Demography, Fiscal Sustainability, and Social Security System in Japan*

Sagiri Kitao† Minamo Mikoshiba‡

November 8, 2024

Abstract

This chapter provides 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, the social security system, fertility and foreign workers within the context of demographic aging in Japan. We then present a numerical analysis using a quantitative general equilibrium model to assess the impact of demographic aging on Japanese households, macroeconomy and the 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 evaluate 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

*The authors would like to thank the editors, Naohiro Yashiro, and participants in the Handbook conference for helpful comments and suggestions.
†National Graduate Institute for Policy Studies: sagiri.kitao@gmail.com
‡Nagoya University: minamo.mikoshiba@gmail.com

15.1 Introduction

The recent demographic trends in Japan, characterized by a secular decline in fertility and a continuous rise in longevity, have significantly altered the age distribution. As shown in Figure 1, the age pyramid now peaks in the early 50s, representing the second baby boom generation born in the early 1970s, and again in the mid-70s, representing those born after World War II.

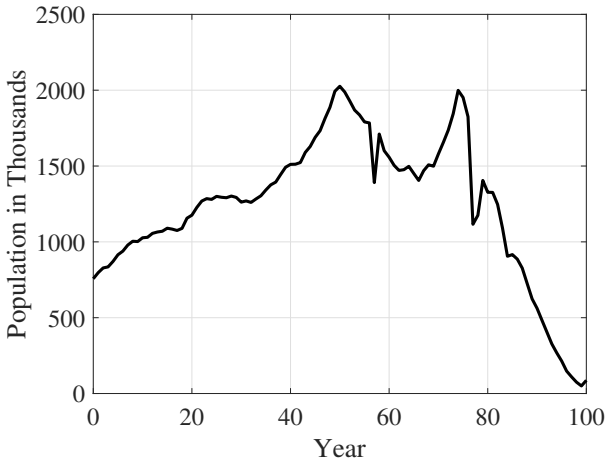
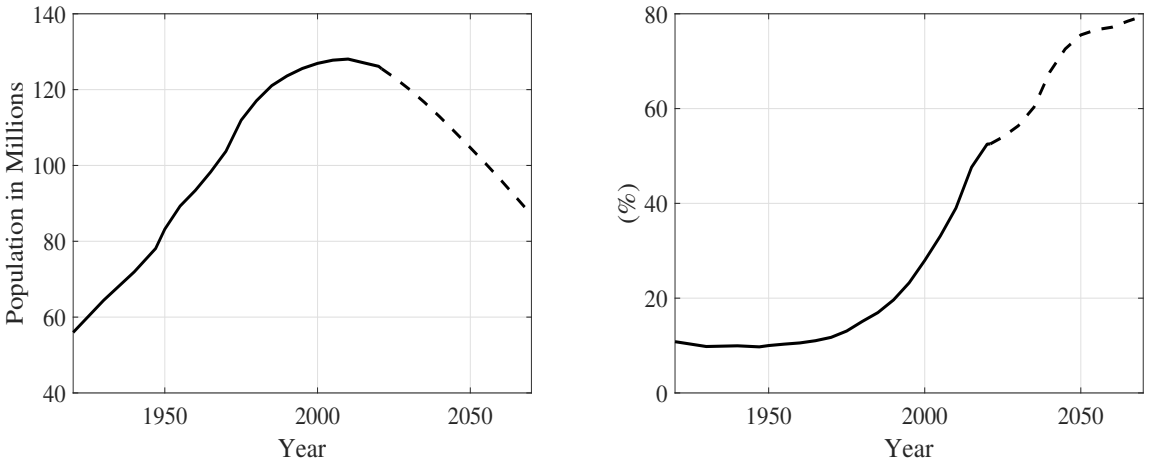


Figure 1: Age Distribution in 2023
Source: Ministry of Internal Affairs and Communications

For the past five decades, since the early 1970s, fertility rates have remained below the replacement level needed to maintain a stable population, leading to a chronic decline in the size of new cohorts. The population peaked at 128.1 million in 2008, and the growth rate has been negative thereafter, as shown in Figure 2a. According to the demographic projections of the National Institute of Population and Social Security Research (IPSS), the population will fall below 100 million by the late 2050s.



(a) Total Population (b) Old-Age Dependency Ratio

Figure 2: Population and Old-Age Dependency Ratio from 1920 to 2070
Source: Ministry of Internal Affairs and Communications, IPSS. Note: Dashed parts are based on the long-run demographic projections of the IPSS.

Improvements in health conditions have reduced mortality risks throughout the life-cycle and led to a significant increase in life expectancy. This change alone would raise the number of older adults and the total population, but the positive effect on the population has not been large enough to offset the impact of persistently low fertility rates. The combination of a rise in longevity and a secular decline in the number of births has resulted in a rapid increase in the population share of older adults. As shown in Figure 2b, the old-age dependency ratio, defined as the ratio of the population aged 65 and above to the population aged between 20 and 64, stayed at around 10% until the 1970s and rose sharply thereafter, reaching above 50% by 2000. It is expected to be as high as 80% by 2070 and remain at an elevated level throughout the century.

What are the impacts of this rapid and massive demographic aging on economic and fiscal variables? First of all, the decline in the working-age population will directly reduce the pool of potential workers and labor supply. The population aged between 20 and 64 was 78.7 million in 2000 and declined to 67.3 million in 2020. According to the IPSS projections, it will fall below 50 million in the early 2050s.

Second, a significant expansion in the government expenditures is expected. The social insurance system in Japan consists of three pillars: public pension, health insurance, and long-term care insurance programs, and expenditures of these programs increase in age. Rising expenditures need to be financed by taxation, which distort economic activities. Higher taxes on workers' earnings, for example, would reduce disposable income of younger

generations and their consumption and saving. Taxes on labor income also negatively affect incentives to participate in the labor market and accumulate human capital.

Third, demographic aging will also affect various macroeconomic variables through general equilibrium channels. A decline in labor supply may tighten the labor market and lead to upward pressure on wages. A rise in longevity would give individuals stronger incentives to save for a longer retirement period, which may put downward pressure on interest rates. The effects on factor prices would also depend on how the fiscal system evolves over time in response to the fiscal challenges.

The decline in the working-age population, a rise in government expenditures and fiscal burden, and changes in factor prices interact with each other and determine how the economy evolves over time. Quantifying the macroeconomic and fiscal consequences of ongoing demographic aging in Japan necessitates a quantitative analysis. A macroeconomic model that incorporates the behavior of households from different generations would be a useful tool for such analysis. The model can also consider interactions between the public and private sectors to account for rising government expenditures due to demographic aging and how individuals respond to changes in the macroeconomic and fiscal environment.

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 policies. As partial equilibrium models, 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 in the literature focused on demographic aging and its macroeconomic impact using different approaches.

Finally, we present a numerical analysis using a quantitative overlapping generations model calibrated to the Japanese economy. This model incorporates heterogeneity in gender, marital status, age, earnings, and household assets. The model economy consists of both public and private sectors, with the government managing social security systems including public pensions, healthcare, and long-term care insurance programs. We quantify how demographic aging over the coming decades will affect government spending in each area and assess the tax burden on future generations. Total expenditures on these three programs amount to 23.1% of GDP in 2020 but are projected to rise rapidly to 33.2% by 2050. This 10.1% increase is driven by higher spending across all programs, with public pensions accounting for 4.6%, health insurance for 3.4%, and long-term care insurance for 2.2%.

Additionally, we explore how alternative scenarios regarding demographic variables and women's labor supply conditions may impact these transition paths. Under the baseline transition scenario, the additional lump-sum tax required to finance the demographic transition is projected to be 0.47 million yen in 2050. However, this would decrease to 0.42 million yen if married women earn as much as single women, and to 0.18 million yen if both single and married women earn as much as men. The labor supply of women, not simply their participation rates but the contribution of each worker, will play an important role.

In Section 15.2, we present a survey of macroeconomic literature on demographic aging and fiscal sustainability. Section 15.3 will discuss a numerical analysis, and Section 15.4 concludes.

15.2 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 15.2.1 surveys models that use aggregate data, and Section 15.2.2 reviews studies incorporating heterogeneous households that belong to overlapping generations, focusing on the roles of fiscal policies in the context of aging economy.

15.2.1 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.

15.2.2 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. Studies that use large-scale overlapping generations models have served as powerful tools for quantitatively analyzing the impact of demographic shifts on macroeconomy and fiscal sustainability. By enriching the models with various dimensions of heterogeneity across households and details of government policies, they have achieved better alignment and consistency with microdata.

The development of so-called Bewley models, pioneered by Bewley (1986), incorporated uninsured idiosyncratic risks and incomplete markets in a life-cycle model and advanced the scope of quantitative analysis.[1] 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 on the Japanese economy that use overlapping generations models to investigate issues including fiscal sustainability, roles of the social security system including public pensions, health and long-term care insurance programs, fertility and family decisions, and the impact of foreign workers and immigration.

15.2.2.1 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

[1] See also İmrohoroğlu (1989), Aiyagari (1994), and Huggett (1996).

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. Other studies including Braun and Joines (2015), Kitao (2015), and McGrattan et al. (2019) also use a structural model of overlapping generations and emphasize the need for an urgent reform before the fiscal burden grows prohibitively large. Braun and Joines (2015) argue that the debt will continue to grow, leading to a default by 2040, without reforms of pension and health insurance programs. Kitao (2015) also shows 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.[2] McGrattan et al. (2019) consider various policy options to finance the demographic transition in Japan and find 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 (2024b) 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,

[2]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.

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.

15.2.2.2 Social Security System

As demonstrated in the papers discussed above on fiscal sustainability, rising expenditures of the social security system are the key factor contributing to the fiscal imbalance associated with demographic aging This implies that if spending on the social security programs including public pensions, health and long-term care insurance 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), which 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) evaluated the impact of public health insurance reforms and 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 expendi-

tures, 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 for medical services, 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) used health insurance claims data to analyze medical expenditure risks and studied effects of health insurance reforms in Japan. 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 a 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. 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.

15.2.2.3 Fertility and Families

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.[3] Driven by concerns over population decline and labor

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

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.

Economic and welfare effects of policies related to childcare have been studied in structural macro models calibrated to the Japanese economy. For example, Oguro et al. (2011) argued that increasing child allowance would improve the welfare of the current and future generations. Okamoto (2020) considered long-run macroeconomic and welfare impacts of changes in child benefits, finding that while the improvement in fertility is limited, the reform would enhance welfare in the long run by increasing the working-age population.

Recent studies 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 with fertility and education decisions and 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) showed 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.[4]

15.2.2.4 Guest Workers and Immigrants

Another policy option to mitigate labor shortages and to address macroeconomic and fiscal challenges is to welcome 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

[4]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.

effect equivalent to a maximum of about 5% 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. Quantitative studies to investigate determinants of foreign workers' migrating decisions and effects of alternative guest worker policies is an area of research that needs to be explored further.

15.3 Quantitative Analysis of the Japanese Economy and Demographic Aging

In this section, we study the effects of demographic aging on the macroeconomy and fiscal situations in Japan, based on the model of overlapping generations developed in Kitao and Mikoshiba (2024a) and Kitao et al. (2023). As discussed in Section 15.2, most of the previous studies on the effects of demographic aging do not explicitly consider the heterogeneity of family structure. The model used 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 (2024b) incorporate marital heterogeneity into overlapping generations models for Japan, and we build on their modeling strategy.[5]

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.

[5]These papers focus 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.

Moreover, a number of recent studies suggested the importance of explicitly incorporating differences in family structure, such as marital status and number of children, into macroeconomic models, as also discussed in Section 15.2. The model used in the analysis in this section 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.

15.3.1 Model Overview

This section presents a brief overview of the macroeconomic model used in our analysis of demographic aging and fiscal sustainability. Technical details of the model can be found in Kitao and Mikoshiba (2024a). We keep the description non-mathematical in this section and refer interested readers to the paper.

15.3.1.1 Households

In our model, individuals are heterogeneous in four dimensions: age, gender, marital status, and assets. The life span is uncertain, and they face conditional probability of surviving that vary by age and also over time, reflecting a rise in longevity. The size of a new cohort changes over time. The economy is populated by single and married households and single individuals face certain probabilities of getting married, which vary by age and over time. We assume that married couples are of the same age and we abstract from divorce and remarriage for simplicity.

Households can save and earn the market interest rate on the stock of assets. Households derive utility from consumption and they choose the paths of consumption and savings to maximize life-time utility. Labor productivity of individuals differ by age, gender and marital status and earnings also depend on market wage, which changes over time as the labor supply evolves with the demographic transition.

Individual face medical and long-term care expenditures over the life-cycle and the amount of these expenditures differ by age and gender. Each individual pays a certain fraction of gross expenditures based on the age-specific copay rates and the rest is paid by the public health and long-term care insurance programs.

15.3.1.2 Firms

The model assumes that firms are competitive and they produce output according to the Cobb-Douglas production function, using aggregate capital and labor as production

inputs. Total factor productivity is assumed to grow at an exogenous rate. In equilibrium, aggregate capital used in the production equals the sum of capital rent from households and aggregate labor equals total labor supply. The market interest rate and wage rates adjust in equilibrium so the capital and labor markets clear. For example, if the labor supply declines and the demand exceeds supply, wages would increase so eliminate the excess demand in equilibrium.

15.3.1.3 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.

The government pays the bond interest rate on its outstanding debt at the beginning of each period. Proportional taxes are imposed on consumption, capital income, labor income, and government bond interest income, at different rates. Note that pension, health, and long-term care insurance premiums are included in the tax imposed on labor income.

Household savings are rent to the government and to firms, and firms use the proceeds as capital in production. We assume that households do not make portfolio choices, and an exogenous share of their savings is allocated to government bonds, while the remaining share is directed to corporate lending.

Individuals who have reached the pension eligibility age start to receive a public pension each period. The amount of pension benefits are determined by a certain fraction of the average earnings of an individual up to the eligibility age. This fraction is called as the pension replacement rate, relative to the average annual income.

We assume that the government provides a transfer, in case the disposable income of households falls below the minimum level of consumption. The subsistence level of consumption is set for single and married households, separately.

In the government budget constraint, we include a lump-sum tax collected from each individual (or a lump-sum transfer if negative). The lump-sum tax 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 movement represents the time-varying fiscal cost of demographic aging during the transition.

15.3.2 Calibration

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

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.

We adjust the consumption by the family size, using the consumption equivalence scale of 1.5 for married couples based on the OECD's modified equivalence scale. We assume a constant-relative-risk-aversion preference and set the risk aversion parameter to 3. The subjective discount rate is set so that the model matches the ratio of total capital to GDP in 2020.

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.

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

[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.

and long-term care insurance programs, as explained below.

We assume the Cobb-Douglas production function and set the capital share to 0.36 and capital depreciation rate to 0.089. For the total factor productivity, the growth rate is set to 0.7%.[7]

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 and net debt in the initial economy to these values.[8] The ratios of government consumption and net debt to GDP are held constant during the transition.

The consumption tax rate is set to 10% and the capital income tax rate to 35% based on the estimates of the effective tax rate by Hansen and İmrohoroğlu (2016). The tax rate on government bond interest is set to 20%. The tax on labor income, which includes social security premiums, is set at 35% based on the estimates of Gunji and Miyazaki (2011). The lump-sum tax 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 replacement rate parameter, is set to 0.33 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 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 (2024b).

15.3.3 Numerical Analysis

This section describes the results of numerical calculations. First, we discuss 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.

[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).

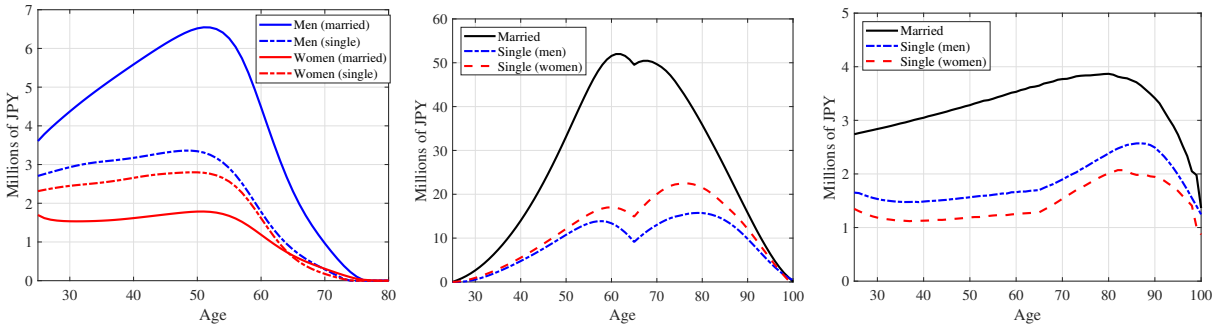
[8]Government spending rose in 2020 due to additional expenditures related to the COVID-19, but government spending in 2015-2019 was about 20% of GDP, and 22% in 2021-2022, close to the level in 2020.

15.3.3.1 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. Over time, however, the peak of the second baby boom generation, who are in their late 40s in 2020, will shift to the right in the age distribution and reach the retirement age in the 2040s before 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. As a result, as we saw in Section 15.1, the old dependency ratio, defined as the ratio of the population aged 65 and over to those aged 25-64, rises rapidly and stays at a high level.

Initial Economy: The age profile of average annual earnings in the initial economy is shown in Figure 3a, 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 (2024b), 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 3b and 3c 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 life-span, 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 3: 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 4a, aggregate labor monotonically declines due to the sharp decline in the working-age population. Figure 4b 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.

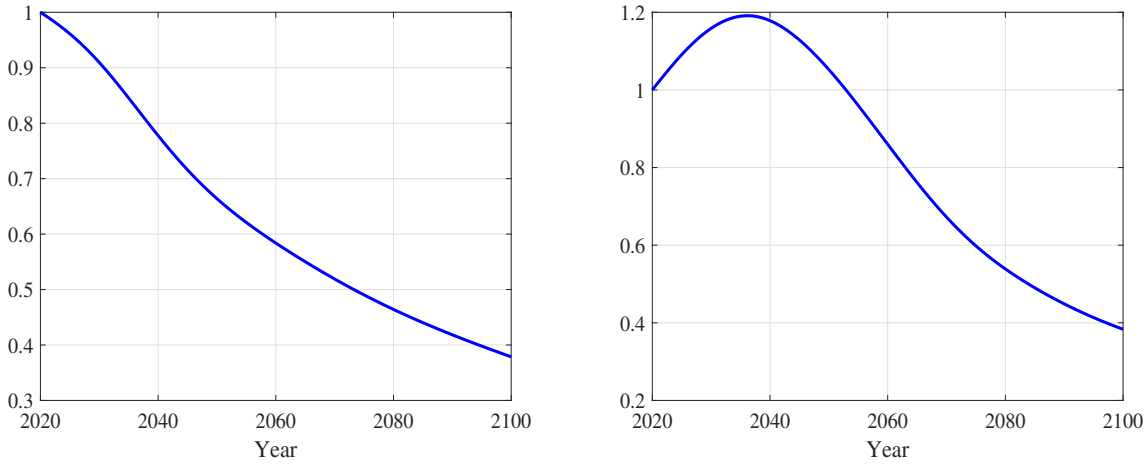
[10]For variables such as capital and consumption that grow with total factor productivity, we show the levels that are adjusted to remove the effect of growth in total factor productivity.

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 4c, 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.

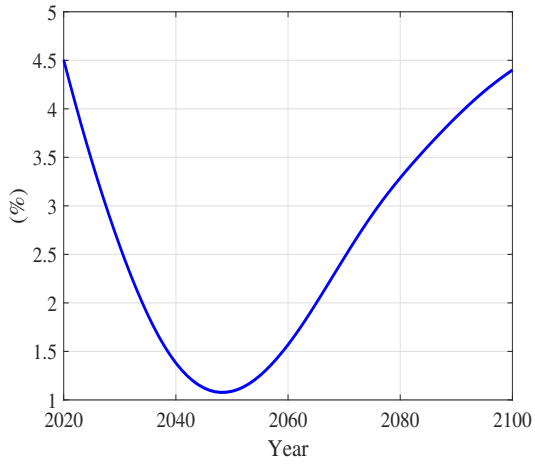
From a fiscal perspective, as the population ages, expenditures on public pension, health and long-term care insurance programs will increase, while the tax base supporting these expenditures will shrink with a declining number of births and workers. Figure 4d shows the path of the lump-sum tax in equilibrium 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.

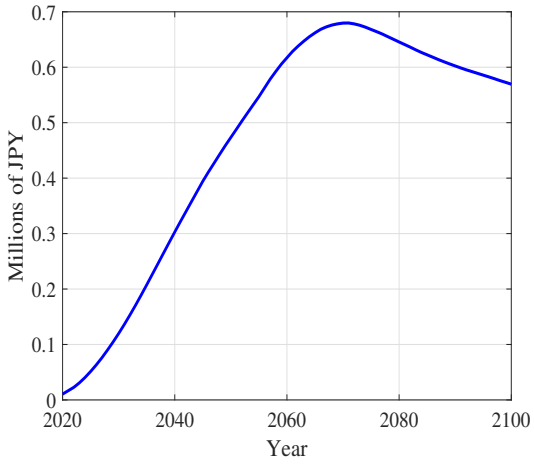


(a) Aggregate Labor

(b) Aggregate Capital



(c) Interest Rate



(d) Lump-sum Tax

Figure 4: Transition of Aggregate Variables: Baseline Model (The level of Aggregate Labor and Capital in 2020=1)

Figure 5 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.

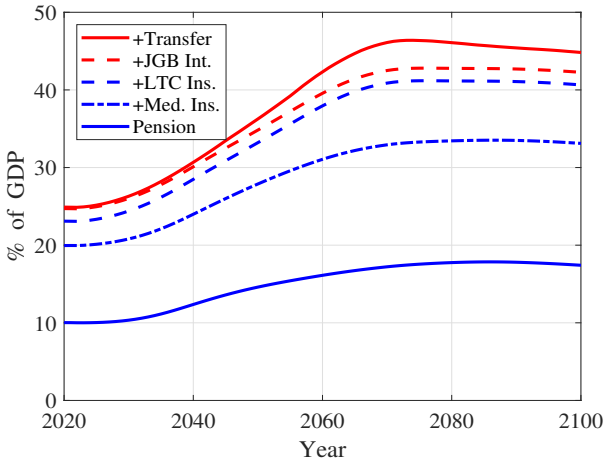


Figure 5: Breakdown of Government Expenditures: Baseline Model

15.3.3.2 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.

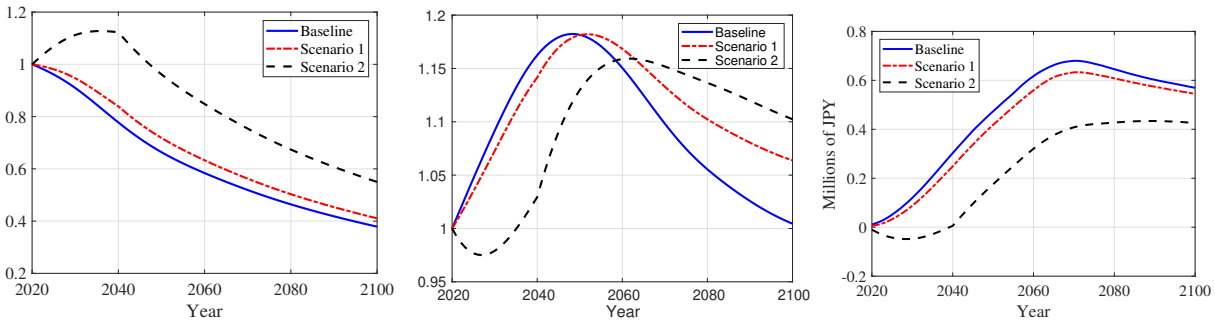
Scenarios about Women's Labor Supply: As discussed above, the average employment rates and earnings of women are lower than those of men. In particular, the earnings of married women are lower than those of single women, suggesting that women's labor market opportunities change significantly upon marriage. 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 6 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 6c, 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.

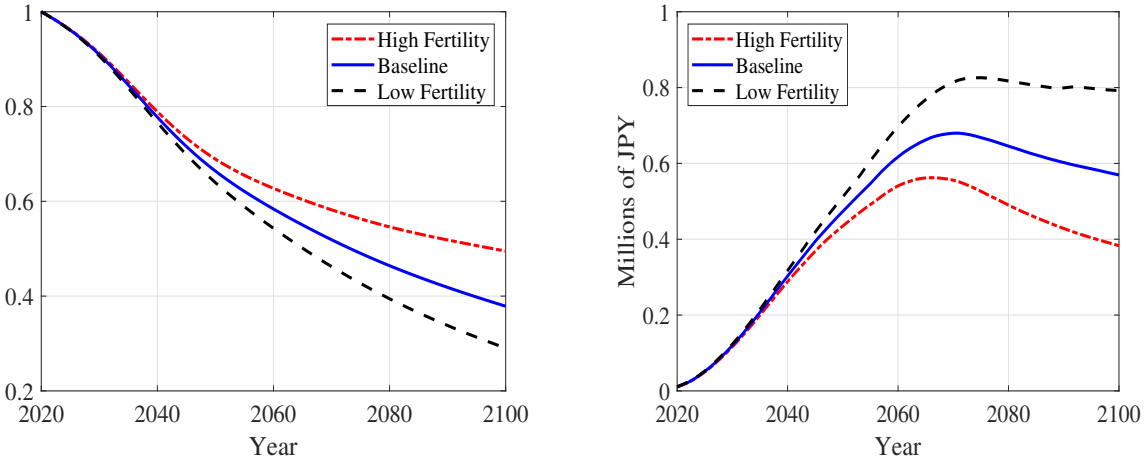


(a) Aggregate Labor (b) Wage (c) Lump-sum Tax

Figure 6: 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 7 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 7b.



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

Figure 7: 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 the macroeconomic environment or fiscal policies, and so can other family-related variables such as marriage rates, the timing of marriage and childbirth, etc. Such analysis will require a structural model that incorporate family formation decisions.[12]

Our model also assumed a simple tax structure that includes proportional taxes on labor income, common across single and married households. Although the tax system is individual-based in Japan, there are elements in the fiscal system that depends on marital status, such as income tax deductions, and social premium exemptions and survivors' pension benefit for low-income dependent spouses.[13] Quantifying the effects of removing such policies under demographic aging and considering the impact on the labor supply would be an interesting topic.

Additionally, our analysis does not explicitly consider the impact of immigrants or

[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.

[13]Kitao and Mikoshiba (2024b) uses a life-cycle model to analyze the effects of these policies on women's labor supply in Japan in a life-cycle model. Borella et al. (2023) studies the effects of marriage-related fiscal policies in the U.S. economy.

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. These will be future research topics.

15.4 Concluding Discussion

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 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.

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.

Borella, M., M. De Nardi, and F. Yang (2023). Are marriage-related taxes and social security benefits holding back female labor supply? *Review of Economic Studies 90*(1), 102–131.

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 (2024a). Aging demographics and fiscal sustainability: Women's labor supply in Japan. Working Paper.

Kitao, S. and M. Mikoshiba (2024b). 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., 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.