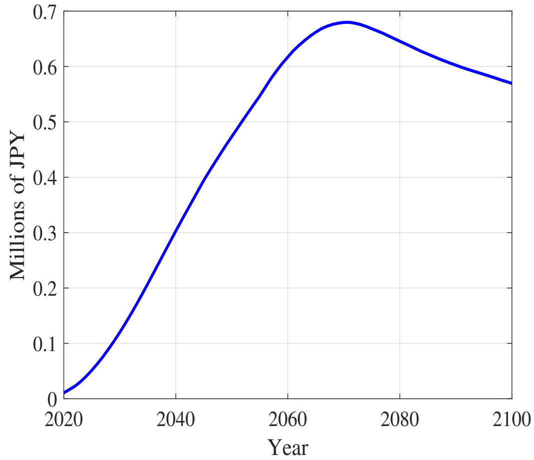
(a) Aggregate Labor



(b) Aggregate Capital



(c) Interest Rate



(d) Lump-sum Tax

Figure 3: Transition of Aggregate Variables: Baseline Model (The level of Aggregate Labor and Capital in 2020=1)

Figure 4 shows the break-down of the changes in fiscal expenditures. Expenditures on the three major social security programs—pensions, health, and long-term care insurance—each contribute to the rising tax burden. The total expenditures will grow from around 25% of GDP in 2020 to about 45% in around 2070.

It should be noted that in this analysis, the debt-to-GDP ratio is assumed to be constant, and government bond interest rates are also exogenously fixed. Expenditures related to the government debt could fluctuate depending on future government bond issuance and interest rate.

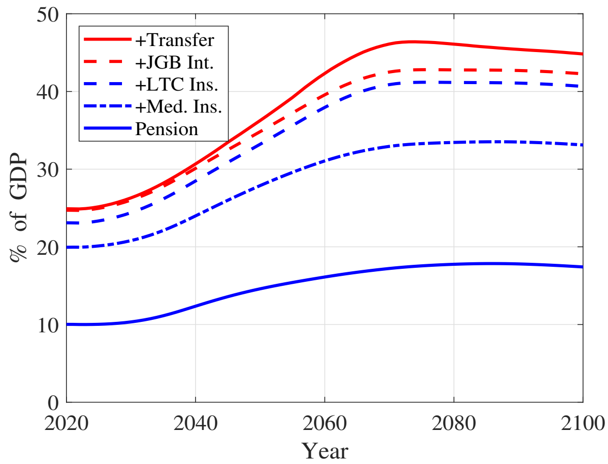


Figure 4: Breakdown of Government Expenditures: Baseline Model

3.3.2 Scenario Analysis

The baseline simulation demonstrated that demographic aging and the continued decline in the labor supply will contract the economy, and the rise in the old dependency ratio will increase the tax burden until around 2070. In the baseline scenario, we made assumptions about labor participation and productivity based on the current data. Population projections were calculated based on the medium assumptions (birth and death rates) of the IPSS. There is, however, considerable uncertainty regarding how these parameters will evolve in the future. In this section, we conduct simulations assuming alternative scenarios for these model elements and analyze how they affect macroeconomic and fiscal outlooks over the coming decades.

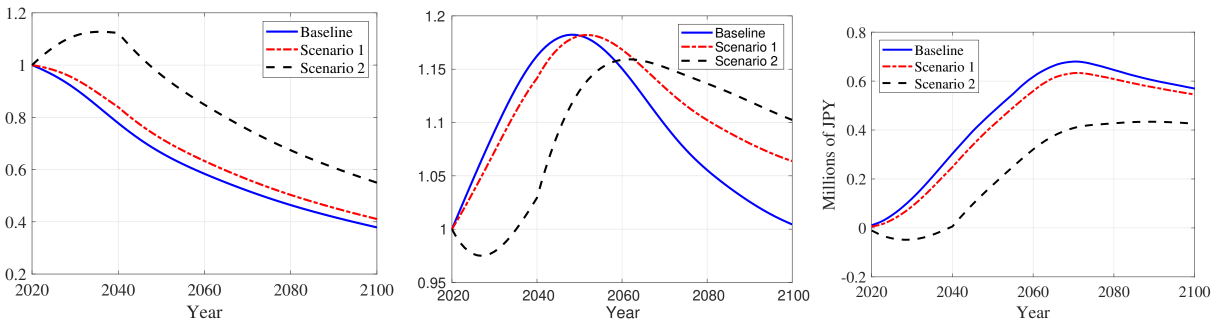
First, regarding assumptions related to the labor market, we examine scenarios concerning the labor participation and productivity of women. Second, we analyze alternative scenarios in which fertility rates follow different paths.

Scenarios about Women's Labor Supply: As discussed above, the average employment rates and earnings of women are lower than those of men. In particular, the earnings of married women are lower than those of single women, suggesting that women's labor market opportunities change significantly upon marriage. In this section, we consider a scenario in which married women supply the same level of labor as single women (Scenario 1). Additionally, as another extreme scenario, we consider the case where the labor supply of single and married women will converge to the same levels as that of single and married men, respectively (Scenario 2).

Under these scenarios, the labor supply of women, measured in terms of their efficiency units, increases, but wages also change through general equilibrium effects. Therefore, earnings do not increase proportionally to the rise in labor supply, and how household income changes is a quantitative matter. In both cases, we assume that labor supply increases over 20 years starting from 2020 and converges to a new level by 2040.

Figure 5 shows the path of aggregate labor, wage and equilibrium lump-sum tax over the coming decades. In Scenario 1, where labor supply of married women increases to the level of single women, the total labor supply exceeds the baseline level, resulting in a change of +4.1% in 2030 and +8.2% in 2050, relative to the baseline transition. In the extreme case of Scenario 2, the labor supply remains above the current level until around 2050. With a rise in total labor supply, wages in equilibrium decrease compared to the baseline. However, in both scenarios, this trend reverses after the 2050s. Wages become higher than the baseline level because the increase in income leads to higher savings, which in turn increases the capital-to-labor ratio in the long-run.

As shown in Figure 5c, the level of lump-sum tax required to satisfy the government budget constraint is lower than in the baseline throughout the transition due to increased tax revenue from higher earnings. In Scenarios 1 and 2, the tax burden decreases by 32,000 yen and 167,000 yen in 2030, and by 56,000 yen and 298,000 yen in 2050, respectively.

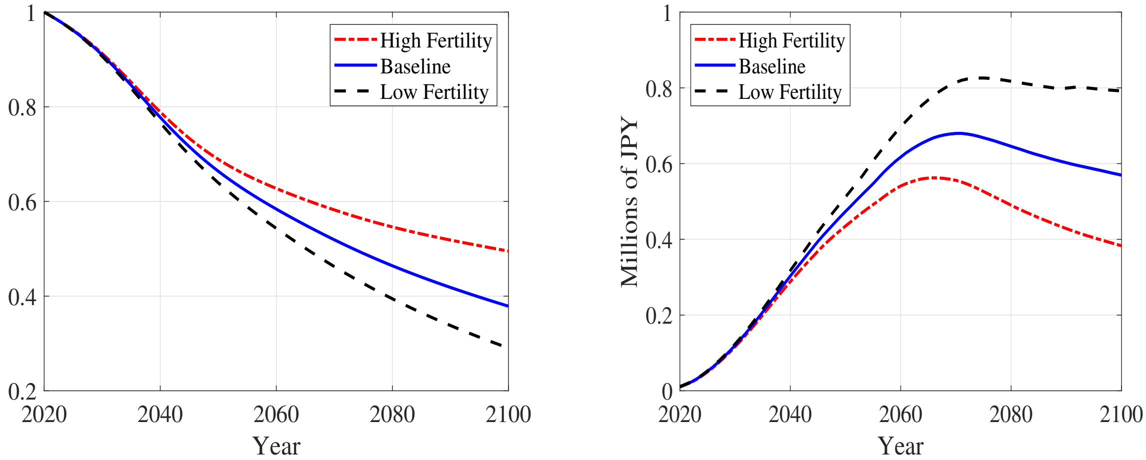


(a) Aggregate Labor (b) Wage (c) Lump-sum Tax

Figure 5: Scenarios about Women's Labor Supply (Aggregate Labor Supply and Wage in 2020=1)

Scenarios about Fertility Rates: The IPSS presents multiple scenarios about the population projections, and we used the medium-fertility and medium-mortality scenario in the baseline model. In this section, we simulate the transition using low and high scenarios about fertility rates.

Figure 6 shows the effects of alternative assumptions about fertility rates on the transition of aggregate labor and lump-sum tax. Since it takes time for a change in fertility rates to affect the labor supply, there is no visible impact for 20 years. However, in the medium to long term, the effects on total labor supply grow, and they also generate a significant long-term impact on the tax burden, as shown in Figure 6b.



(a) Aggregate Labor

(b) Lump-sum Tax

Figure 6: Scenarios about Fertility Rates (Aggregate Labor Supply in 2020=1)

In this analysis, fertility rates are set exogenously, but we note that fertility can also change with a change in marriage rates, the timing of marriage, and the age of having the first child, etc.[12] Additionally, our analysis does not explicitly consider the impact of immigrants or foreign workers in Japan. The IPSS projections include several scenarios regarding net foreign migration. It is also important to consider the age composition of incoming foreign workers, the length of time they stay and work in Japan, and their marriage and childbirth behavior. This remains a future research topic.

4 Conclusion

In this chapter, we first reviewed recent literature investigating the effects of demographic aging in Japan on macroeconomy and welfare. We then built a general equilibrium model of overlapping generations that incorporates heterogeneity in gender, family structure, earnings, and assets. The model also includes age-specific medical and long-term care

[12] See, for example, Doepke and Kindermann (2019) and Santos and D. Weiss (2016), that build a structural model to analyze the timing of marriage and childbirth.

expenditures and details of the social security system so that it can account for rising government expenditures over the coming decades associated with demographic aging. We quantitatively analyzed what the shifts in the demographic structure imply for the growth of the economy and the tax burden on future generations. We have shown that whether fertility rates continue to stagnate or begin to rise will not affect short-term macroeconomic trends or fiscal conditions, but it will have a significant impact in the long-run. We also show that although the decline in the aggregate labor supply is inevitable, the negative effects of population aging can be significantly mitigated by more active participation of married women. We emphasize that what makes a difference is not simply more participation of women, and their wage growth is the key. The tax burden to finance the demographic transition can be significantly reduced if the productivity of female workers increases close to the level of male workers.

Finally, we refer to several directions of research that are likely to be important as an extension of the current study. First, to enhance the productivity of scarce labor force, investment in human capital is essential. It is important to examine under what conditions effective skill accumulation is possible and whether there are policies that prevent or promote such incentives. Second, our model analysis highlights that dynamics of family formation and family decision-making, such as time allocation of husbands and wives, can be crucial elements in analyzing macroeconomic trends of an aging society. A model that explicitly considers the interaction between family decisions and age-related policies would provide insights into how to cope with demographic issues considering the age structure as part of policy objectives. Lastly, by refining the firm sector, which connects workforce and human capital to production and growth, it would be possible to approach a wide range of issues. We would be able to better understand, for example, the wage structures by industry and skill levels, perhaps reflecting the demand system that shifts with demographic aging. These topics are left for future research.

Appendix A Value Functions

In this section, we present the value functions for households of four types: young single $S^y(j,g,a)$, young married $M^y(j,a)$, old single $S^o(j,g,a)$, and old married $M^o(j,a)$.[13]

- Value Function of Young/Single Households

$$S^y(j,g,a_t) = \max_{c_t,a_{t+1}\geq 0} \{u^S(c_t/\eta) + \beta[(1-\zeta_{j+1,g,t+1})S^y(j+1,g,a_{t+1}) + \zeta_{j+1,g,t+1}\widehat{M}^y(j+1,g,a_{t+1}+\tilde{a}_{t+1})]\}$$

subject to

$$(1+\tau_t^c)c_t + a_{t+1} + o_{j,g,t} = R_t(a_t+b_t) + (1-\tau_t^l)\varepsilon_{j,g,S,t}w_t + tr_{S,t} - \tau_t^{ls}$$

where $\tilde{a}_{t+1}$ denotes assets of a spouse if the single individual marries in the next period.

- Value Function of Young/Married Households

$$M^y(j,a_t) = \max_{c_t,a_{t+1}\geq 0} \left\{u^M(c_t/\eta) + \beta M^y(j+1,a_{t+1})\right\}$$

subject to

$$(1+\tau_t^c)c_t + a_{t+1} + \sum_g o_{j,g,t} = R_t(a_t+2b_t) + (1-\tau_t^l)\sum_g \varepsilon_{j,g,M,t}w_t + tr_{M,t} - 2\tau_t^{ls}$$

- Value Function of Old/Single Households

$$S^o(j,g,a_t) = \max_{c_t,a_{t+1}\geq 0} \left\{u^S(c_t/\eta) + \beta\phi_{j+1,g,t+1}S^o(j+1,g,a_{t+1})\right\}$$

subject to

$$(1+\tau_t^c)c_t + a_{t+1} + o_{j,g,t} = R_t(a_t+b_t) + (1-\tau_t^l)\varepsilon_{j,g,S,t}w_t + p_{j,g,t} + tr_{S,t} - \tau_t^{ls}$$

- Value Function of Old/Married Households

[13] We also define the value functions of each married individual, denoted by $\widehat{M}^y(j,g,a)$ and $\widehat{M}^o(j,g,a)$, but we do not include the description here to save the space.

$$M^o(j,a_t) = \max_{c_t,a_{t+1}} \{u^M(c_t/\eta) + \beta[\phi_{j+1,m,t+1}\phi_{j+1,f,t+1}M^o(j+1,a_{t+1})+$$
$$\phi_{j+1,m,t+1}(1-\phi_{j+1,f,t+1})S^o(j+1,m,a_{t+1}) + \phi_{j+1,f,t+1}(1-\phi_{j+1,m,t+1})S^o(j+1,f,a_{t+1})]\}$$

subject to

$$(1+\tau_t^c)c_t + a_{t+1} + \sum_g o_{j,g,t} = R_t(a_t + 2b_t) + (1-\tau_t^l)\sum_g \varepsilon_{j,g,M,t}w_t + \sum_g p_{j,g,t} + tr_{M,t} - 2\tau_t^{ls}$$

Appendix B Competitive Equilibrium

For given demographics, total factor productivity, each worker's productivity, and a stream of fiscal parameters, the competitive equilibrium of this model is defined by each household's savings a_{t+1} and consumption c_t, household distribution $\mu_{x,t}$, aggregate capital K_t, aggregate labor L_t, factor prices r_t^k and w_t, and lump-sum tax τ_t^{ls}, that satisfy the following conditions.

1. Household savings a_{t+1} and consumption c_t are the solutions to the household optimization problems.

2. Factor prices are competitively determined in equilibrium and satisfy the following conditions.

$$\begin{aligned} r_t^k &= F_{K_t}(Z_t, K_t, L_t) - \delta = \alpha Z_t \left(K_t/L_t\right)^{\alpha-1} - \delta \\ w_t &= F_{L_t}(Z_t, K_t, L_t) = (1-\alpha) Z_t \left(K_t/L_t\right)^{\alpha} \end{aligned}$$

3. The aggregate demand for capital by firms equals total savings of households net of holdings of government bonds. The aggregate labor demand equals total labor supply of households.

4. The lump-sum tax τ_t^{ls} satisfies the government budget constraint in each period,

given as follows.

$$G_t + (1+r_t^b)B_t + \sum_{j=j^R}^{J}\sum_g p_{j,g,t}\mu_{j,g,t} + MED_t^g + LTC_t^g + \sum_x tr_t(x)\mu_{x,t}$$
$$= \tau_t^l w_t \sum_{j,g,q} \varepsilon_{j,g,q,t}\mu_{j,g,q,t} + [p^b\tau_t^b r_t^b + (1-p^b)\tau_t^k r_t^k]\sum_a (a_t + b_t)\mu_{a,t}$$
$$+\tau_t^c \sum_x c_t(x)\mu_{x,t} + \tau_t^{ls}\sum_x \mu_{x,t} + B_{t+1}$$

where $c_t(x)$ and $tr_t(x)$ represent consumption and government transfer for an individual in state $x = (j,g,q,a)$. MED_t^g and LTC_t^g denote the total government payments for medical and long-term care insurance programs, and are given as $MED_t^g = \sum_{j,g}(1-\lambda_{j,t}^{med})med_{j,g,t}\mu_{j,g,t}$ and $LTC_t^g = \sum_{j,g}(1-\lambda_{j,t}^{ltc})ltc_{j,g,t}\mu_{j,g,t}$, respectively.

5. The accidental bequests received by an individual equal the total assets left by the deceased, satisfying the following equation.

$$b_t = \frac{\sum_x a_t(x)(1-\phi_{j,g,t})\mu_{x,t-1}}{\sum_x \mu_{x,t}}$$

6. The distribution of households $\mu_{x,t}$ is given by the change in population structure and the savings function derived as the solution to the household optimization problem.

7. The allocation is feasible and the following resource constraint is satisfied each period.

$$F(Z_t, K_t, L_t) + (1-\delta)K_t = C_t + K_{t+1} + G_t + MED_t + LTC_t$$

where $C_t = \sum_x c_t(x)\mu_{x,t}$ denotes the aggregate consumption. $MED_t = \sum_{j,g} med_{j,g,t}\mu_{j,g,t}$ and $LTC_t = \sum_{j,g} ltc_{j,g,t}\mu_{j,g,t}$ denote aggregate medical and long-term care expenditures, respectively.

References

Aiyagari, S. R. (1994). Uninsured idiosyncratic risk and aggregate saving. *Quarterly Journal of Economics 109*(3), 659–684.

Auerbach, A. J. and L. J. Kotlikoff (1987). Evaluating fiscal policy with a dynamic simulation model. *American Economic Review 77*(2), 49–55.

Bewley, T. F. (1986). Stationary monetary equilibrium with a continuum of independently fluctuating consumers. In W. Hildenbrand and A. Mas-Colell (Eds.), *Contributions to Mathematical Economics in Honor of Gerald Debreu*, pp. 79–102. Amsterdam: North-Holland.

Braun, A. R. and D. H. Joines (2015). The implications of a graying Japan for government policy. *Journal of Economic Dynamics and Control 57*, 1–23.

Braun, R. A., D. Ikeda, and D. H. Joines (2009). The saving rate in Japan: Why it has fallen and why it will remain low. *International Economic Review 50*(1), 291–321.

Broda, C. and D. Weinstein (2005). Happy news from the dismal science: Reassessing the Japanese fiscal policy and sustainability. In T. Ito, H. Patrick, and D. Weinstein (Eds.), *Reviving Japan's Economy.* The MIT Press.

Chen, K., A. İmrohoroğlu, and S. İmrohoroğlu (2007). The Japanese saving rate between 1960 and 2000: productivity, policy changes, and demographics. *Economic Theory 32*, 87–104.

Diamond, P. (1965). National debt in a neoclassical growth model. *American Economic Review 55*(5), 1126–1150.

Doepke, M., A. Hannusch, F. Kindermann, and M. Tertilt (2023). The economics of fertility: a new era. In S. Lundberg and A. Voena (Eds.), *Handbook of the Economics of the Family*, Volume 1. Amsterdam: Elsevier. Chapter 4.

Doepke, M. and F. Kindermann (2019). Bargaining over babies: Theory, evidence, and policy implications. *American Economic Review 109*(9), 3264–3306.

Doepke, M. and M. Tertilt (2016). Families in macroeconomics. In J. B. Taylor and H. Uhlig (Eds.), *Handbook of Macroeconomics*, Volume 2B. Amsterdam: Elsevier. Chapter 23.

Doi, T., T. Hoshi, and T. Okimoto (2011). Japanese government debt and sustainability of fiscal policy. *Journal of the Japanese and International Economies 25*(4), 414–433.

Fukai, T., H. Ichimura, S. Kitao, and M. Mikoshiba (2024). Medical expenditures over the life-cycle: Persistent risks and insurance. Working Paper.

Greenwood, J., N. Guner, and R. Marto (2023). The great transition: Kuznets facts for family-economists. In S. Lundberg and A. Voena (Eds.), *Handbook of the Economics of the Family*. Amsterdam: Elsevier.

Gunji, H. and K. Miyazaki (2011). Estimates of average marginal tax rates on factor incomes in Japan. *Journal of The Japanese and International Economies 25*(2), 81–106.

Hagiwara, R. (2022). Welfare effects of health insurance reform: The role of elastic medical demand. Technical report, Institute for Monetary and Economic Studies, Bank of Japan.

Hagiwara, R. (2024). Macroeconomic and welfare effects of family policy: Cash transfers vs in-kind benefits. Working Paper.

Hansen, G. D. and S. İmrohoroğlu (2016). Fiscal reform and government debt in Japan: A neoclassical perspective. *Review of Economic Dynamics 21*, 201–224.

Hoshi, T. and T. Ito (2014). Defying gravity: can Japanese sovereign debt continue to increase without a crisis? *Economic Policy 29*(77), 5–44.

Hsu, M. and T. Yamada (2019). Population aging, health care, and fiscal policy reform: The challenges for Japan. *The Scandinavian Journal of Economics 121*(2), 547–577.

Huggett, M. (1996). Wealth distribution in life-cycle economies. *Journal of Monetary Economics 38*, 469–494.

Ihori, T., R. R. Kato, M. Kawade, and S.-i. Bessho (2006). Public debt and economic growth in an aging Japan. In K. Kaizuka and A. O. Krueger (Eds.), *Tackling Japan's fiscal challenges: Strategies to cope with high public debt and population aging*, pp. 30–68. Springer.

İmrohoroğlu, S., S. Kitao, and T. Yamada (2016). Achieving fiscal balance in Japan. *International Economic Review 57*(1), 117–154.

İmrohoroğlu, S., S. Kitao, and T. Yamada (2017). Can guest workers solve Japan's fiscal problems? *Economic Inquiry 55*(3), 1287–1307.

Imrohoroglu, S. and N. Sudo (2011). Productivity and fiscal policy in Japan: Short-term forecasts from the standard growth model. *Monetary and Economic Studies 29*, 73–106.

İmrohoroğlu, A. (1989). Cost of business cycles with indivisibilities and liquidity constraints. *Journal of Political Economy 97*(6), 1364–1383.

Kitao, S. (2015). Fiscal cost of demographic transition in Japan. *Journal of Economic Dynamics and Control 54*, 37–58.

Kitao, S. (2018). Policy uncertainty and cost of delaying reform: The case of aging Japan. *Review of Economic Dynamics 27*, 81–100.

Kitao, S. and M. Mikoshiba (2020). Females, the elderly and also males: Demographic aging and macroeconomy in Japan. *Journal of the Japanese and International Economies 56*, 1–16. Article 101064.

Kitao, S. and M. Mikoshiba (2024). Why women work the way they do in Japan: Roles of fiscal policies. Working Paper.

Kitao, S., M. Mikoshiba, and K. Nakakuni (2023). Female labor supply and demographic aging and their impacts on the aggregate economy and fiscal sustainability: A general equilibrium-OLG approach. ESRI Discussion Paper Series No. 384 (in Japanese).

Kitao, S. and K. Nakakuni (2024). On the trends of technology, family formation, and women's time allocations. Working Paper.

McGrattan, E. R., A. Peralta-Alva, and K. Miyachi (2019). On financing retirement, health, and long-term care in Japan. Federal Reserve Bank of Minneapolis.

Mikoshiba, M. (2023). Universal insurance with in-kind transfers: The welfare effects of long-term care insurance in Japan. Working Paper.

Nakakuni, K. (2024). Macroeconomic analysis of the child benefit: Fertility, demographic structure, and welfare. *Journal of the Japanese and International Economies 73*, 101325.

Oguro, K., M. Shimasawa, and J. Takahata (2013). Child benefits and welfare for current and future generations: Simulation analyses in an overlapping-generations model with endogenous fertility. *Asian Economic and Financial Review 3*(4), 490.

Oguro, K., J. Takahata, and M. Shimasawa (2011). Child benefit and fiscal burden: OLG model with endogenous fertility. *Modern Economy 2*(04), 602.

Okamoto, A. (2013). Welfare analysis of pension reforms in an ageing Japan. *The Japanese Economic Review 64*, 452–483.

Okamoto, A. (2020). Childcare allowances and public pensions: Welfare and demographic effects in an aging Japan. *The BE Journal of Economic Analysis & Policy 20*(2), 20190067.

Samuelson, P. A. (1958). An exact consumption-loan model of interest with or without the social contrivance of money. *Journal of Political Economy 66*(6), 467–482.

Santos, C. and D. D. Weiss (2016). "Why not settle down already?" A quantitative analysis of the delay in marriage. *International Economic Review 57*(2), 425–452.

Shimasawa, M. and K. Oguro (2010). Impact of immigration on the Japanese economy: A multi-country simulation model. *Journal of The Japanese and International Economies 24*, 586–602.

Yamada, K. (2011a). Labor supply responses to the 1990s Japanese tax reforms. *Labour Economics 18*(4), 539–546.

Yamada, T. (2011b). A politically feasible social security reform with a two-tier structure. *Journal of the Japanese and International Economies 25*(3), 199–224.

Yamaguchi, S. (2019). Effects of parental leave policies on female career and fertility choices. *Quantitative Economics 10*(3), 1195–1232.