Aging Demographics and Fiscal Sustainability: Women's Labor Supply in Japan

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Abstract

This paper presents a general equilibrium model of overlapping generations that incorporates heterogeneity in gender, marital status, earnings, and assets to quantify how demographic aging influences the economy's transition path. The model is calibrated to the Japanese economy and its social security system, including public pension, healthcare, and long-term care insurance programs. We demonstrate that while a decline in the aggregate labor supply and output is inevitable, the negative effects of population aging can be significantly mitigated by an increase in the labor supply of married women. What makes a difference is not simply greater participation by women, but wage growth comparable to that of men is essential.

Keywords: Demographic aging, female labor supply, social security.
JEL Classification: E00, E20, H55, J11

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1 Introduction

How will ongoing demographic aging affect the macroeconomy and fiscal situations? While the decline in the working-age population and the rise in fiscal burden are inevitable, what changes in the labor market could mitigate the impacts, and to what extent? We develop a general equilibrium model of overlapping generations, calibrated to the Japanese economy, which incorporates heterogeneity in gender, marital status, earnings, and household assets. The model also includes details of the social security system, so that we account for rising expenditures as the share of the elderly increases.

There are significant differences in employment rates and earnings in the labor market, not only between men and women but also based on marital status. Notably, the average earnings of married women are significantly lower than those of single women throughout the life cycle. We quantify how a shift in these patterns would affect the future path of macroeconomic variables and fiscal burden due to demographic aging.

In the tradition of the quantitative models of overlapping generations, originating from Auerbach and Kotlikoff (1987), recent studies on fiscal sustainability demonstrate that significant tax increases or spending cuts are inevitable in a rapidly aging economies such as Japan (Kitao 2015, Braun and Joines 2015, McGrattan et al. 2019, Kitao and Mikoshiba 2020). We contribute to this literature by constructing a model that incorporates heterogeneity in family structure, marital status, and differences in labor supply, showing how these factors interact with the path of the macroeconomy and fiscal burden in an aging economy.

2 Model

Individuals are heterogeneous along four dimensions: age $j = \{1, ..., J\}$, gender $g = \{m, f\}$, marital status $q = \{S, M\}$ (single or married), and assets a. The conditional probability of survival is denoted by $\phi_{j,g,t}$, and $\Phi_{j,g,t}$ represents the unconditional probability of survival from birth to age j. The cohort size grows at rate $n_{g,t}$. Upon entry, a certain fraction of individuals are single, and singles of age j marry with probability $\xi_{j,t}$.

The utility function for single and married individuals are given as $u^S(c_{j,t}/\eta) = (c_{j,t}/\eta)^{1-\sigma}/(1-\sigma)$ and $u^M(c_{j,t}/\eta) = 2(c_{j,t}/\eta)^{1-\sigma}/(1-\sigma)$, respectively. η denotes the equivalence scale. We assume that individuals own no assets when entering the economy and they face a no-borrowing constraint. Individuals supply $\varepsilon_{j,g,q,t}$ efficiency units of labor and receive a market wage w_t per efficiency unit. They also earn the market interest rate r_t on their savings. Accidental bequests are distributed as lump-sum transfers to all surviving individuals, denoted by b_t.

Firms are competitive, and a representative firm produces output according to the production function $Y_t = Z_t K_t^{\alpha} L_t^{1-\alpha}$, using aggregate capital K_t and labor L_t. Total factor productivity $Z_t$grows at rate γ_t, and capital depreciates at rate δ.

Government expenditures consist of payments for public pension, health insurance, long-term care, government transfers, other government consumption, and debt service. Individuals face medical and long-term care expenditures, denoted by $med_{j,g,t}$ and $ltc_{j,g,t}$, respectively. They pay a fraction $\lambda_{j,t}^{med}$ and $\lambda_{j,t}^{ltc}$ as out-of-pocket expenses, with the remainder covered by the public insurance. Government debt is denoted by B_t, and government consumption expenditures by G_t. The government pays the bond interest rate r_t^b. Proportional taxes are imposed on consumption, capital and labor income, and government bond interest income, at rates τ_t^c, τ_t^k, τ_t^l, and τ_t^b, respectively.

Households rent their savings to the government and firms. 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 is $r_t = R_t - 1$. p_t^b represents the share of government bond in households' total savings. We assume that a constant share of their savings is allocated exogenously to government bonds, and the remainder is directed to corporate lending.

Individuals receive a public pension once reaching the pension eligibility age j^R. The pension amount is given by $p_{j,g,t} = \rho W_{j,g,t}/(j^R - 1)$. ρ represents the replacement rate, relative to the average earnings $W_{j,g,t}$, which is the sum of the individual's earnings until the retirement age.

The government provides a transfer tr_t to guarantee a minimum level of consumption, which prevents zero or negative consumption in the model. The government budget constraint includes a lump-sum tax τ_t^{ls} collected from each individual. This tax serves as an adjustment variable to satisfy the government budget constraint each period. Its variation reflects the time-varying fiscal cost of demographic aging, while holding other fiscal parameters fixed.

The household optimization problem is solved recursively. Value functions are classified into 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 $M^o(j,a)$, as presented below.[1]

[1] We also define the value functions of each married individual of gender g, denoted by $\widehat{M}^y(j,g,a)$ and $\widehat{M}^o(j,g,a)$, which are omitted here to save the space.

$$
\begin{aligned}
S^y(j,g,a_t) &= \max_{c_t,a_{t+1}\geq 0}\{u^S(c_t/\eta)+\beta[(1-\zeta_{j+1,g,t+1})S^y(j+1,g,a_{t+1})+\zeta_{j+1,g,t+1}\widehat{M}^y(j+1,g,a_{t+1}+\tilde{a}_{t+1})]\} \\
M^y(j,a_t) &= \max_{c_t,a_{t+1}\geq 0}\left\{u^M(c_t/\eta)+\beta M^y(j+1,a_{t+1})\right\} \\
S^o(j,g,a_t) &= \max_{c_t,a_{t+1}\geq 0}\left\{u^S(c_t/\eta)+\beta\phi_{j+1,g,t+1}S^o(j+1,g,a_{t+1})\right\} \\
M^o(j,a_t) &= \max_{c_t,a_{t+1}}\{u^M(c_t/\eta)+\beta[\phi_{j+1,m,t+1}\phi_{j+1,f,t+1}M^o(j+1,a_{t+1})+ \\
&\quad \phi_{j+1,m,t+1}(1-\phi_{j+1,f,t+1})S^o(j+1,m,a_{t+1})+\phi_{j+1,f,t+1}(1-\phi_{j+1,m,t+1})S^o(j+1,f,a_{t+1})]\}
\end{aligned}
$$

The budget constraint of young single households is given as follows.

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

The constraints for other types of households are similarly defined: pension benefits are added to the constraint of old households, and variables of both a husband and a wife are included for married households.

The competitive equilibrium is defined by each household's savings and consumption, household distribution, aggregate capital and labor, factor prices, and lump-sum tax, which satisfy the conditions in each period: household savings and consumption are solutions to the optimization problems; factor prices are determined competitively; firms' aggregate demand for capital and labor equal total household savings net of government bond holdings, and total household labor supply, respectively; the lump-sum tax satisfies the government budget constraint; accidental bequests received equal the total assets left by the deceased; the distribution of households is determined by demographic variables and policy functions from the household problem; and the allocation is feasible.

3 Calibration

For the calibration of demographic variables, we use the 2020 Census Data and the 2023 population projections by the National Institute of Population and Social Security Research. Individuals enter the economy at age 25, start receiving public pensions at age 65, and survive up to a maximum age of 100.[2] Marriage rates by age are computed using the 2020 Census data.

The consumption equivalence scale η is set to 1 for singles and 1.5 for married couples

[2]We assume that the mortality rate is zero for ages 25-64 for simplicity. This assumption does not affect quantitative results since the death probability is very small.

based on the OECD's modified equivalence scale. The risk aversion parameter σ is set to 3. The subjective discount rate β is set to 1.023 to match a total capital-to-GDP ratio of 2.7 in 2020 (Hansen and İmrohoroğlu 2016). For individual labor productivity, we use data from the 2017 Employment Status Survey. Average annual earnings are calculated by multiplying the employment rate by the average earnings of working individuals. For the production function, we set $\alpha = 0.36$ and $\delta = 0.089$. The growth rate of TFP is set to 0.7%.

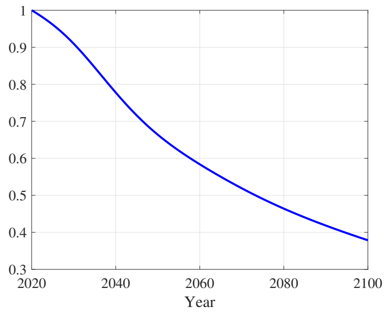
Government spending, including social insurance expenditures, accounted for 21% of GDP in 2020. We set G_t to 7.9% of GDP to match this ratio. Net government debt was 162% of GDP in 2020, and we assume that these ratios remain constant during the transition. We set τ_t^c to 10%, τ_t^a to 35% (Hansen and İmrohoroğlu 2016). τ_t^b is 20%, and the bond interest rate is fixed at 1%. τ_t^l is set to 35% (Gunji and Miyazaki 2011).

The eligibility age for public pension benefits is 65, and the replacement rate is set to 0.332 to match the ratio of total pension expenditures to GDP at 10%. For medical and long-term care expenses, we use data from the Ministry of Health, Labour and Welfare. Co-payment rates for health insurance are 30% for individuals under 70, 20% for those aged 70-74, and 10% for those aged 75 and older. The co-payment rate for long-term care insurance is 10%. The consumption floor is set to 870,000 yen for a single person and 1,320,000 yen for a married couple (Kitao and Mikoshiba 2024).

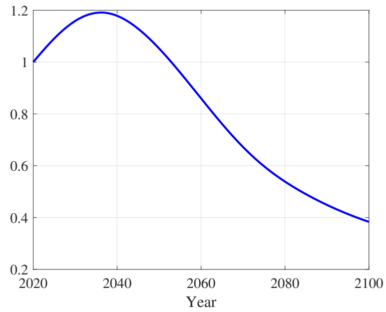
4 Numerical Results

Baseline Transition Path: To compute the transition dynamics of the baseline model, we first compute the equilibrium in the initial economy of 2020, and the equilibrium in the final steady state, corresponding to 2300 economy. We then calculate the path connecting the initial and final economies. As shown in Figure 1a, aggregate labor decreases monotonically due to the sharp decline in the working-age population. Figure 1b shows that aggregate capital increases until the mid-2030s, and falls thereafter. While rising life expectancy increases incentives to save for retirement, the rapidly decreasing number of savers offsets this effect. As a result, the capital-labor ratio increases until the late 2040s, but then declines as the drop in aggregate capital accelerates. As shown in Figure 1c, the interest rate decreases until the late 2040s, as labor becomes scarcer relative to capital, but then rises as capital becomes scarcer thereafter. Over the next 20 years, the shrinking working-age population will keep the labor market tight, while increased longevity will sustain high saving growth.

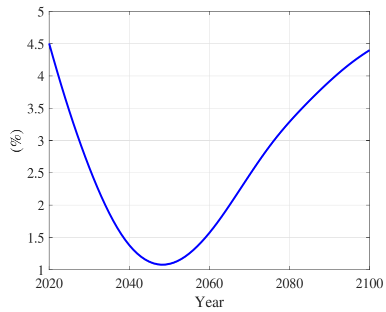
From a fiscal perspective, as the population ages, expenditures on public pension, health, and long-term care insurance programs will rise, while the tax base supporting these expenditures shrinks due to declining birth rates and a shrinking workforce. As shown in Figure 1d, the fiscal burden increases monotonically until around 2070, with the lump-sum tax required to finance the demographic transition peaking at nearly 700,000 yen. Figure 1e breaks down the changes in government expenditures. Spending on the three major social security programs—pensions, health, and long-term care insurance—all contribute to the rising tax burden. Total expenditures are projected to grow from around 25% of GDP in 2020 to about 45% by 2070.



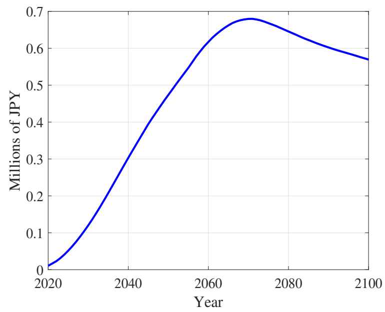
(a) Aggregate Labor



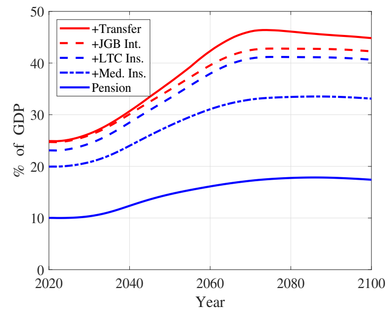
(b) Aggregate Capital



(c) Interest Rate



(d) Lump-sum Tax



(e) Government Expenditures

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

The baseline simulation demonstrates that demographic aging and the continued decline in the labor supply will contract the economy, while the rise in the old-age 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. As shown in Figure 2, there is a large difference in the average earnings by gender and marital status. Next we conduct simulations assuming alternative scenarios regarding the labor supply of married and single women.

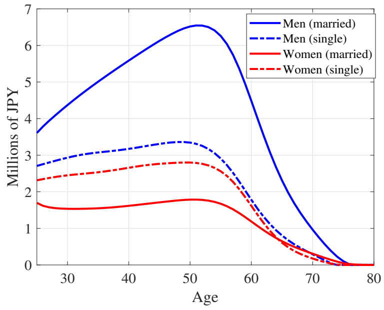
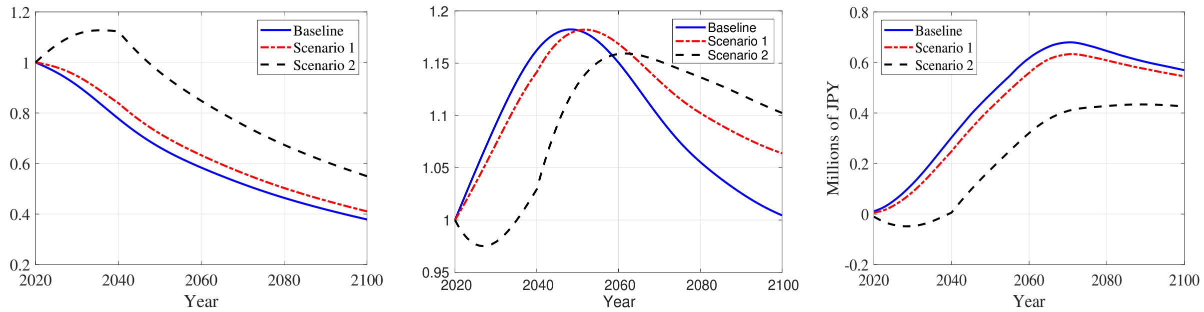


Figure 2: Age Profiles of Earnings: Baseline Model

Scenarios about Women's Labor Supply: As discussed above, the average participation rates and earnings of women are significantly lower than those of men. Moreover, the earnings of married women remain below those of single women throughout their life-cycle. We now consider a scenario in which married women supply the same level of labor as single women (Scenario 1). Additionally, as another extreme case, we consider a scenario where the labor supply of single and married women converges to the same levels as that of single and married men, respectively (Scenario 2). In both cases, we assume that labor supply increases over 20 years starting from 2020 and converges to a new level by 2040.

Under these scenarios, the labor supply of women, measured in terms of their efficiency units, increases, but wages also change through general equilibrium effects, making the change in household income a quantitative matter. Figure 3 shows the path of aggregate labor, wages and lump-sum tax. In Scenario 1, aggregate labor is higher than in the baseline path by 4.1% in 2030 and 8.2% in 2050. In the extreme case of Scenario 2, the labor supply remains above 2020 level until around 2050. With a rise in total labor supply, wages in equilibrium decrease compared to the baseline. However, after the 2050s, wages become higher than the baseline level because the increase in income leads to higher savings, which, in turn, raises the capital-labor ratio in the long-run.

As shown in Figure 3c, the 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 3: Scenarios about Women's Labor Supply (Aggregate Labor Supply and Wage in 2020=1)

5 Conclusion

We built a general equilibrium model of overlapping generations that incorporates heterogeneity in gender and family structure. The model also accounts for age-specific medical and long-term care expenditures, as well as details of the social security system, allowing it to capture the rising government expenditures driven by demographic aging. We demonstrate that, while a decline in aggregate labor and output is inevitable, the negative effects of population aging can be significantly mitigated by increasing the labor supply of married women. Crucially, they key factor in making a quantitative difference is not merely higher participation, but wage growth. A rise in the productivity of female workers to a level approaching that of male workers would substantially reduce the tax burden required to finance the demographic transition.

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