Japan's Aging Workforce: Determinants and Outlook *

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Abstract

This paper analyzes recent trends in the Japanese labor market, with a particular focus on the elderly workforce. Japan's elderly employment rates are notably high compared to other OECD countries and have increased significantly over the past two decades. We explore the characteristics of elderly workers, including their industry distribution, health status, and wealth. To assess the factors influencing elderly employment, we develop a structural life-cycle model with consumption-saving decisions and endogenous labor supply, considering both intensive and extensive margins. We find that social security reforms to raise the retirement age by five years and reduce the replacement rate by 20% would increase labor force participation among men in their 60s from 58% to 69% and 67%, respectively, while also encouraging higher retirement savings. Additionally, we find that overall labor productivity growth reduces elderly participation due to income effect, whereas productivity growth among the elderly, driven by lower skill depreciation, incentivizes them to remain in the labor force longer.

Keywords: Retirement, life-cycle model, health, public pension, Japan.
JEL Classification: D15, E21, E24, H55, J14,

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1 Introduction

Ongoing demographic aging in many countries presents a significant economic challenge, primarily due to the shrinking labor force and the rising fiscal pressures from age-related public expenditures. However, the labor supply is influenced not only by the size of the working-age population but also by the participation rates across different age groups and their labor productivity.

In the first part of this paper, we examine labor market trends in Japan and present a descriptive empirical analysis, with a focus on the behavior of different age groups, placing particular emphasis on the elderly. Using multiple data sources, including the Basic Survey of Wage Structure (BSWS), Labour Force Survey (LFS), and Japan Household Panel Survey (JHPS/KHPS), we analyze the life-cycle employment and earnings patterns over time since the 1990s and across different cohorts.

Employment rates of elderly men and women across age groups are high relative to other developed countries and have been on the rise since 2000. Men's employment rate in their early 60s rose from 65.1% in 2000 to 84.4% in 2023, and women's from 37.8% to 63.8%. Earnings are hump-shaped over the life-cycle and the trend differs from that of employment rates. Men's earnings at young and middle ages have declined since the 1990s and very recent cohorts of men earn less than those in earlier cohorts. We study the personal characteristics of working elderly and find that health, marital status, receipt of public pensions, and the level of household assets appear to matter for the employment status of men. The industry distribution of elderly men and women also shifted significantly over the last two decades, since the early 2000s. The share of those working in the agriculture, forestry, and fisheries declined sharply from 25% to 12% for men and from 30% to 10% for women. Instead, the shares for workers in the services, medical and health care services increased to absorb the share.

In the second part, we develop a structural life-cycle model, calibrated to the economic environment and labor market experiences of male individuals born between 1936 and 1940. This cohort was chosen to allow us to track the full career trajectory of the same group of individuals.

We simulate the model under alternative assumptions about the social security scheme and the labor productivity of young and old workers. Our findings indicate that the specifics of social security rules significantly impact individuals' labor supply decisions. Raising the retirement age from 60 to 65 and reducing the replacement rate by 20% would increase the average employment rate of men in their 60s from 58.1% to 74.9% in total. Individuals also accumulate more wealth over the life-cycle, as a result of optimally choosing the combination of additional labor supply and more savings to prepare for retirement.

While higher overall productivity tends to reduce elderly participation due to the income effect, an increase in the productivity of elderly workers (or a decrease in the rate of skill depreciation) leads to higher participation among them. Although economic growth might generally lower participation rates, improving working conditions for the elderly could counteract these negative effects and enhance their employment.

This paper builds on the literature that investigates the life-cycle pattern of labor supply and its interaction with the macroeconomic environment, using a quantitative model of heterogeneous individuals. French (2005) is an early paper that estimates a life-cycle model with endogenous saving and labor supply in both intensive and extensive margins and studies the roles of social security scheme in individuals' decisions. French and Jones (2011) build a life-cycle model of older individuals with medical expenditure risks and show that Medicare plays an important role in retirement decisions of the elderly. Fan et al. (2024) construct a model with endogenous consumption, labor supply, and human capital and emphasize the roles of human capital accumulation and depreciation in accounting for the life-cycle profiles of labor supply and wages. Borella et al. (2023) examine the effects of marriage-related tax provisions and social security benefits and demonstrate distortionary effects of these provisions on the saving and labor supply of men and women.

There are papers that focus on the roles of health in the life-cycle behavior of households. De Nardi et al. (2024) investigate the lifetime costs of bad health, focusing on how predetermined health types influence economic outcomes over the life-cycle. Capatina (2015) investigates how health risks affect labor supply, asset accumulation, and welfare over the life-cycle through different channels including productivity, medical expenditures, time endowment, and survival probabilities.

The papers listed above parametrize the models to the U.S. economy. There are recent papers that build quantitative life-cycle models focusing on the Japanese economy and study the roles of various policies on life-cycle decisions of households.[1] Braun and Joines (2015) analyze the medium- to long-run impact of demographic aging and fiscal sustainability in a general equilibrium life-cycle model. Kitao (2015) builds a model with endogenous labor supply in both intensive and extensive margins and studies the roles of demographic aging and the effects of social security reform.

Some papers focus on the roles of fiscal policy in the labor supply decision of women. Yamada (2011) studies the impact of tax reform in the 1990s on the labor supply decisions of married women over the life-cycle. Kitao and Mikoshiba (2024) construct a model of labor supply and human capital accumulation of women, with heterogeneity in marital status and family structure. Okada (2023) builds a life-cycle model of the elderly and

[1] For quantitative models of labor supply in other countries, see, for example, Laun and Wallenius (2015), who examine the impact of the Swedish pension reform, focusing on how the reform affects retirement behavior and disability insurance claiming of old workers. Alonso-Ortiz (2014) uses a life-cycle model with incomplete markets to study the roles of social security features in accounting for the variation in employment rates across OECD countries.

studies the effects of the social security earnings test on their labor supply, saving, and welfare.

Our study is also related to the empirical literature on the labor supply of the elderly in Japan. Oshio et al. (2020) and Oshio et al. (2023) investigate the effects of public pension programs and implicit taxes on the work incentives of the elderly. Oshio et al. (2024) analyze old workers' health capacity to work using data on the life expectancy and health status of both young and old workers, and find that the elderly in Japan have significant health capacity to continue working. Kondo (2016) studies whether a rise in elderly employment crowds out young workers, finding no clear evidence of substitution, though there is some indication of a modest crowding out of middle-age female part-time workers.

2 Data and Policy: The Work Environment of the Elderly

2.1 Data Source

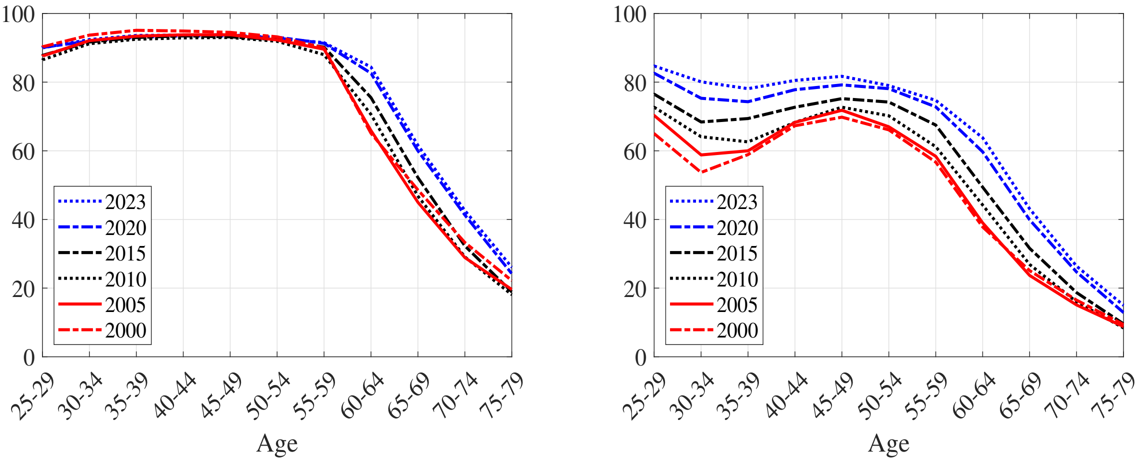
In this section, we analyze labor market trends in Japan over the past few decades, focusing on employment, earnings, and work hours across the life-cycle, with particular attention to the behavior of the elderly. Employment-related statistics are drawn from the Labour Force Survey (LFS), a household survey conducted monthly since 1947 by the Statistics Bureau of the Ministry of Internal Affairs and Communications (MIC). The LFS provides comprehensive data on employment and unemployment among individuals residing in Japan.

For wage and work hour information, we rely on the Basic Survey of Wage Structure (BSWS), an annual establishment survey conducted by the Ministry of Health, Labour and Welfare since 1947. Both the LFS and BSWS are designated as Fundamental Statistics under the Statistics Act.

Additionally, we use microdata from the Japan Household Panel Survey (JHPS/KHPS) to explore various factors related to elderly labor force participation. The JHPS/KHPS, a household panel survey conducted by the Panel Data Research Center at Keio University since 2004, collects detailed information from 4,000 households and 7,000 individuals nationwide, covering topics such as family structure, employment, health status, and assets.

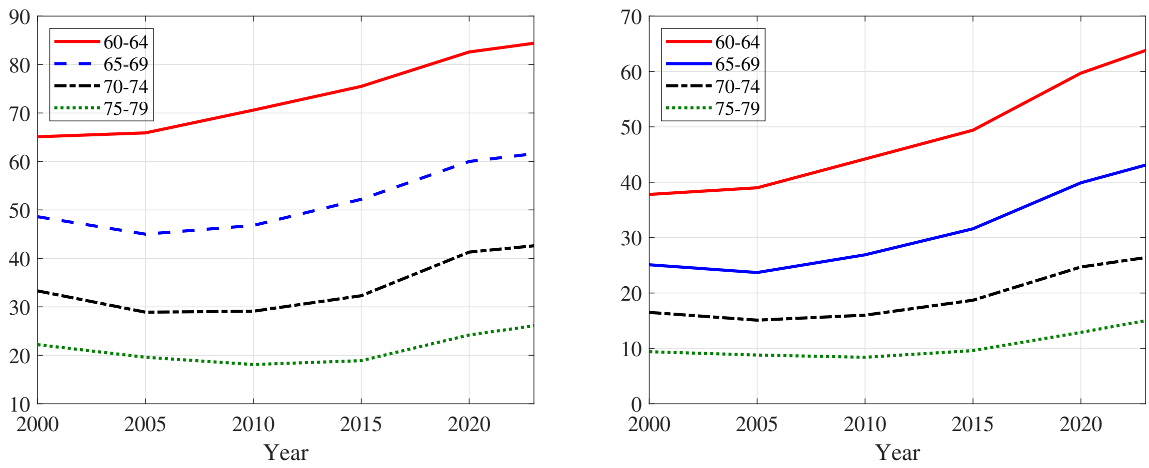
2.2 Labor Market Trends

Figure 1 shows the recent trends in participation rates of men and women between 2000 and 2020. While the participation rates for prime-age men aged 20 to 50 have changed little, there has been a noticeable increase in labor market participation among elderly men in recent years. For women, participation rates have increased across all age groups. Figure 2 shows the participation rates of those aged 60 to 79 to highlight the trends among the elderly. Participation rates of men and women aged 60 to 64 have risen by about 10 and 25 percentage points, respectively, since 2000.



(a) Men (b) Women

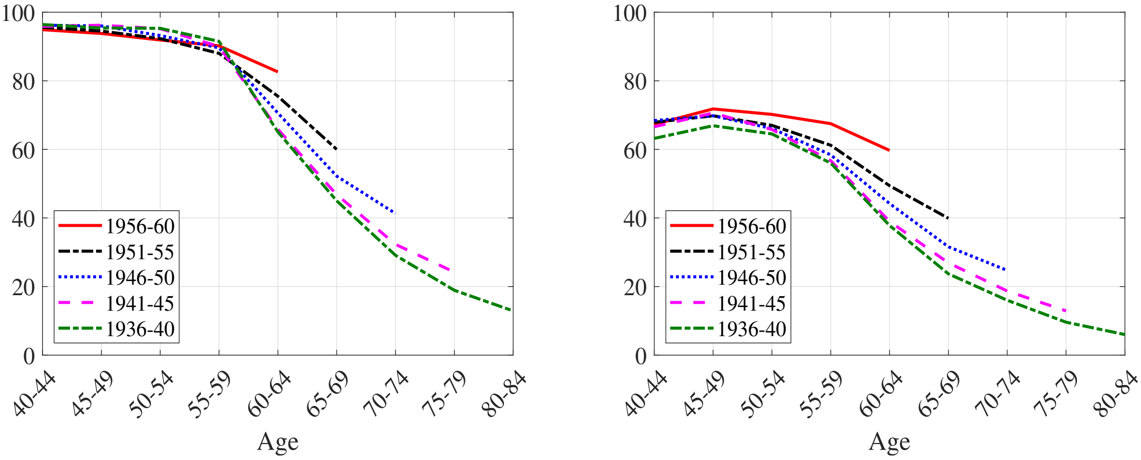
Figure 1: Employment Rates of Men and Women by Year (Source: Labour Force Survey)



(a) Men (b) Women

Figure 2: Employment Rates of Men and Women by Age Group (Source: Labour Force Survey)

Figure 3 illustrates the trend in elderly participation from a cohort perspective. Using cross-sectional data on labor force participation by age, we constructed life-cycle profiles for cohorts born between 1936 and 1960. More recent cohorts are remaining in the labor force longer, with many continuing to work well into their 60s. For men aged 60-64, the participation rate exceeds 70% across all cohorts, increasing from just above 70% for the early-1940s cohort to over 85% for the late-1950s cohort. Notably, over 40% of the late-1940s cohort, now aged 70-74, are still working. Elderly women's participation follows a similar trend, although their participation rates are lower than those of men across all age groups.



(a) Men (b) Women

Figure 3: Employment Rates of Men and Women by Cohort (Source: Labour Force Survey)

There has been considerable attention to women's labor force participation, particularly the diminishing M-shaped pattern in recent decades as more women remain in the labor force through their late 20s and 30s.[2]

In many quantitative models focusing on women's labor supply, men's participation decisions have received less attention and are often abstracted away by assuming that men always work. Additionally, many models assume that individuals leave the labor force and begin collecting social security benefits at an exogenously determined age, typically set at the eligibility age of 65 for the public pension.

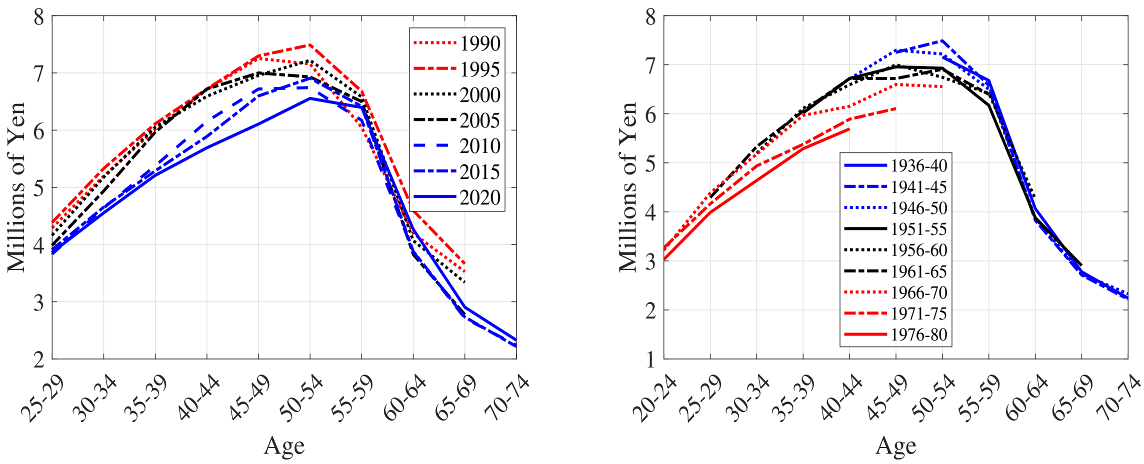
However the figures above demonstrate that many men continue working well beyond the normal retirement age for public pensions. Moreover, there has been a significant increase in the labor supply of elderly men in recent decades. This paper focuses on men's life-cycle work decisions, aiming to understand the factors that influence elderly men's participation and the potential reasons behind the rise in participation over the past few decades.

Figure 4 presents the average annual earnings of male workers by year and cohort, based on data from the Basic Survey on Wage Structure (BSWS). Although not entirely

[2]See, for example, (Kawaguchi, Kawata, and Toriyabe 2021) for an empirical analysis of labor market dynamics during the Abenomics period in the 2010s.

monotonic across age groups and years, there is a noticeable decline in earnings among prime-age men over the last few decades, as shown in Figure 4a. For example, the average earnings of men aged 40 fell by 14% from 6.7 million yen in 1990 to 5.7 million yen in 2020.[3]

Figure 4b shows the age profile of earnings by cohort, computed from cross-sectional averages, similar to how cohort participation rates were calculated above. This figure also illustrates a decline in earnings throughout the life-cycle for more recent cohorts.



(a) By Year

(b) By Cohort

Figure 4: Earnings of Male Workers (Source: Basic Survey on Wage Structure)

Figure 5 shows the average work hours of male workers across age groups from 1990 to 2015 based on the BSWS.[4] Work hours declined sharply across all age groups during the 1990s. This decline coincides with revisions to the Labor Standards Act in the early 1990s, which reduced the standard weekly work hours from 48 to 40, with some exceptions. In each year, average work hours remain relatively flat for workers aged 25 to 59, before declining sharply thereafter.

[3]Throughout the analysis, the nominal amounts are adjusted with the CPI to make them all in terms of 2020 yen.

[4]We intentionally focus on this time period, not including data after 2020 due to a change in the classification of short-term workers that year, which prevents us from computing average work hours under a consistent definition.

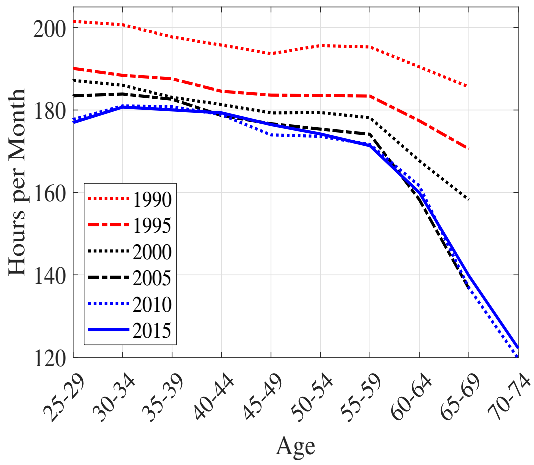
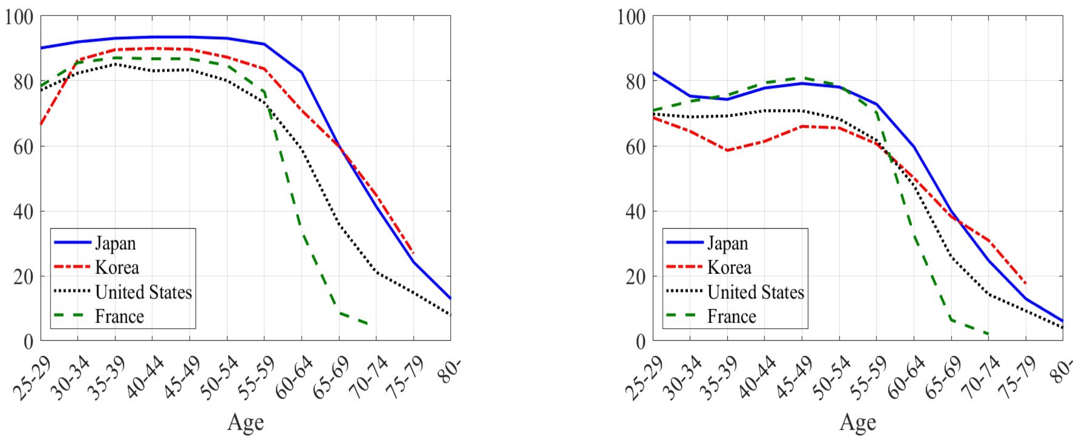


Figure 5: Work Hours of Male Workers (Source: Basic Survey on Wage Structure)

2.3 Labor Market Trends in Other Countries

Are the relatively high participation rates and the rising employment trend among the elderly unique to Japan? Figure 6 compares the employment rates of men and women with those in other countries including Korea, the U.S., and France.

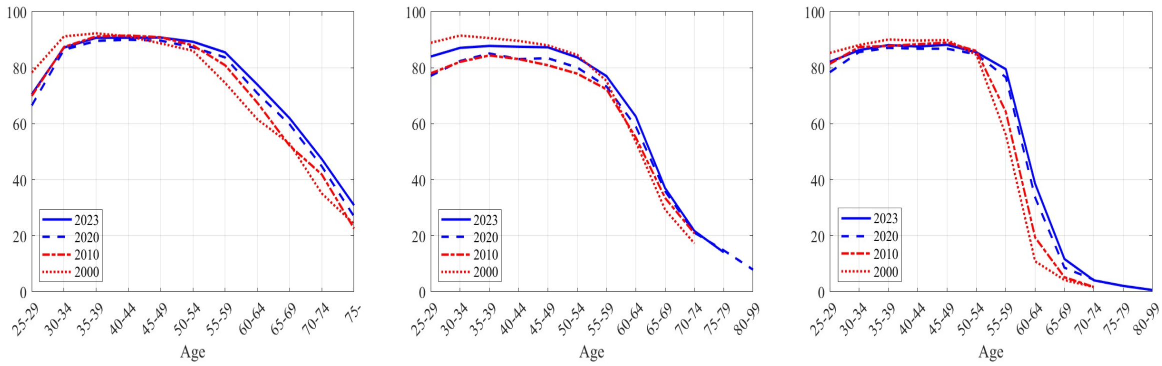


(a) Men

(b) Women

Figure 6: Employment Rates of Other Countries in 2020 (Source: OECD)

Figure 7 shows the trend of male employment rates in Korea, the U.S., and France. Although the levels differ across countries, employment rates of the elderly above age 60 are rising in all three countries, following a similar trend to that of Japan. Although the quantitative analysis of this paper focuses on the Japanese economy, the methodology is likely applicable to the analysis of the labor market trends in other countries with proper modifications.



(a) Korea (b) United States (c) France

Figure 7: Employment Rates of Other Countries by Year (Source: OECD)

2.4 Factors Related to Elderly Participation in Japan

We now use the microdata from the Japan Household Panel Survey (JHPS/KHPS) to investigate factors related to the participation of elderly men. We first study the relationship between labor force participation and personal characteristics by running the following probit regression:

$$P(y_i = 1 \mid j \geq 60) = \Phi(\alpha + \boldsymbol{x}_i \beta + \varepsilon_i), \tag{1}$$

where $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution, and the dependent variable y_i takes the value 1 if the individual aged 60 and above is employed, and 0 otherwise. Explanatory variables $\boldsymbol{x}_i$ include age, the square of age, indicators of fair and poor health status, an indicator of high education, an indicator of being married, the log of asset, an indicator of whether the individual is receiving a pension.[5] ε_i is the error term.

Table 1 presents the results of the probit regression, displaying the coefficients in the first column and the corresponding average marginal effects in the second column. The survey asks respondents to report their health status by choosing one of five options, listed in order of descending health conditions. We group the first three responses as "good," the fourth response as "fair," and the last one as "poor," comprising the three health statuses. Health status emerges as one of important determinants of labor force participation among the elderly. The results show a negative association, with deteriorating health leading to a lower likelihood of labor force participation. Compared to individuals reporting good health, which is the reference category, those in fair health are 10.2 percentage point less likely to work, while those in poor health have a substantial 30.6 percentage point lower probability.

[5]High education includes those with a college degree or higher, while those with lower educational levels are classified as low education.

Table 1: Personal Characteristics and Labor Participation of Elderly

Variable	Coefficient	Average Marginal effects
Age	$-.221^{***}$	$-.071^{***}$
	(.042)	(.014)
Age^2	$.001^{***}$	$.0003^{***}$
	(.0003)	(.0001)
Health		
Fair	$-.316^{***}$	$-.102^{***}$
	(.031)	(.010)
Poor	-1.036^{***}	$-.306^{***}$
	(.085)	(.021)
Education	.0126	.004
	(.026)	(.008)
Marital Status	$.217^{***}$	$.069^{***}$
	(.035)	(.011)
Pension	$-.687^{***}$	$-.228^{***}$
	(.038)	(.012)
Log Asset at Age 60	$-.042^{***}$	$-.013^{***}$
	(.004)	(.001)
Constant	11.208^{***}	-
	(1.52)	-

Note: (*), (**), (***) denote significance at the 10%, 5%, and 1% levels, respectively. Sample period: 2004–2022. Number of observations: 13,471. Pseudo R^2: 0.1731. The sample includes individuals aged 60 or older. Values in parentheses represent the standard errors for coefficients and the Delta-method standard errors for average marginal effects. For the log of assets at age 60, if the asset at age 60 is not reported, we use the earliest reported asset value after age 60 as a proxy.

In addition to health, other individual characteristics also play a role. Age exhibits a non-linear relationship, with the probability of working decreasing with age. Education shows a positive but not statistically significant association. Coefficients on marital status and gender are both significant. Married men are more likely to participate than singles. Pension receipt is associated with a lower probability of employment, likely reflecting the financial security provided by pensions that incentivizes some individuals to retire. Finally, the log of assets at age 60 has a negative coefficient, indicating that wealthier individuals are less inclined to work.

Health: As shown in the regression analysis, health is an important factor in accounting for the labor force participation over the life-cycle. Using the JHPS/KHPS data, we divide individuals into three health status, good, fair and poor, as explained above. Figure 8 shows the shares of individuals in fair and poor health status. The health status deteriorates as individuals age, and the share of those in either fair or poor health increases from less than 10% in their 20s to 20% in their 70s.

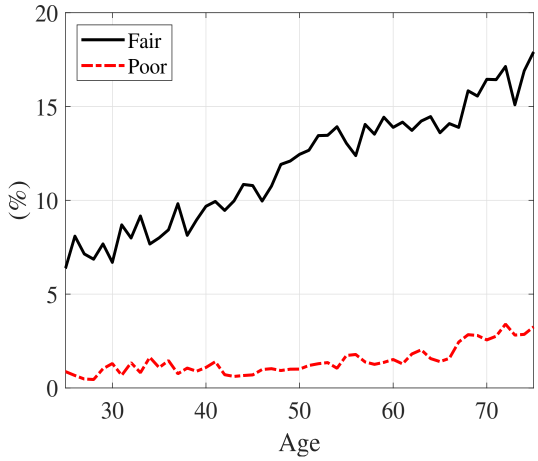
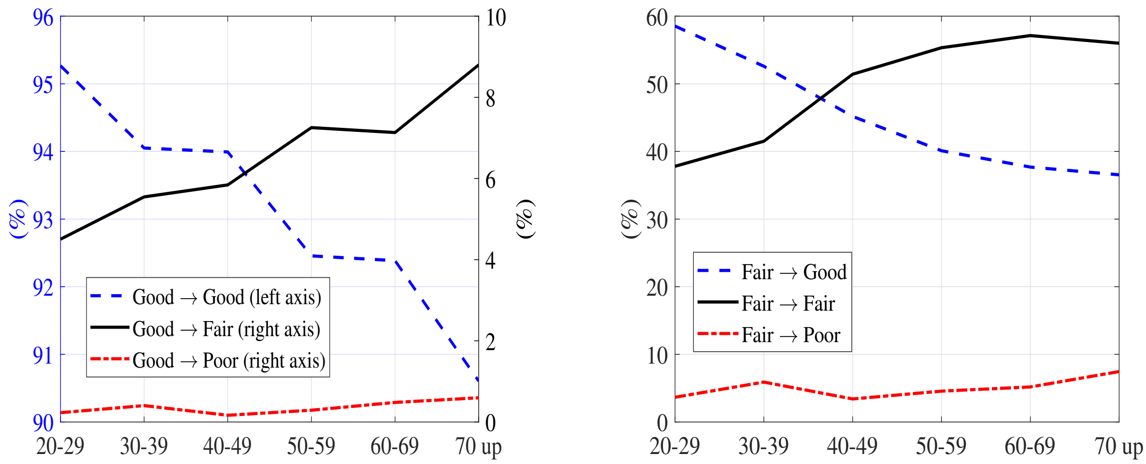


Figure 8: Shares of Individuals in Fair and Poor Health Status (Source: JHPS/KHPS)

Figure 9 report the transition probabilities of health status for individuals who are currently in good and fair health status. As shown in Figure 9a, the probability of staying in good health status in the next period declines in age and more individuals transit to either fair or poor health status. From fair health status, fewer individuals recover to good health status as they age and more individuals remain in fair health status or experience a further deterioration to poor health. These movements contribute to a rise in the share of individuals in fair and poor health status.



(a) From Good Health

(b) From Fair Health

Figure 9: Transition of Health Status (Source: JHPS/KHPS)

As indicated in the regression analysis, health plays an important role in accounting for the participation. Participation rates of individuals in poor health status are significantly lower than those in good or fair health. Since the share of individuals in fair and poor health status increases in age, deterioration of health contributes to a more important role of health in participation decision of older individuals. We include health as one of state variables and the transition process of an individual's health status over the life-cycle in the quantitative model presented in Section 3.

2.5 Fiscal Policy, Public Pension, Health Insurance and Long-term Care

In this section, we briefly review the trends in the social security and fiscal systems in Japan surrounding workers and their life-time budget. In Japan, the pension system started as workers' insurance scheme in 1942, and the national scheme started to provide universal coverage in 1961. The public pension system consists of two parts: the national pension system that provides basic pension benefits, and the employees' pension insurance system. The benefits of the second part are determined based on the contributions of workers made at work. The standard eligibility age to receive the basic pension benefits has been 65, and the eligibility age for the employees' pension has been increasing from 60 since 2000, and will reach 65 in 2025.

The public pension, health insurance, and long-term care insurance constitute the three main pillars of the social security system in Japan, with the total expenditures accounting for 20% of GDP in 2021, according to the Financial Statistics of Social Security in Japan reported by the IPSS. Figure 11 shows the expenditures of the three programs as a share of GDP. Note that the long-term care insurance system started in 2000.

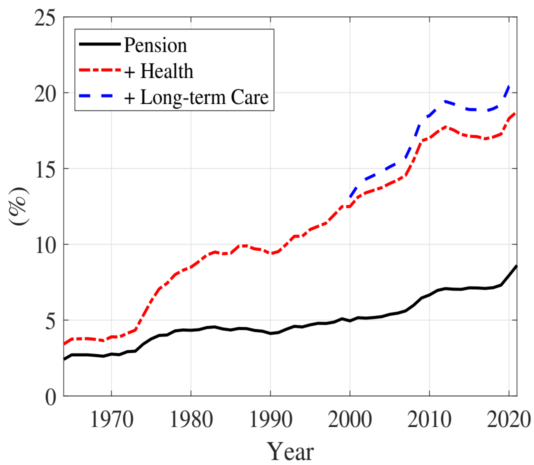
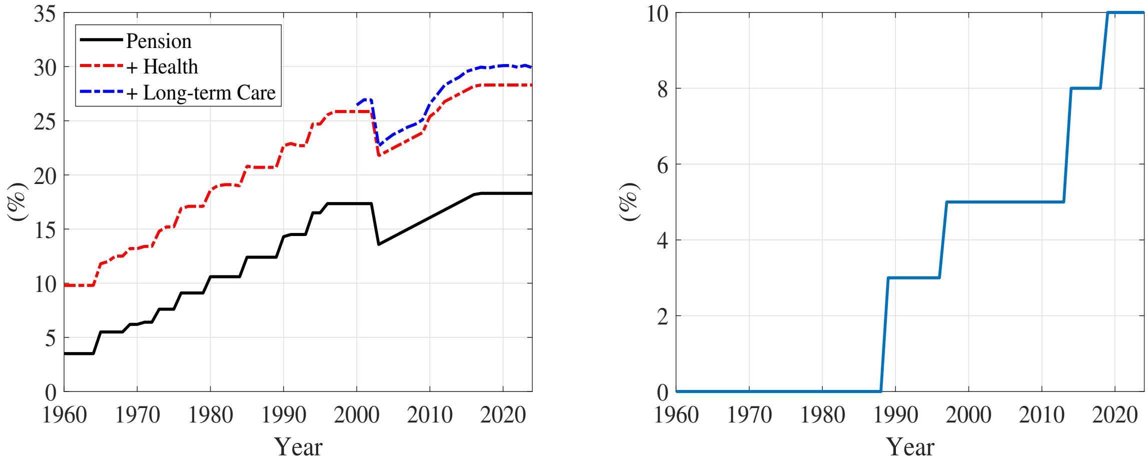


Figure 10: Social Security Expenditures as a Share of GDP (Source: IPSS)

With a steady increase in the expenditures, the tax burden has increased over time. Figure 11 shows the path of social security taxes for each program. The consumption tax was introduced in the late 1990s and rose to 10% in 2019.



(a) Social Security Tax

(b) Consumption Tax

Figure 11: Social Security and Consumption Tax

2.6 Employment Across Industries

We now examine the distribution of workers across industries by age group and over time. We use the LFS data since 2003 and summarize the share of workers in selected industry groups in Table 2.[6] The LFS classifies industries into 20 categories according to the Japan Standard Industrial Classification (JSIC). We further consolidate them into seven larger categories.

[6]Industry categories vary over time in the LFS and we chose the starting year of 2003, when there were major changes in the industry group.

Table 2: The Share of Each Industry Among the Employed

	Agriculture	Manufacture	Services	Medical	Transport	Wholesale	Others
Male							
≥ 65							
2003	25.3	23.3	25.7	3.7	4.7	15.5	1.4
2013	16.5	23.4	30.6	4.6	7.2	14.4	2.6
2023	12.2	23.4	33.7	6.7	7.5	12.4	3.9
≤ 64							
2003	2.7	36.1	24.7	3.1	11.2	15.3	6.9
2013	2.4	33.2	25.5	5.0	12.1	14.3	7.4
2023	1.9	31.9	25.4	6.1	13.5	13.5	7.5
Female							
≥ 65							
2003	30.0	14.4	28.3	5.0	0.6	20.0	1.1
2013	16.6	13.0	38.1	10.5	1.6	18.2	2.0
2023	10.3	11.6	36.6	18.7	2.1	17.4	3.4
≤ 64							
2003	3.0	18.9	33.6	15.6	4.0	21.8	3.1
2013	2.0	14.1	33.6	21.6	4.4	20.1	4.0
2023	1.3	13.6	33.6	22.8	5.7	18.0	5.0

Source: Labour Force Survey

Note: The units are percentages. All industries are covered, but due to rounding, the sum of each row may not equal 100. The JSIC industries are consolidated into 7 groups: Agriculture (agriculture, forestry and fisheries), Manufacturing (mining and quarrying of stone and gravel, construction, and manufacturing), Services (finance and insurance, real estate and goods rental and leasing, scientific research, professional and technical services, accommodations, eating and drinking services, living-related and personal services and amusement services, education, learning support, compound services, and services, N.E.C.), Medical (medical, health care and welfare), Transport (transport and postal activities, and information and communications), Wholesale (wholesale and retail trade), and Others (electricity, gas, heat supply and water, government, and industries unable to classify).

The data show a noticeable shift in employment trends among men aged 65 and over from 2003 to 2023. The share of those employed in agriculture has significantly decreased from 25.3% in 2003 to 12.2% in 2023. There has been an increase in the share of male workers in the services sector, from 25.7% in 2003 to 33.7% in 2023, and the share of the medical sector also increased by 3 percentage points.

By comparing these trends with male workers aged 64 and under, a similar but less pronounced pattern emerges. The share of young and middle-aged men in agriculture also decreased from 2.7% to 1.9%, while the medical sector saw an increase, from 3.1% to 6.1%. While both older and younger males have been moving into the services and medical sectors, younger male workers have experienced a more moderate shift.

The group of female workers aged 65 and over also shows notable changes in the employment patterns across industries. The share of agriculture drastically decreased from 30.0% in 2003 to 10.3% in 2023, a steeper decline than that observed for men. The most substantial increases are in the services and medical sectors. The share of elderly women in services increased from 28.3% to 36.6% and that in the medical sector rose from 5.0% to 18.7%. This observation is consistent with the findings of Kawaguchi et al. (2021), who examine the labor market dynamics between 2012 and 2020, during the Abenomics period.

In comparison, younger women exhibit similar trends, with agriculture decreasing from 3.0% to 1.3%. The share of the services sector remained unchanged at 33.6%, while the share of the medical sector grew from 15.6% to 22.8%. The overall trend among younger women mirrors that of older women, with some differences in magnitudes across industries.

3 Model

In this section, we present our quantitative model. The unit of the model is an individual. We consider a life-cycle model of individuals who are heterogeneous in multiple dimensions. Individuals differ in age, assets, health status, labor productivity in both fixed and stochastic components. We also assume preference heterogeneity in patience to account for a fraction of individuals who save none or very little over the life-cycle. We focus on male individuals and abstract from heterogeneity in family structure and gender.

In each period, individuals choose the amount of assets to carry into the next period and decide whether to participate in the labor market and, if so, how many hours to work. Individuals face uncertainty in three dimensions. First, life span is uncertain, and they face survival probabilities in each period that vary by age. Second, health status is uncertain, which we assume affects the utility cost of participating in the labor market. Third, labor productivity includes an idiosyncratic stochastic component. We assume that individuals take macroeconomic conditions, including factor prices and fiscal policies, as given, and that there is no aggregate shock.

3.1 Demographics

Individuals enter the economy at age $j = 1$ and live up to the maximum age of $j = J$. Life span is uncertain, and the conditional probability of survival from age j to age $j + 1$ is denoted as s_{j+1}, with $s_{J+1} = 0$.

3.2 Endowments

In each period, individuals are endowed with a unit of disposable time that they allocate between market work and leisure. Individuals' productivity consists of three components. First, they are born with an ability type α, which is fixed throughout their life-cycle. Second, there is an idiosyncratic stochastic component denoted by η. Third, there is age-specific productivity denoted as ν_j. Earnings of a working individual are given as $y = \alpha\eta\nu_j hw$, where h denotes work hours and w is the wage per efficiency unit. The interest rate r is exogenously given.

3.3 Health

Health status of an individual is denoted as m, and $\pi_j^m(m, m')$ represents the probability that the health status will be m' in the next period, given that the current health status is m for an individual of age j.

3.4 Preferences

Individuals derive utility from consumption c and leisure l in each period according to the following utility function.

$$u(c, l) = \frac{[c^\gamma l^{1-\gamma}]^{1-\sigma}}{1-\sigma},$$

where

$$l = L - h - (\theta_j + \phi_m)I_h.$$

L denotes the total time endowment of an individual, and h is work hours chosen by an individual. θ_j denotes participation costs that may vary with age, and ϕ_m represents participation costs that vary with health status. I_h is an indicator that takes a value of 1 if an individual participate, i.e. $h > 0$.

The lifetime utility of an individual is defined as

$$E\left\{\sum_{j=1}^{J} \beta_i^{j-1} u(c_j, l_j)\right\}, \tag{2}$$

where the expectation is with respect to idiosyncratic productivity shocks, mortality risks and health shocks. We assume preference heterogeneity in discount factors and β_i in equation (2) denotes subjective discount factor of type-i individuals. We assume the value of discount factor remains constant throughout the life-cycle.[7]

[7]See Krusell and Smith (1998) and Hendricks (2007), for example, for papers that incorporate heterogeneity in discount factors.

3.5 Government

The government collects taxes from individuals and provides social security benefits and means-tested transfers for eligible individuals.

Once reaching the pension eligibility age, which we call as the normal retirement age, denoted as j_R, each individual starts to receive pension benefits $ss(p)$. The benefits are given as an increasing function of past earnings. The index p summarizes an individual's past earnings up to the normal retirement age.

The index p is defined recursively as

$$p' = \frac{(j-1)p + y}{j}$$

for $j < j^R$ and $p' = p$ for $j \geq j^R$, where y is an individual's earnings at age j. Note that the normal retirement age j_R is the age at which individuals start to receive public pensions benefits. The retirement age for the public pension does not have to be the same as the age at which individuals leave the labor force and retire from work.

The government imposes taxes on consumption at rate τ^c, labor income at τ^l, and capital income τ^a. Earnings are also subject to a proportional payroll tax denoted as τ^p. The after-tax gross interest rate is denoted as $R = 1 + r(1 - \tau^a)$.

The government provides a means-tested transfer tr to an individual to guarantee a minimum consumption level of $\underline{c}$. The transfer amount is given as in equation (3) and it is zero if disposable assets exceed $\underline{c}$ plus consumption taxes.

$$tr = \max\{0, (1+\tau^c)\underline{c} - \underline{a}\} \tag{3}$$

$\underline{a}$ denotes the disposable assets of an individual, defined as follows.

$$\underline{a} = Ra + (1 - \tau^l - \tau^p)y + ss(p)$$

3.6 Individuals' Problem

Individuals are heterogeneous in multiple dimensions, and the state vector is given as $(j, a, i, \alpha, \eta, m, p)$, where j denotes age, a assets, i preference type, α fixed productivity, η stochastic productivity, m health (medical) status, and p an index for past earnings. The value function of an individual in state x is given as

$$V(j, a, i, \alpha, \eta, m, p) = \max_{c,e,a'} \{u(c, l) + \beta_i s_{j+1} \mathbb{E} V(j+1, a', i, \alpha, \eta', m', p')\}$$

subject to

$$\begin{aligned} (1+\tau^c)c + a' &= Ra + (1 - \tau^l - \tau^p)y + ss(p) + tr \\ y &= \alpha\eta\nu_j hw \\ a' &\geq 0 \end{aligned}$$

The expectation operator is with respect to the health status m' and productivity shock η' in the next period. Social security benefits, denoted as $ss(p)$, are paid to those at and above the normal retirement age j^R and it takes a value of zero otherwise. Welfare transfer tr is positive for eligible individuals and zero otherwise.

4 Calibration

In this section, we present the parametrization of the model. We use various databases including the Labour Force Survey (LFS), the Basic Survey of Wage Structure (BSWS), the Japan Household Panel Survey (JHPS/KHPS), and estimates from the National Institute of Population and Social Security Research (IPSS), to obtain the data counterparts of our model variables and to derive target moments for our calibration.

Our basic strategy is to calibrate parameters to match the life-cycle profiles of variables for the cohort born between 1936 and 1940, which we refer to as the 1940 cohort. This cohort is in their early 80s by 2020 and we have labor market data for most of their working ages. We also use the demographic variables and government policies that vary over time, consistently with what this cohort experienced over their life-cycle. Table 3 summarizes the calibration results.

4.1 Demographics

Individuals enter the economy at age $j = 1$ (25 years old) and live up to the maximum age of $J = 76$ (100 years old). Survival probabilities s_j for the 1940 cohort are obtained from the life table reported by the Ministry of Health, Labour and Welfare (MHLW).

4.2 Endowments

An individual's earnings is given by $y = \alpha\eta\nu_j hw$ and the logarithm of the wage is given as

$$\log\alpha + \log\eta + \log\nu_j + \log w$$

We calibrate the distribution of the fixed ability type α and the stochastic process of the idiosyncratic component η to match the life-cycle profile of wage dispersion estimated by Lise et al. (2014), who use the BSWS data to estimate various moments of male wages by age for different cohorts. We use their estimates of variance for the 1940 cohort.

We assume that there are two values of α, a fixed ability type, to match the variance of wages at the initial age of 25. Lise et al. (2014) demonstrate that the wage variance rises monotonically and almost linearly with age. To approximate this pattern, we assume that the idiosyncratic shocks η are permanent and calibrate the variance of the error ε_η^2 to match the growth of the variance between ages 25 and 59.

The age-specific component ν_j is based on the average wage by age for individuals aged 25-59 from the BSWS. The average wage level declines from age 60 onwards in the data, and we assume that the age-specific component falls at a rate δ from age 60. We set this value to match the ratio of average wages between ages 60 and 80 in the BSWS. Note that the depreciation rate δ is set in the model so that the growth rate of the average wage of participating workers matches the data. The interest rate is exogenous in the model and is set to 2%.

4.3 Health

We assume that an individual's health status evolves stochastically over the life-cycle and affects participation costs. We use the JHPS/KHPS data to compute the health transition matrix $\pi_j^m(m, m')$. As we discussed in section 2, we use responses to the survey question about individuals' subjective health status and group them into three health categories: good, fair and poor. We then compute conditional transition probabilities for each health state and derive the 3-by-3 transition matrix.

4.4 Preferences

In the utility function, we set γ, the weight parameter on consumption relative to leisure, so that the average work hours in the model match those in the data.[8] We set the risk aversion parameter σ to 2.

We allow for heterogeneity in the discount factor β_i, assuming that there are two types of individuals to better approximate the pattern of savings. A fraction of individuals save very little over the life-cycle. Acccoding to the JHPS/KHPS data, about 15% of individuals report owning zero asset around retirement age.[9] We assume that there is a group of individuals who are hand-to-mouth (type 2), by setting β_2 to zero for 15% of the individuals. For all other individuals (type 1), we set their discount factor β_1 so that the average wealth at age 60 aligns with the data.

There are two types of participation costs: those that depend on age θ_j and those that depend on health ϕ_m, respectively. For the age-dependent costs, given that participation rates start to decline only after age 60, we assume positive participation costs only for individuals aged 60 and above. The functional form as follows:

$$\theta_j = \Theta_1 + \Theta_2 j^{\Theta_3}$$

[8]Average weekly work hours for men aged 25-59 is 199 hours for the 1940 cohort, according to the BSWS. We set the target $h = 199/480 = 0.42$.

[9]This share of individuals with little wealth is similar to what is reported in Kitao and Yamada (2019), who use the NSFIE data.

We set the parameters Θ_1, Θ_2, and Θ_3 to match the participation profile of those aged 60 and above.[10]

Among individuals aged between 60 and 74, the average participation rate of those in fair and poor health is lower than that of those in good health by 10 and 37 percentage points, respectively. We set the health-dependent participation costs to match these differences.

4.5 Government

We set the capital income tax rate τ^a and labor income tax rate τ^l to 0.35 and 0.18, respectively, based on the estimates of effective tax rates by Gunji and Miyazaki (2011). The consumption tax was introduced in 1989 and set at 3% and was gradually raised to 10% by 2019. We assume that the consumption tax rate τ^c varies over time accordingly.

The payroll tax τ^p captures the social insurance premium, including payments for public pension, health insurance and long-term care insurance programs. The total tax rate paid by employed workers rose from 5.9% in 1965, when the 1940 cohort was 25 years old, to 15.0% in 2024. We let the payroll tax rate τ^p grow over time correspondingly.

The replacement rate of social security κ is set so that the average pension benefits of the 1940 cohort match the data. We set the pension retirement age to 60 years old ($j_R = 41$ in the model). The retirement age has been gradually raised from 60 to 65 since 2001, and we will simulate the model with an alternative retirement age and a different replacement rate in section 5.

For the welfare transfer, we set the consumption floor to match the path of the standard amount of living assistance for single individuals.

[10] In the calibration algorithm, we use the average participation rate in their 60s and 70s, as well as the zero participation in their 90s as target moments. The age in the functional form represents the number of years from age 59.

Table 3: Parameters of the Model

Parameter	Description	Value/Source
Demographics		
J	Maximum age	76 (age 100)
s_j	Survival probability	Life Table
Endowment		
α	Fixed ability	{0.77, 1.30}, Lise et al. (2014)
σ_η	Idio. productivity std. dev.	0.091, Lise et al. (2014)
ν_j	Age-specific productivity	See text, BSWS
δ	Skill depreciation rate	0.037, BSWS
Health		
$\pi(h, h')$	Health status transition	See text, JHPS/KHPS
Preference		
β_i	Subjective discount factor	{0, 0.998}
σ	Risk aversion parameter	2.0
γ	Preference weight	0.403
θ_j	Participation cost by age	See text, BSWS
ϕ_m	Participation cost by health	{0,0.015,0.064}, JHPS/KHPS
Government		
j_R	Pension retirement age	46 (age 65)
κ	Public pension replacement rate	0.417
τ_l	Labor income tax rate	0.18
τ_a	Capital income tax rate	0.35
τ_p	Payroll tax rate	Time-varying
τ_c	Consumption tax rate	Time-varying
Other Parameters		
r	Interest rate	2.0%

5 Numerical Results

5.1 Baseline Model

Figure 12 shows the employment rates of individuals in our baseline model, compared to the data for the cohort of men born in 1936-1940, constructed from the LFS data. In our model, individuals continue to work until age 60 and then gradually begin to leave the labor force, reaching nearly full retirement by age 90, as observed in the data.

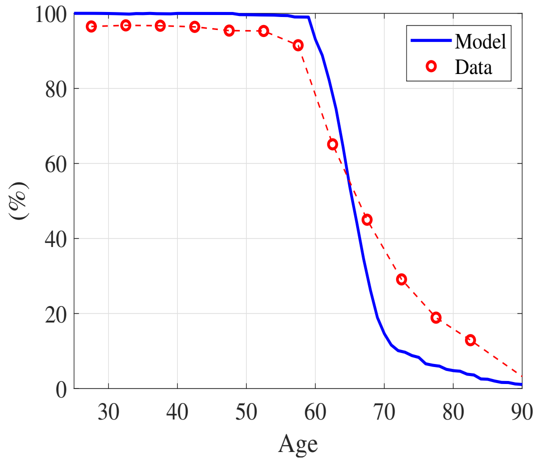


Figure 12: Employment Rates: Baseline Model

Note that we are not able to explain the small percentage of individuals aged between 25 and 60 who do not work in the labor market. This group likely includes individuals who are not working due to reasons such as unemployment, disability, hospitalization, etc., which are not accounted for by the elements of our model. The main goal of our quantitative model is to approximate the pattern of gradual decline in employment for individuals above age 60, and we achieve this with a parsimonious set of parameters that define work and participation disutility and productivity.

Figure 13 shows the participation rates by health status for individuals aged 60 and above. Note that we target the difference in participation rates across health types using the health-specific participation costs for individuals in fair and poor health status, respectively.

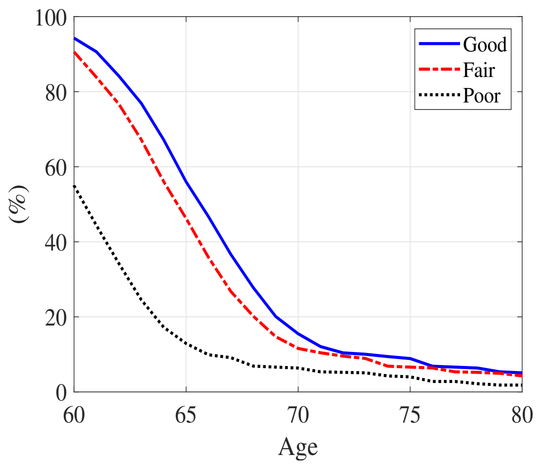
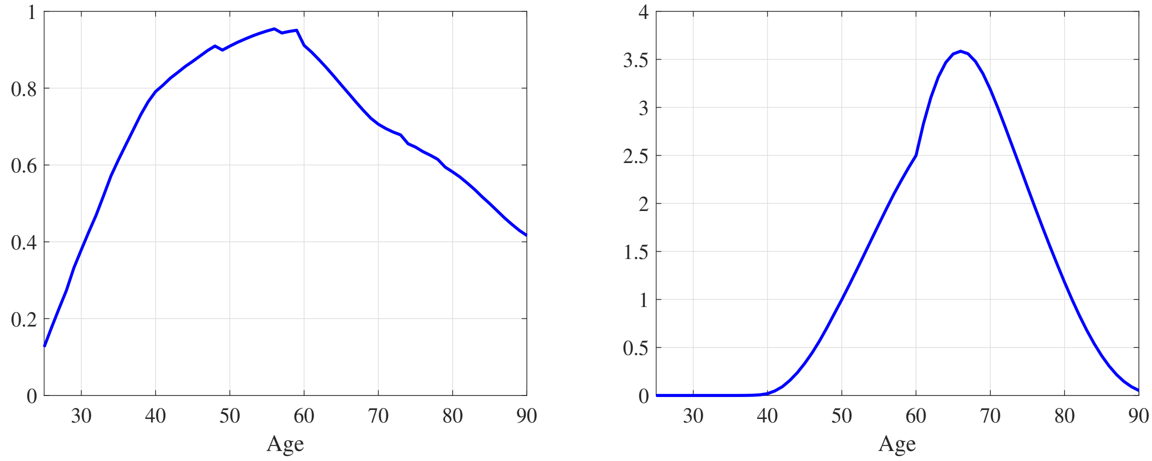


Figure 13: Employment Rates by Health (Age 60 and above): Baseline Model

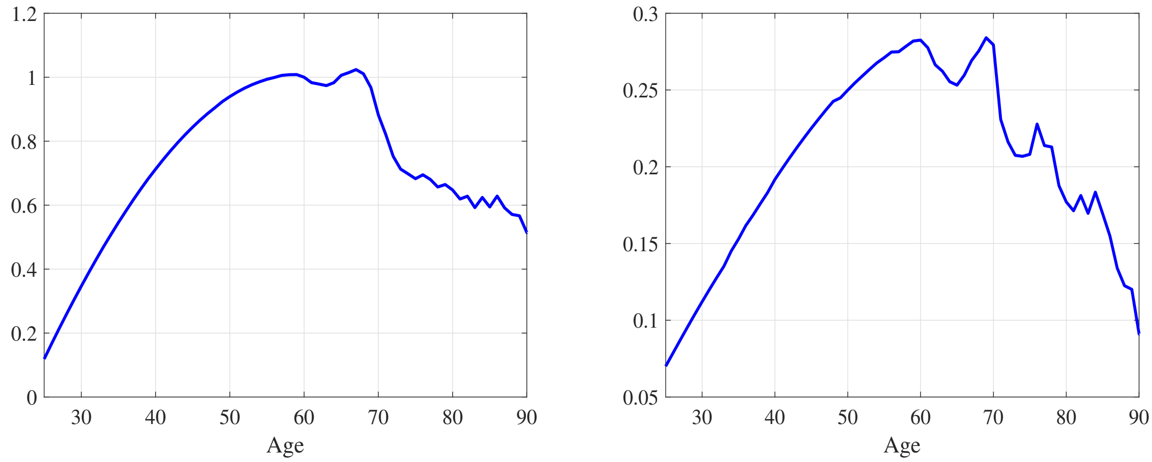
Figure 14 shows the life-cycle profiles of consumption and assets. The consumption profile is hump-shaped, and in a similar shape as those reported in empirical studies, such as Kitao and Yamada (2024). Assets increase towards the retirement period and peak in their mid-60s.



(a) Consumption (b) Assets

Figure 14: Consumption and Asset over the Life-cycle: Baseline Model (Average Earnings=1)

Figure 15 shows the age profiles of average wages and wage variance. Both the levels and variances rise over the life-cycle until around age 60 and decline thereafter.



(a) Average Wage (Age 60=1) (b) Log-wage Variance

Figure 15: Average Wage Level and Variance over the Life-cycle: Baseline Model

Figure 16 shows average work hours of workers by age in the baseline model, expressed in the model units and as a fraction of total disposable time. They work approximately 40% of their disposable time until their late 50s, after which many begin to work fewer hours when they start receiving social security benefits. Worker productivity declines at older ages, and the deterioration of health increases participation costs, which also contribute to the decline in work hours at older ages.

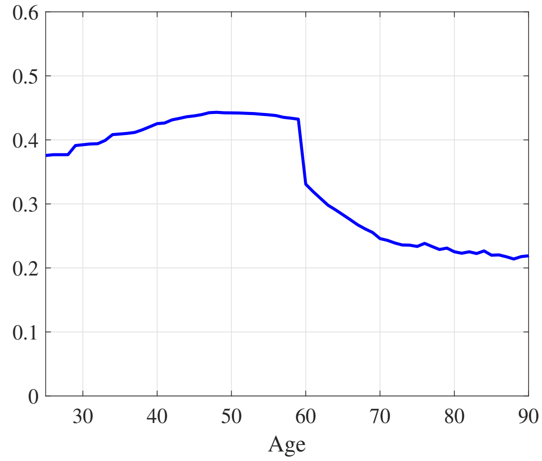


Figure 16: Average Work Hours of Workers: Baseline Model

Figure 17 shows the share of recipients of welfare transfers by age. According to the National Survey on Public Assistance Recipients by the Ministry of Health, Labour, and Welfare (MHLW), the share of welfare recipients rises with age, and the profile is similar to that of our model.[11]

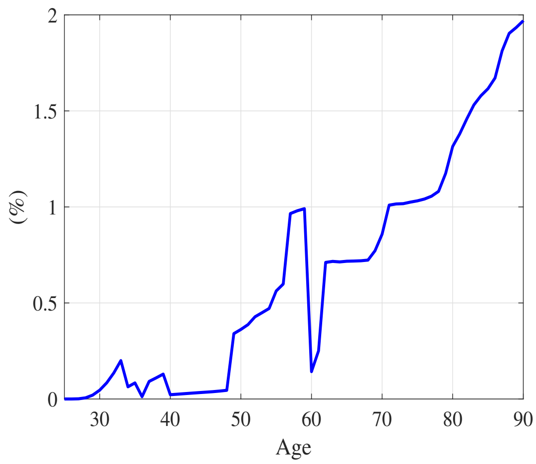


Figure 17: The Share of Welfare Recipients: Baseline Model

5.2 Factors Related to Elderly Participation

In section 2.4, we studied several factors that likely influence the participation of the elderly. We now investigate how some of these factors, along with others, affect the life-cycle behavior of individuals in our model. In the first set of simulations, we assume

[11]Following the coverage by age for the 1940 cohort, the share increases from 0.6% in their 20s (in 1960) to 1.6% in their 60s (in 2000). Survey data is available at https://www.mhlw.go.jp/toukei/list/74-16.html (in Japanese).

alternative scenarios for the public pension scheme. In the second set of simulations, we consider different scenarios for individuals' labor productivity.

5.2.1 Social Security Reform

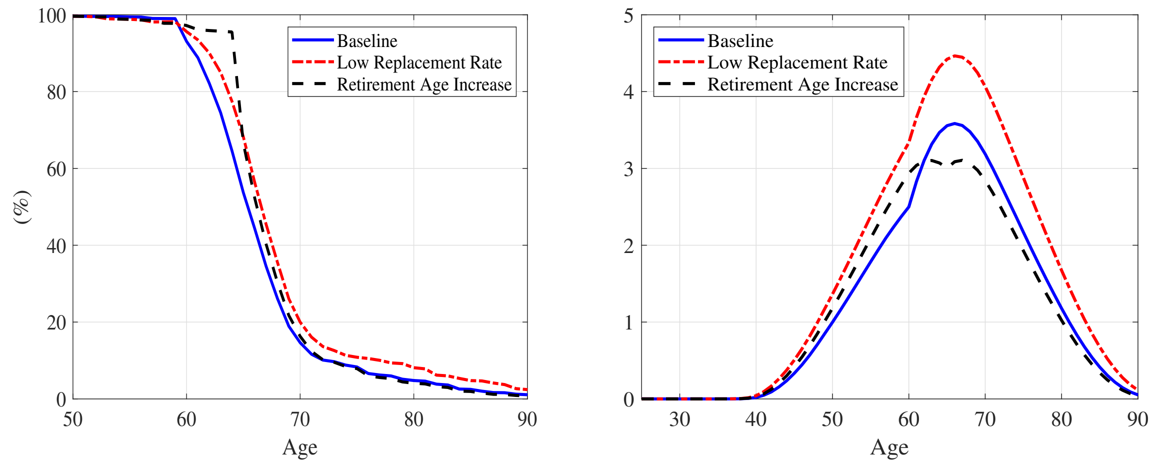
In the baseline model calibrated to the 1940 cohort, individuals start receiving the public pension at age 60, and the replacement rate is set to match the average pension benefits of the cohort. In this section, we simulate the model under alternative assumptions about the normal retirement age and the replacement rate.

Since 2001, the retirement age has been gradually raised from 60, and it will reach 65 by 2025 for men and by 2030 for women. Moreover, to cope with the rising fiscal burden to cover age-related expenditures, the government introduced the 'macroeconomic slide' scheme in the pension reform in 2004. The scheme is designed to adjust the amount of public pensions automatically in response to demographic changes, including an extension of average life expectancy, and a decline in the insured working-age population. However, the scheme includes an exemption from adjustments in a deflationary economy to prevent a decline in benefits in nominal terms. Due to this exemption and other reasons, adjustments were not made in many years, and the scheme has been implemented only several times so far. Adjustments will continue, and according to the government's 2024 Financial Projection of Pension (*zaisei kensho*), published by the Ministry of Health, Labour and Welfare (MHLW), the pension replacement rate is expected to decline by approximately 20% under the baseline growth scenario.

Given these past and ongoing developments, we simulate a reform that raises the retirement age from age 60 to 65, and a reform that reduces the replacement rate by 20%. Figure 18 shows the paths of employment rates and assets under these two scenarios. With a lower replacement rate, individuals have stronger incentives to save for retirement, resulting in higher asset levels throughout the life-cycle. At age 65, the average asset level is 24% higher than in the baseline model. Individuals also stay in the labor force longer, with the average employment rate in their 60s at 67.3%, compared to 58.1% in the baseline model.

When the retirement age for receiving pension benefits is raised from 60 to 65, individuals save more than in the baseline model until their early 60s. Thereafter, they decumulate wealth faster, as they need to wait an additional five years for pension benefits to begin. Many individuals choose to stay in the labor force longer, with the employment rate remaining particularly high until the new retirement age. The average employment rate in their 60s rises to 69.2%, about 11 percentage points above the baseline level.

These two experiments demonstrate that individuals adjust to lower pension benefits by increasing their savings and extending their working period. When combining the two scenarios-raising the retirement age to 65 and reducing the replacement rate by 20%-the average employment rate in their 60s increases to 74.9%, 16.8 percentage points above the baseline model. This indicates that part of the rise in elderly participation rates in recent years is likely due to changes in the social security system and a decline in the expected receipt of benefits.



(a) Employment Rates

(b) Assets

Figure 18: Social Security Reform

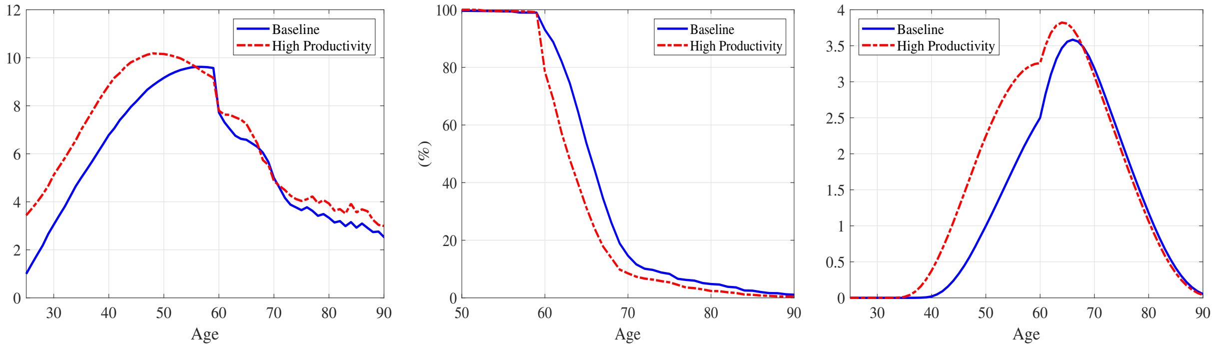
Note: Assets are expressed in units of average earnings in the baseline model in (b).

5.2.2 Productivity Growth and Depreciation

The labor productivity of workers depends on the age-dependent deterministic component ν_j, as well as other idiosyncratic components. We calibrated the deterministic component for individuals aged 25 to 59 so that the wage profile by age would match the profile of the 1940 cohort. After age 60, we assume that deterministic productivity declines at a rate δ.

In this section, we simulate the model with two alternative scenarios regarding individuals' labor productivity. In the first scenario, we assume higher average productivity for prime-age individuals aged between 25 and 59, using the wage profile of the 1960 cohort based on the BSWS data. In the second scenario, we consider a scenario with a lower depreciation rate of old individuals' productivity, setting δ at one percentage point below the baseline level.

Figure 19 shows the results for the scenario of high productivity. As shown in Figure 19a, labor income is significantly higher among young and middle-aged individuals, leading them to accumulate more wealth until their mid-60s. The asset level at age 60 is 30.3% higher than in the baseline model. Due to the strong income effect, the employment rate is lower after the retirement age, as shown in Figure 19b.

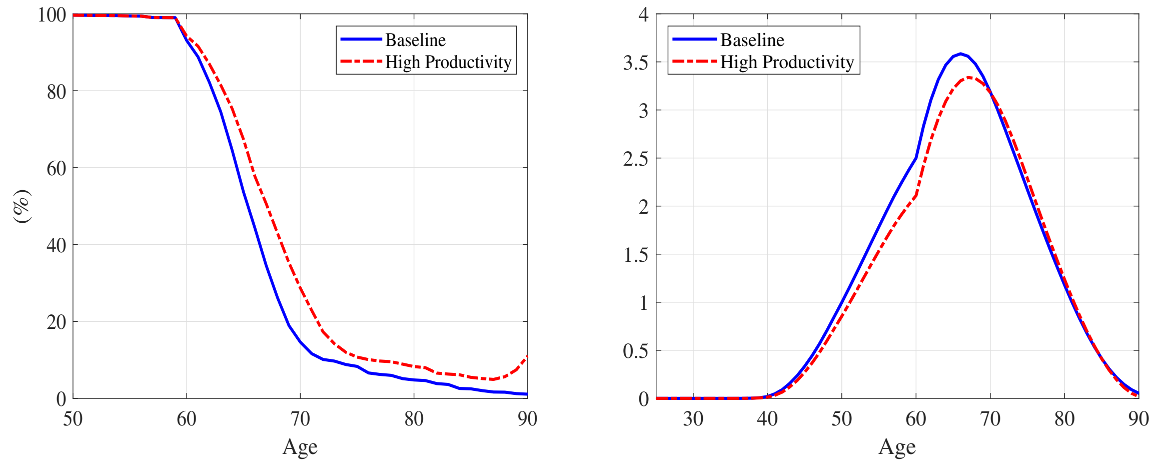


(a) Earnings (b) Employment Rates (c) Assets

Figure 19: Productivity Growth

Note: Average earnings are for workers only. Earnings at age 25 in the baseline=1 in (a). Assets are expressed in units of average earnings in the baseline model in (c).

Figure 20 shows the profiles of employment rates and assets when we assume a lower depreciation rate of skills after age 60. Employment rates decline more gradually, with the average employment rate in their 60s reaching 68.4%, approximately 10 percentage points higher than in the baseline model. Anticipating higher wages and longer working years, individuals save less than in the baseline model until around age 70, as shown in Figure 20b, although the asset level is similar thereafter as their earnings are higher on average.



(a) Employment Rates (b) Assets

Figure 20: Higher Productivity of Old Workers

Note: Assets are expressed in units of average earnings in the baseline model in (b).

The two experiments demonstrate that higher productivity and wages may or may not lead to more employment of the elderly, depending on how such changes occur. Economic growth and higher income generally imply income effects and tend to reduce participation, but a rise in the productivity of the elderly will induce them to work longer. Improvement in the working capacity of the elderly or changes in the labor market and working conditions for the elderly would encourage their participation. Such changes could potentially be achieved in different ways, for example, by improving health conditions and working environment, better maintenance of human capital through recurrent and life-long education, and a shift towards jobs that require less physical strength.

6 Conclusion

This paper consists of two parts. In the first part, we provide a descriptive empirical analysis of labor market trends among the elderly in Japan. We then construct a quantitative structural model calibrated to the life-cycle behavior of the cohort of individuals born between 1936 and 1940.

Using data from the Labour Force Survey (LFS) and the Basic Survey of Wage Structure (BSWS), we analyze trends in employment, earnings, and work hours for men and women over the past several decades. Employment rates for those aged 60 and above are significantly higher in Japan than in many other OECD countries, and these rates have continued to rise since 2000. However, average earnings for young and middle-aged male workers have been declining since the 1990s. Additionally, we use data from the Japan Household Panel Survey (JHPS/KHPS) to study factors related to the elderly employment.

We then construct a model of heterogeneous individuals to account for their life-cycle behavior, allowing for heterogeneity in age, labor productivity, assets, health status, preference in the discount factor, and past earnings. The calibrated model is used to quantify the effects of factors related to elderly participation decisions. We find that pension reforms to lower the replacement rate or to raise the retirement age lead to higher participation rates among the elderly. Additionally, we show that an overall productivity increase and higher wages for young and middle-aged workers will lower participation of elderly due to income effects, but higher productivity of the elderly due to lower skill depreciation provides them with more incentives to stay longer in the labor force.

Finally, we discuss several limitations of our quantitative analysis and suggest areas for future research. First, as a partial equilibrium life-cycle analysis, our model does not consider how changes in individual behavior might affect macroeconomic variables, such as factor prices, tax revenues and government expenditures. Exploring these general equilibrium effects under alternative policy scenarios would be a valuable extension. Second, our structural model focuses on men's behavior. The empirical section highlights that employment and earnings patterns differ between men and women, with women experiencing different trajectories over the past decades. Developing a model to account for both men's and women's behavior, possibly considering decisions within households with different family structures, would be a challenging but important direction for future research.

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