Foreign Workers, Skill Premium and Fiscal Sustainability in Japan*

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Abstract

Japan faces rapid and severe demographic aging and rising fiscal deficits due to increasing expenditures and shrinking tax revenues. This paper studies how an inflow or an outflow of foreign workers affects projections of macroeconomic and fiscal variables. We show that foreign workers help slow down a decline in labor force and mitigate fiscal pressures, but effects are not large enough to wipe away concerns even under a very optimistic scenario. We also evaluate effects of foreign workers on skill-specific wages in Japan and welfare consequences across heterogeneous individuals. A rapid rise in the relative size of high-skilled labor force in Japan will give strong downward pressure on skill premium and an arrival of foreign workers is shown to have large differential effects on skill prices and the trend of wage inequality, depending on their size and skill composition.

Keywords: Demographic aging, fiscal sustainability, foreign workers, wage inequality, skill premium.

J.E.L. classification codes: H50, H60, J11.

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1 Introduction

Japan faces rapid demographic aging and concerns about fiscal sustainability. Due to a decades-long decline in fertility rates, working-age population will continue to shrink over the coming decades, while the number of retirees rapidly rises as children of the first baby-boom generations start to reach a retirement age in the late 2030s. The government faces rising expenditures for social security programs including public pension, health insurance and long-term care insurance. At the same time, tax revenues are likely to decline as the population falls and tax bases shrink with a rapid fall in the working age population and labor force. How the government would weather consequences of the unprecedented magnitude of demographic aging and fiscal challenges over the next decades remains to be seen.

One important trend in the labor force that we observed over the last decade is that while the Japanese working-age population declined, the number of employed foreign workers rose sharply. According to the Ministry of Labour, Health and Welfare (MLHW), the number of foreign workers more than doubled over the last ten years, rising from less than 0.5 million in 2008 to 0.7 million in 2013 and then to 1.7 million in 2019.[1] The share, however, of foreigners among all workers in Japan remains low, standing at 2.5% in 2019, much smaller than in other countries.[2]

Motivated by the demograPhic challenges facing Japan and an increasing presence of foreign workers in Japan, this paper quantitatively studies roles of foreign workers in the Japanese macroeconomy and fiscal situations. We investigate how an alternative patterns of inflow and outflow of foreign workers during the next few decades would affect the fiscal sustainability and the aggregate economy. Effects are not only through a change in the aggregate labor supply but also through various other channels, including their contribution through tax payments to the government. Moreover, additional labor supply provided by foreigners will change the relative scarcity of labor inputs and affect overall wage level as well as skill-specific wage rates. If, for example, foreign workers are predominantly low-skilled, a large inflow of such workers may reduce wages of the low-skilled workers in Japan. Such losses, however, if any, may be mitigated if additional economic activities and output growth raise tax revenues and help reduce fiscal pressures. The net welfare effect depends on the magnitude of each of these effects and calls for an analysis using a quantitative equilibrium model. The skill composition of foreign workers is likely to affect such tradeoffs and a model that incorporates the heterogeneity is needed to disentangle the forces.

In order to quantitatively evaluate macro and micro effects and welfare impact of having more foreign workers in the Japanese labor market, we build a large scale overlapping generations model, in which households maximize their utility over a life-cycle. Wages of different skill types are determined in the production sector which combines labor supply of different skills as imperfect substitutes.

Our baseline model also includes key ingredients of the economy that will impact

[1] See the summary of foreign workers' employment in Japan (in Japanese) https://www.mhlw.go.jp/content/11655000/000590310.pdf

[2] The total labor force is 68.86 million in 2019, based on the Labor Force Survey.

fiscal imbalances. The government in the model operates pay-as-you-go transfer programs including public pension, health insurance and long-term care insurance programs, and revenues are raised through taxes on labor income, capital income and consumption and by issuing bonds. We calibrate the model to approximate the current Japanese economy including details of fiscal institutions and partially segmented labor market that consists of low- and high-skilled, native and foreign workers. The calibrated model is used to quantify medium and long-run effects of demographic aging and impact of receiving a different number of foreign workers with alternative skill compositions.

This paper contributes to the literature that quantitatively analyzes effects of foreign workers in a dynamic general equilibrium model. Borjas (1999) is an influential early study on labor market effects of immigration, and provides a comprehensive survey of theoretical and empirical studies of immigration, emphasizing on equilibrium reallocation of factors caused by immigration in the host country. Storesletten (2000) uses a calibrated life-cycle model to study effects of immigration in the U.S. economy and argues that an inflow of high-skilled immigrants in their 40s will significantly mitigate fiscal problems associated with demographic aging. Fehr et al. (2004) build a three-region general equilibrium model and study how skill-specific immigration policies affect wages and fiscal imbalances in different regions.

Borjas (2003) studies impact of immigrations in the U.S. taking into account heterogeneous skills and experience of immigrants and shows that imperfect substitutability across different groups of workers implies differential effects on wages of competing workers. Busch et al. (2020) study macroeconomic and distributional effects of refugee immigration in Germany. They build a dynamic life-cycle model of heterogeneous households, where output is produced according to a production function that exhibits imperfect substitutability between low- and high-skilled, between natives and foreign and among immigrants origins, and compare welfare effects of immigration on natives of different skill groups.[3] We take a similar approach as Busch et al. (2020) in using a quantitative general equilibrium model of native and foreign workers and study how the flows of foreign workers influence macroeconomy in Japan and how they interact with the rapid demographic aging.

Our paper also builds on a line of literature that studies demographic aging and fiscal issues in Japan using a macroeconomic equilibrium model. İmrohoroğlu et al. (2016) build an overlapping generations model that incorporates details of the pension system in Japan and study effects of pension reforms on the paths of government debt and public pension fund. Braun and Joines (2015) simulate a quantitative life-cycle model that incorporates demographic transition and argue that a consumption tax needs to rise to 35 to 45% to achieve fiscal sustainability. Kitao (2015) builds a model with endogenous participation as well as details of public pension, health insurance and long-term care

[3]There are papers that model decisions to migrate from or return to a home country, such as Kirdar (2012), who studies fiscal effects of immigrants in Germany in a model with endogenous return migration decisions. Papers that analyze effects of immigration policies include Guerreiro et al. (2020), who study the combination of the optimal immigration and tax policy in the U.S. and show that it is optimal to allow free immigration of high-skilled workers and to restrict low-skill immigration when natives and immigrants are treated alike.

insurance programs and reaches a similar conclusion. Kitao and Mikoshiba (2019) argue that a rise in labor supply of females and the elderly, not just in the extensive margin but also in the productivity, will be important in coping with a decline in the labor force over the next few decades.[4]

Closest to this paper is İmrohoroğlu et al. (2017), who build a general equilibrium model of overlapping generations calibrated to the Japanese economy and study various immigration policies that differ in the number and skill composition of immigrants. The paper, however, assumes that low- and high-skilled labors are perfect substitutes and the equilibrium wage is common across them. This paper extends the study by introducing imperfect substitutability of labor inputs and pricing skills as differentiated factors of production.

Wage premium of college graduates rose sharply in the U.S. and numerous papers investigate the causes. Katz and Murphy (1992) is one of early works that investigate roles of a rising demand for high-skilled workers to account for the wage inequality. Card and Lemieux (2001) emphasize effects from a deceleration in the supply of high-skilled workers relative to low-skilled workers.[5] Kawaguchi and Mori (2016) show that college premium has been stable in Japan between the mid 1980s to the late 2000s contrast the trend with that of the U.S. They argue that a rapid increase in the number of college graduates played a key role in accounting for the stark difference between Japan and the U.S. We take into account these effects by distinguishing between low- and high-skilled workers in the labor market equilibrium, incorporating a shift in the skill distribution of the labor force, as well as skill-specific productivity growth that would explain observed changes in earnings inequality. As in Borjas (2003) and Busch et al. (2020), the model enables us to quantify how an inflow and outflow of foreign workers with different skill compositions could affect wage inequality and welfare across different types of individuals in Japan.

The remainder of the paper is organized as follows. Section 2 presents the model and section 3 describes the data and parametrization of the model. Section 4 presents the results of the baseline model and different policy experiments and section 5 concludes.

2 Model

This section descries our quantitative model. We first present the model of native workers, firms and the government, second, discuss modeling assumptions of foreign workers and finally, present definition of a competitive equilibrium.

[4]Other papers include İmrohoroğlu et al. (2016) and Shimasawa and Oguro (2010). There are many studies on economic effects of foreign workers written in Japanese, which include Nakamura et al. (2009) and Goto (2015). See Hagiwara and Nakajima (2013) for a comprehensive survey of related studies.

[5]See, for example, Topel (1997), Krusell et al. (2000), Acemoglu (2002) and Autor et al. (2008) for earlier influential works on wage inequality across skills in the U.S.

2.1 Demographics

Individuals enter the economy at age $j = 1$ and live up to J years. Life-time is uncertain and $s_{j+1,t+1}$ denotes conditional probability that agents of age j at time t survives to age $j + 1$ at time $t + 1$. $s_{J+1,t} = 0$ for all t. $S_{j,t+j-1}$ denotes unconditional probability that an individual born at time t survives until age j at time $t + j - 1$. That is, $S_{j,t+j-1} = \prod_{k=1}^{j} s_{k,t+k-1}$. The size of a new cohort grows at rate n_t.

Individuals are born with a skill type denoted as $e = \{l, h\}$, low and high, which is fixed throughout the life-cycle. We denote by $\mu_{j,e,t}$ the number of individuals of age j and skill e, at time t.

2.2 Preferences, Endowments and Earnings

The lifetime utility of an individual who enters the economy at time t is given by

$$\sum_{j=1}^{J} \beta^{j-1} S_{j,t+j-1} \frac{c_{j,t+j-1}^{1-\theta}}{1-\theta} \tag{1}$$

where $c_{j,t+j-1}$ denotes consumption of an individual born at time t, at age j and time $t + j - 1$. β represents the subjective discount factor and θ is the coefficient of relative risk aversion.

Each individual is endowed with a unit of time in each period, which is inelastically supplied in the labor market until he reaches the retirement age j^R. Net earnings of an individual of age j and skill e at time t is denoted as

$$y_{j,e,t} = (1 - \tau_{l,t} - \tau_{p,t})\eta_{j,e} w_{e,t},$$

where $\eta_{j,e}$ denotes efficiency units that each worker of age j and skill e provide to the market and $w_{e,t}$ denotes the market wage for each efficiency unit of a skill type e. $\tau_{l,t}$ and $\tau_{p,t}$ denote proportional labor income and payroll tax rates, respectively.

2.3 Technology

Firms produce output Y_t using as inputs aggregate stock of capital K_t and aggregate labor L_t, which consists of low-skilled and high-skilled labor inputs denoted as $L_{l,t}$ and $L_{h,t}$, respectively. The production function is given as the following nested CES technology, $F(K_t, L_{l,t}, L_{h,t})$.

$$Y_t = Z_t K_t^{\alpha} L_t^{1-\alpha} \tag{2}$$

$$L_t = \left[(Z_{l,t} L_{l,t})^{\frac{\sigma-1}{\sigma}} + (Z_{h,t} L_{h,t})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{3}$$

Z_t denotes the total factor productivity and $Z_{l,t}$ and $Z_{h,t}$ denote the productivity of labor inputs of the two skill types. α is the capital share and $1 - \alpha$ the labor labor share. σ represents the elasticity of substitution between low- and high-skilled labor.

Capital depreciates at rate δ. Factor prices are given as a marginal product of each factor in a competitive market.

$$r_{k,t} = F_{K,t} - \delta \tag{4}$$
$$w_{l,t} = F_{L_l,t} \tag{5}$$
$$w_{h,t} = F_{L_h,t} \tag{6}$$

The skill premium, defined as the ratio of high-skilled wage and low-skilled wage and denoted as π_t, is given as

$$\pi_t = \frac{w_{h,t}}{w_{l,t}} = \left(\frac{Z_{h,t}}{Z_{l,t}}\right)^{1-\frac{1}{\sigma}} \left(\frac{L_{h,t}}{L_{l,t}}\right)^{-\frac{1}{\sigma}}$$

2.4 Government

In each period the government raises revenues from taxes on consumption at rate $\tau_{c,t}$, labor income at $\tau_{l,t}$, return from capital at $\tau_{k,t}$ and return from the government bond at $\tau_{b,t}$, respectively. They also impose payroll tax at rate $\tau_{p,t}$ on labor income, and lump-sum tax (or transfer if negative) $\tau_{ls,t}$ on each individual, and raise revenues from issuance of new debt denoted as B_{t+1}.

Total tax revenues denoted as T_t and proceeds from new government debt are used to finance government expenditures G_t, the payment of the principal and interest on the government debt B_t, total pension benefits to retirees P_t, expenditures for health insurance M_t and long-term care insurance LT_t. The interest rate on the government debt is denoted as $r_{b,t}$. We assume that the rate on the government debt is exogenously given.

The government operates a pay-as-you-go pension program. Individuals receive public pension $p_{j,e,t}$ once they reach the retirement age j^R. Pension benefits depend on past earnings and are defined as

$$p_{j,e,t} = \kappa_t \frac{W_{j,e,t}}{j^R - 1}.$$

$W_{j,e,t}$ represents cumulated past gross earnings of an individual aged j with skill e and is defined recursively as

$$W_{j,e,t} = \begin{cases} \eta_{j,e} w_{e,t} & \text{if } j = 1 \\ \eta_{j,e} w_{e,t} + W_{j-1,e,t-1} & \text{if } 1 < j < j^R \\ W_{j-1,e,t-1} & \text{if } j \geq j^R \end{cases}$$

We let the lump-sum tax rate $\tau_{ls,t}$ absorb the residual from the government budget constraint and adjust to balance revenues and spendings in each period.

2.5 Individuals' Problem

An individual's problem is to maximize his life-time utility (1) by optimally choosing a sequence of consumption and saving, subject to a budget constraint. We assume that individuals can accumulate one-period riskless savings, denoted as $a_{j,t}$. There is no bequest motive and assets of the deceased individuals are collected and distributed as a lump-sum transfer denoted as b_t to all surviving individuals at time t.

We let $r_{a,t}$ denote the interest rate on saving of individuals. Savings are invested in a composite of assets that consists of private capital and the government bond. $\phi_{b,t}$ denotes a fraction of assets held in the form of the government bond, $\phi_{k,t}$ denotes a fraction allocated to physical capital, with $\phi_{b,t} + \phi_{k,t} = 1$ for all t.

The budget constraint of an individual at time t is given as follows.

$$c_{j,t}(1 + \tau_{c,t}) + a_{j+1,t+1} = (1 - \tau_{l,t} - \tau_{p,t})\eta_{j,e}w_{e,t} + p_{j,e,t} + R_t a_{j,t} + b_t - \tau_{ls,t},$$

where R_t denotes the after-tax gross interest rate and it is given as

$$R_t \equiv 1 + (1 - \tau_{b,t})\phi_{b,t}r_{b,t} + (1 - \tau_{k,t})\phi_{k,t}r_{k,t}.$$

2.6 Foreign Workers

The model includes foreign workers, who are distinct from the Japanese workers and we denote individual variables that pertain to them with a tilde. We denote by $\tilde{\mu}_{j,e,t}$ the number of foreign individuals of age j and skill e at time t. Each foreign worker of age j and skill e inelastically supplies $\tilde{\eta}_{j,e}$ units of labor.

Foreign workers in our model are different from immigrants, who economically are not distinguishable from the native Japanese as they participate in economic activities by consuming, saving and supplying labor and are subject to the same regulations including taxes on different sources of income and consumption and benefits under the same conditions.

In Japan, the majority of foreign workers are characterized as temporary workers who stay and work in Japan for a regulated duration according to their working visa status, rather than immigrants or naturalized citizens.[6] In this paper, we assume that foreign workers stay in Japan for a limited time and their behaviors are different from those of the Japanese individuals. More precisely, we make the following assumptions about economic roles played by foreign workers in our model.

First, we assume that foreign workers consume a given fraction of their earnings and send the remaining income to their home country. Foreign workers do not save in Japan or invest in capital and government bonds as the Japanese individuals do. Second, we assume that foreign workers pay taxes $\tau_{l,t}$ on their earnings and $\tau_{c,t}$ on consumption and are imposed a lump-sum tax $\tau_{ls,t}$. For payroll taxes, we assume that not all foreigners are

[6] See Goto (2015), for example, for more detailed description of immigration status of foreign workers in Japan. See also "Employment Status of Foreigners" ("*gaikokujin koyojokyo*" report in Japanese) of the Ministry of Health, Labour and Welfare (MHLW) in 2019, which reports detailed information of foreign workers by residence status, countries of origin, etc.

enrolled in the social security system and assume that the payroll tax rate $\tau_{p,t}$ is adjusted by the coverage rate ϕ_f. The government provides health insurance to foreigners covered in the system and pays the same fraction of medical expenditures as the Japanese. In the computation, foreign workers' medical expenditures are adjusted by the same fraction ϕ_f relative to those of the Japanese, reflecting the partial coverage of foreigners in the system. Finally, we assume that all foreign workers return to their home country once they exit the labor force and before they reach the retirement age and that they do not receive public pension benefits.

2.7 Equilibrium Definition

Given a sequence of demographic parameters $\{s_{j,t}, n_t, \mu_{j,e,t}\}$, government policy parameters $\{\tau_{c,t}, \tau_{l,t}, \tau_{k,t}, \tau_{b,t}, \tau_{p,t}, \kappa_t\}$, interest rate on the government debt $r_{b,t}$ and asset allocation rules $\{\phi_b, \phi_k\}$, a competitive equilibrium is given by a sequence of consumption and asset choices $\{c_{j,e,t}, a_{j,e,t}\}$ for individuals of age j, skill e at time t, factor prices $\{r_{k,t}, w_{l,t}, w_{h,t}\}$, and lump-sum tax rates $\{\tau_{ls,t}\}$ that satisfy the following conditions.

1. Individuals' allocations solve the optimization problem described in section 2.5.
2. Factor prices are determined competitively as in equations (4), (5) and (6).
3. The markets for capital, bond, and labor of each skill type clear.

$$\begin{aligned} K_t &= \phi_{k,t} \sum_{j,e} a_{j,e,t}\mu_{j,e,t} \\ B_t &= \phi_{b,t} \sum_{j,e} a_{j,e,t}\mu_{j,e,t} \\ L_{l,t} &= \sum_{j} (\eta_{j,l}\mu_{j,l,t} + \tilde{\eta}_{j,l}\tilde{\mu}_{j,l,t}) \\ L_{h,t} &= \sum_{j} (\eta_{j,h}\mu_{j,h,t} + \tilde{\eta}_{j,h}\tilde{\mu}_{j,h,t}) \end{aligned}$$

   Also note that savings of individuals are allocated to the aggregate capital and government bonds in equilibrium.

$$A_t \equiv \sum_{j,e} a_{j,e,t}\mu_{j,e,t} = K_t + B_t$$

4. The goods market clears.

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

   where $C_t = \sum_{j,e} c_{j,e,t}\mu_{j,e,t} + \sum_{j,e} \tilde{c}_{j,e,t}\tilde{\mu}_{j,e,t}$ denotes aggregate consumption and F_t denotes part of foreign workers' earnings sent to their home country.

5. The lump-sum tax $\tau_{ls,t}$ satisfies the government budget constraint.

$$B_{t+1} + T_t = G_t + P_t + M_t + LT_t + (1 + r_{b,t})B_t, \tag{7}$$

where

$$\begin{aligned}
T_t &= \tau_{c,t}\left(\sum_{j,e} c_{j,e,t}\mu_{j,e,t} + \sum_{j,e} \tilde{c}_{j,e,t}\tilde{\mu}_{j,e,t}\right) + (\tau_{b,t}\phi_{b,t}r_{b,t} + \tau_{k,t}\phi_{k,t}r_{k,t})\sum_{j,e} a_{j,e,t}\mu_{j,e,t} \\
&+ (\tau_{l,t} + \tau_{p,t})\sum_{j,e} \eta_{j,e}w_{e,t}\mu_{j,e,t} + (\tau_{l,t} + \phi_f\tau_{p,t})\sum_{j,e} \tilde{\eta}_{j,e}w_{e,t}\tilde{\mu}_{j,e,t} \\
&+ \tau_{ls,t}\left(\sum_{j,e} \mu_{j,e,t} + \sum_{j,e} \tilde{\mu}_{j,e,t}\right) \\
P_t &= \sum_{j,e} p_{j\geq j^R,t}\mu_{j,e,t} \\
M_t &= \sum_{j,e} m_{j,t}\mu_{j,e,t} + \sum_{j,e} \phi_f m_{j,t}\tilde{\mu}_{j,e,t} \\
LT_t &= \sum_{j,e} lt_{j,t}\mu_{j,e,t}
\end{aligned}$$

where $m_{j,t}$ and $lt_{j,t}$ denote an insurance payment by the government for medical and long-term expenditures, respectively, for an individual of age j at time t.

3 Calibration

This section presents parametrization of the model. Parameters and values are summarized in Table 1. The frequency of the model is annual. We compute the transition between 2015 and a distant future and our focus in on the dynamics of variables over the next several decades.[7]

Demographics: We assume that individuals enter the economy at age 20 ($j = 1$) and live up to the maximum age of 104 ($J = 85$). Survival probabilities $s_{j,t}$ and growth rates of a new cohort n_t are based on the estimates of the National Institute of Population and Social Security Research (IPSS) published in 2017, for years up to 2065. We assume that the survival probabilities remain constant thereafter. The growth rate of a new cohort n_t will converge from a negative value in 2065 to zero in the long run, assuming a smooth convergence by 2200.

As discussed below, we treat individuals with a college degree and above as high-skilled and the rest as low-skilled. Skill distribution across age groups is computed based on the college graduation rates according to the School Basic Survey of the Ministry of Education, Culture, Sports, Science and Technology. The college graduation rate

[7] In the program, we compute the transition between 2015 and 2400.

rose almost monotonically over the last several decades, and the fraction of high skilled significantly varies by age as of now. In 2015, the ratio stands at around 20% among aged 60-64 and it is 42% among 25-29. In the baseline scenario, we assume that the fraction of high-skilled among entrants will rise smoothly to 50% from 2015 to 2020 and stay at that level thereafter.

Preferences: Risk aversion parameter θ is set to 2.0. We set the value of subjective discount factor β at 1.058 so that capital output ratio is 3.5 in 2018, which is based on the stock of production capital and the aggregate output in the national account data in the same year.

Endowment: Age and skill specific productivity $\eta_{j,e}$ consists of the product of labor efficiencies and labor participation rates by age for each skill type. The labor efficiencies are estimated from the Basic Survey on Wage Structure (BSWS) and the Employment Status Survey (ESS), both of which are collected by the Ministry of Health, Labour and Welfare (MHLW). We compute the average efficiency using the BSWS data on average earnings of workers by age groups, gender and education background.[8] The Census Survey (*kokusei chosa*) is used to compute labor participation rates by age for each skill type.

Technology: Capital share α in the production function is set to 0.4 and the depreciation rate of capital δ at 8.3%, based on the National Accounts of Japan (SNA) in 2018. The growth rate of the total factor productivity, computed as the annual growth rate of the residual factor, was 0.7% in 2000-2018 and we set this value as the growth rate of the productivity Z_t.

The parameter σ that represents the elasticity between low- and high-skilled labor is set to 1.4 in the baseline model. Using the U.S. data, which lie in the range of estimates by Katz and Murphy (1992), Borjas (2003) and Autor et al. (2008) in the U.S. Busch et al. (2020) estimate the elasticity among three education groups at 3.1 in Germany, which they argue is higher than the above estimates in the U.S. given more detailed education categories they used. Kawaguchi and Mori (2016) find that levels of estimated elasticities of substitution between the U.S. and Japan are similar, in a model that assumes the same speed of skill-biased technological change (SBTC) in the two countries.[9]

For the skill-specific productivity, we adjust the growth rate of high-skilled labor $Z_{h,t}$ relative to that of low-skilled labor $Z_{l,t}$ so that the model matches a change in the wage premium observed in the data, computed as a change in the ratio of average earnings of high-skilled workers relative to that of low-skilled workers. More precisely, the skill

[8] Note that the BSWS reports earnings of full-time workers by education, age group and gender, but the education background of part-time workers is not available. We obtain weights from the ESS to calculate the average earnings of low- and high-skilled workers, including both full- and part-time workers.

[9] Kawaguchi and Mori (2016) shows that the almost linear trend of the supply of college graduates in Japan makes it difficult to precisely estimate the time trend of the SBTC and also renders the estimate of the elasticity between education groups imprecise. They use the estimated U.S. trend of the SBTC as an exogenous growth rate of the skill premium to overcome the problem. The levels of estimated elasticities vary across alternative model specifications.

premium of workers in their 40s declined by about 1% annually in the 2010s (1.12% in 2015-2018) and we let $Z_{h,t}$ grow faster than $Z_{l,t}$ by 2.26% annually between 2015 and 2020 to match this target. We assume that the same growth differential remains after 2020 for a quarter of a century but gradually decreases after 2045 to zero in the baseline transition. In section 4.3, we consider alternative scenarios on how the growth differentials evolve in the future.[10]

Government: The public pension benefits are paid to individuals of age $j^R = 46$ (65 years old) and above and the replacement rate κ_t is set to 0.455 so the model matches the total public pension expenditures that stand at 10% of GDP in 2018. The health insurance benefits covered by the government are based on the national medical gross expenditure data of the Ministry of Health, Labour and Welfare. We use the age-specific medical expenditures and apply the insurance coverage rates for different age groups, which vary from 70% to 90%.[11] Similarly expenditures for long-term care insurance are computed from the data of the MHLW and the coverage rate of 90%. The payroll tax rate $\tau_{p,t}$ encompasses the premiums collected for the public pension, health insurance and long-term care insurance and is set to 30.1%.[12] The consumption tax rate is 8% until 2018 and raised to 10% in October 2019.[13] The labor income tax rate $\tau_{l,t}$ is set to 9.7% so that the total labor income tax revenue is 5.8% of GDP in 2018 as in the data. The tax rate on capital income is 35%, based on the estimate of effective capital income tax rate, as also used in Kitao and Mikoshiba (2019). The interest rate on the government bond is taxed at 20%.

As to the government expenditures G_t, not including spending for public pension, health insurance and long-term care insurance programs, is set to 12% of GDP as in the data in 2018. Per-capita government expenditures are computed based on the amount of the total expenditures and the population and assumed to remain constant throughout the transition. Therefore, total government expenditures vary as the total population changes over time, although per-capita expenditures remain unchanged.

The government debt is set to 170% of the aggregate output, which is the ratio of the government debt net of financial assets to GDP in 2018. The interest rate of the government debt is set to 1%. The lump-sum tax is computed as a residual to satisfy the government budget constraint (7) in each year and the path is presented in section 4.

[10] Kawaguchi and Mori (2016) studies the trend of college premium in Japan between the late 1980s and the late 2000s, which was much more stable than in the U.S., where the college premium rose sharply during the same period. They argue that a rapid rise in the supply of high-skilled workers in Japan contributes to the difference.

[11] Medical expenditure and long-term care data (in Japanese) are available at
https://www.mhlw.go.jp/toukei/list/37-21.html and
https://www.mhlw.go.jp/toukei/list/45-1.html.

[12] The tax rate is computed as a sum of the premium for the public pension program at 18.3%, health insurance at 10% and long-term care at 1.8%.

[13] In the computation, we assume that the consumption tax rate is 9.5% in 2019 since it is 8% during the first three quarters of the year and 10% in the last quarter.

Foreign Workers: The number of foreign workers rose from 0.91 million in 2015 to 1.66 million in 2019, according to the reports filed by employers and summarized by the MHLW.[14] In the baseline simulation, we let the total number of foreign workers follow the data from 2015 to 2019 and assume that the level remains constant thereafter. In section 4, we simulate alternative scenarios about the number of foreign workers in Japan after 2020.

We do not have data on earnings of foreign workers by age and education. In 2019, however, the Basic Survey of Wage Structure started to report information of earnings of foreign workers by the immigration status, and we categorize workers with the residence status of "professional and technical field" as high-type and those with the status of specific field such as nurse trainees, care work trainees, construction workers, technical interns, part-time student workers, and others as low-type.[15] Out of all foreign workers in the BSWS, about 20% are of the high-type and the rest are of the low-type and we use this ratio as the skill composition of foreign workers in the baseline simulation.

We compute the average earnings of each type and set the productivity $\tilde{\eta}_{j,e}$ to the value, independently of workers' age. The average age of low- and high-type foreign workers is 32.3 and 33.7, respectively, based on the BSWS and we assume that the age distribution of foreign workers is uniform over a 10-year range between 28 and 37.

We assume that foreign workers consume 50% of their earnings. Although we do not have comprehensive data on the consumption and saving behavior of foreign workers, some papers analyze them based on a survey of a group of foreign workers. Saka (2010), for example, surveys foreign workers in Toyama prefecture and finds Brazilian and Chinese workers spend 50 to 60% of their earnings. Other papers find that foreigners send a large fraction of their earnings to their home country based on surveys of a specific group of foreign workers.[16]

We assume that the government incurs the same per-capita expenditures for each foreign worker and also provides the same health insurance coverage as the Japanese to those who are enrolled in the system. We also do not have administrative data on the social insurance coverage of foreign workers. Studies at prefectural or community levels reveal a imperfect coverage of foreigners.[17] We set ϕ_f, the fraction of foreigners who are enrolled in the social security system and pay the contribution, to 50%.

[14]The report summary is available at
https://www.mhlw.go.jp/content/11655000/000590310.pdf.

[15]Workers in the "professional and technical field" (*senmonteki/gijutsuteki bunya*) includes those engaged in occupations such as business owners and managers, lawyers, accountants, and doctors.

[16]See, for example, Fujikawa (2009).

[17]See, for example, Shiho (2007) and other articles included in the special issue of the Quarterly of Social Security Research (2007, Vol. 43) on the social insurance coverage of foreign workers in Japan.

Table 1: Parameters of the Model

Parameter	Description	Value
Demographics		
J	Maximum age	85 (104 years old)
j^R	Retirement age	46 (65 years old)
$s_{j,t}$	Survival probabilities	IPSS (2017)
n_t	Cohort growth rates	IPSS (2017)
Preference and Endowment		
β	Subjective discount factor	1.0584
θ	Risk aversion parameter	2.0
η_j	Labor productivity	see text
Production		
Z_t	TFP level	Normalization
g_z	TFP growth rate	0.7%
σ	Elasticity of sub. L_l and L_h	1.4
α	Income share of capital	0.4
δ	Depreciation rate of capital	0.083
Government		
τ_c	Consumption tax rate	8% to 10%
τ_l	Labor income tax rate	9.7%
τ_a	Capital income tax rate	35%
τ_b	Tax on government bond int.	20%
τ_p	Payroll tax rate	30.1%
tr	Lump-sum transfer/tax	See text
κ	Pension replacement rate	45.5%
B_t	Government bond	170% of GDP
G_t	Government expenditures	12% of GDP
r_b	Government bond interest rate	1.0%

4 Numerical Results

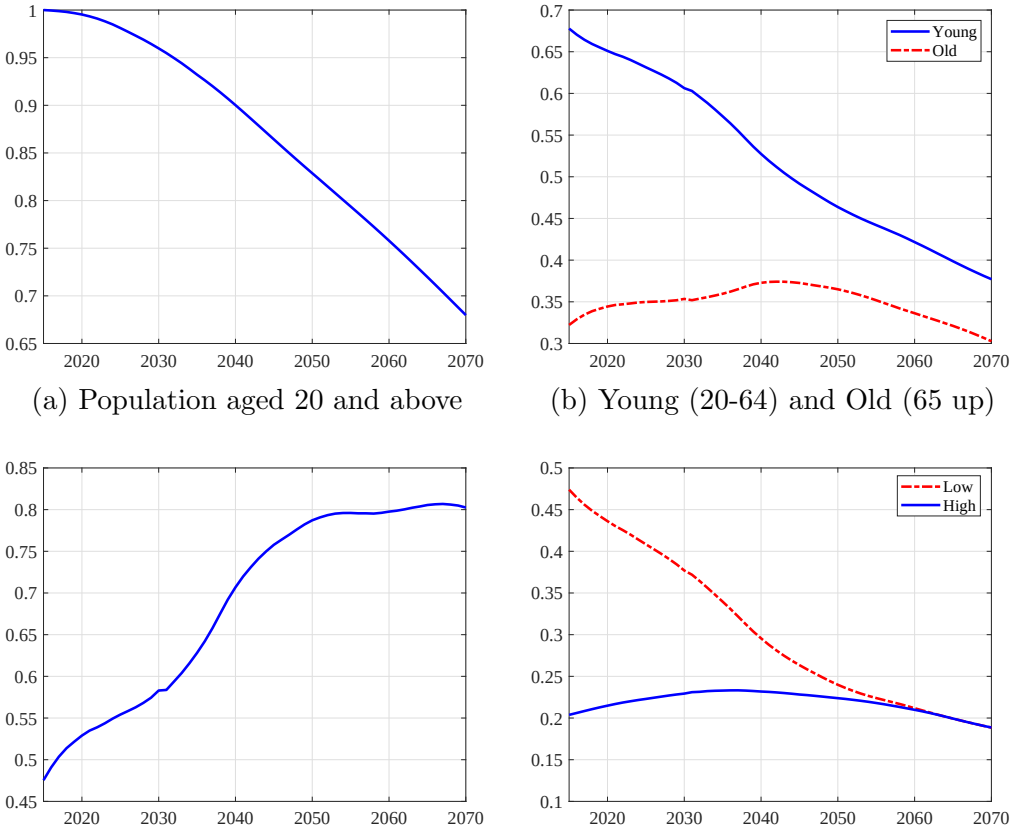
In this section we will first present quantitative results of the baseline model and the transition dynamics. We then discuss results of some policy experiments as well as outcome under alternative assumptions of the model's parameters.

4.1 Baseline

Figure 1 shows the demographic trends between 2015 and 2070 and changes in the skill composition in Japan. As shown in Figure 1a, the population will decline rapidly for the rest of the century, but the trend during the next few decades is very different across age groups as shown in Figure 1b. The number of individuals aged 65 and above will rapidly rise until the early 2040s, while those aged between 20 and 64 will decline sharply. The

old-age dependency ratio defined as the ratio between the population aged 65 and above to that aged 20-64 increases from below 50% in 2015 to 80% in the early 2050s and the ratio will remain at the elevated level, as indicated in Figure 1c.

Figure 1d shows how the skill composition of working-age individuals aged 20-64 in Japan will change over the next decades. College graduation rates increased sharply during the past decades and the fraction of college graduates vary significantly by age, as discussed in section 3. As a result, the fraction of low-skilled will fall from around 70% in 2015 to 50% by around 2060. While the size of the working-age population shrinks rapidly, the number of high-skilled individuals aged 20-64 will increase during the next 15 years and stay above the level of 2015 until the early 2060s. The number of low-skilled individuals monotonically declines until 2070.



(a) Population aged 20 and above

(b) Young (20-64) and Old (65 up)

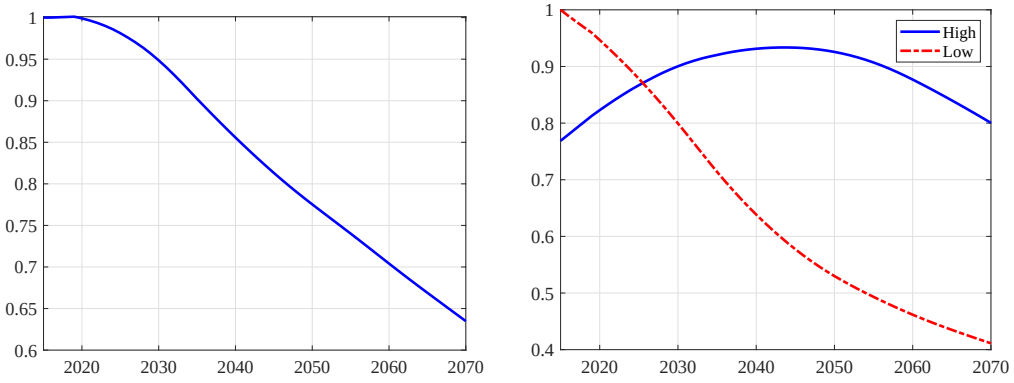
(c) Dependency Ratio (65 up/20-64)

(d) By Skill (20-64)

Figure 1: Demographic Trend (normalized by total population aged 20 and above in 2015

Figure 2 shows the path of labor supply by skills. Based on the calibration using the BSWS data, each high-skilled worker supplies more efficiency units than a low-skilled worker and contributes more to the labor supply. As shown in Figure 2b, total efficiency units of high-skilled labor will surpass those of low-skilled labor in the mid-2020s. High-skilled labor supply will continue to rise until the mid-2040s due to a rise in the fraction of the college graduates among working-age individuals but gradually fall thereafter because of the decline in the working-age population. Low-skilled labor supply will rapidly decrease

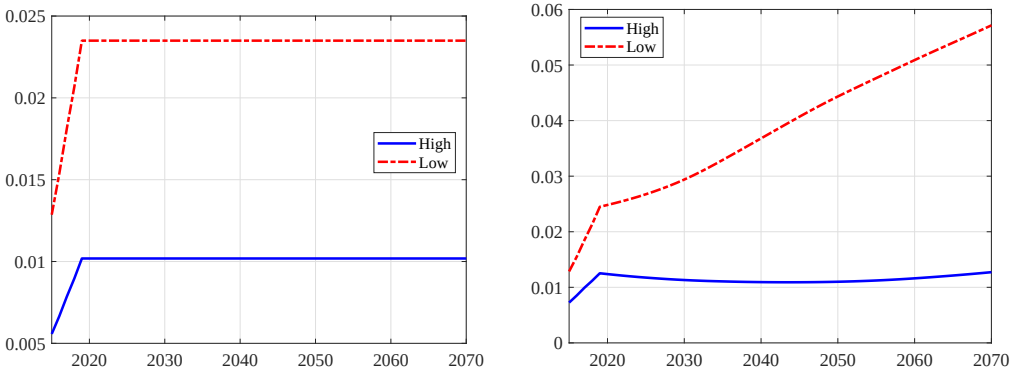
during the next three decades, at a much faster pace than the speed of a decline in the total labor supply.



(a) Total Labor Supply (b) By Skill (norm. by $L_{l,2015}$)

Figure 2: Labor Supply

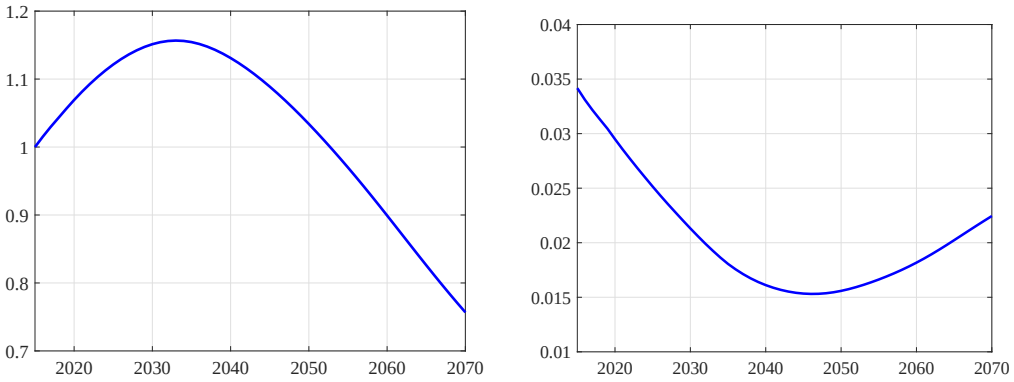
Figure 3 shows the number of foreign workers in the baseline simulation. We assume that the number remains unchanged after 2020, as shown in Figure 3a. The ratio, however, of labor supply provided foreign workers in each skill type changes as the labor supply shifts with the demographic transition. Given a large decline in low-skilled labor in Japan, the fraction of low-skilled labor provided by foreigners will rise from around 2.5% in 2020 to above 5% by 2060. The ratio for the high-skilled will stay at around 1%.



(a) Normalized by $L_{l,2015}$ (b) Ratios to $L_{l,t}$ and $L_{h,t}$

Figure 3: Labor Supply of Foreign Workers in the Baseline Scenario

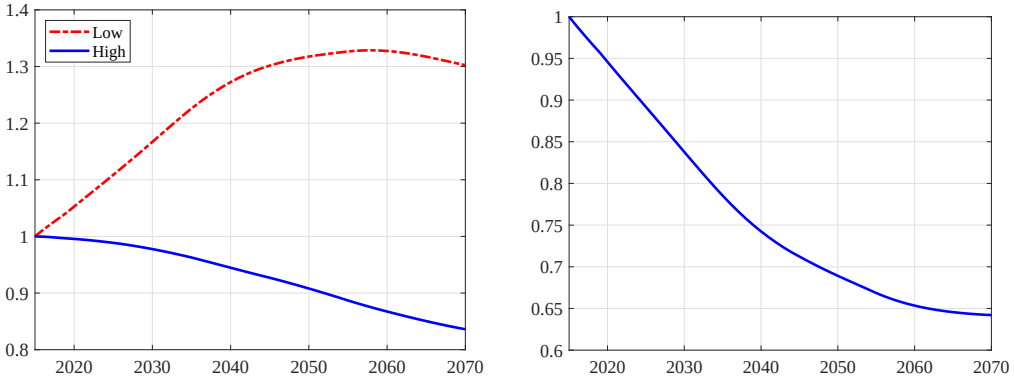
Figure 4 shows the path of aggregate capital and interest rate. Individuals have stronger incentives to save, when faced with a rising longevity, and leads to a higher level of saving and aggregate capital. This effect, however, is eventually offset by the decline in the number of savers and the aggregate capital starts to decline in the early 2030s, as shown in Figure 4a. A rise in capital-labor ratio implies a decline in the interest rate, but eventually capital falls more rapidly than the labor supply and the interest rate starts to rise in the mid-2040s, as shown in Figure 5b.



(a) Aggregate Capital (b) Interest Rate

Figure 4: Capital and Interest Rate

Figure 5 shows the transition paths of wage rates by skills and the ratio of the high-skilled wage to the low-skilled wage. Wage levels are normalized to 1.0 for each skill. A rapid decline in low-skilled labor supply, as we saw in Figure 2b implies a rise in the low-skilled wage, while the wage of high-skilled labor declines gradually as it becomes more abundant. As a result, relative wage declines sharply until it stabilizes in the 2060s.



(a) Wage by Skills (b) Relative Wage ($w_{h,t}/w_{l,t}$)

Figure 5: Wages

Demographic transition implies a major increase in government expenditures for the public pension, health insurance and long-term care insurance programs, while the tax revenues decline as the labor force shrinks. Figure 6 shows the path of total lump-sum taxes required to balance the government budget in each period. Total lump-sum tax revenues are expressed in terms of aggregate consumption in each period in the figure. The tax burden rises sharply, amounting to more than 20% of consumption by 2050 and 30% by 2060. The magnitude of projected costs of demographic transition is equivalent to those estimated in other papers.[18]

[18]See, for example, Hansen and İmrohoroğlu (2016), Braun and Joines (2015) and Kitao (2015).

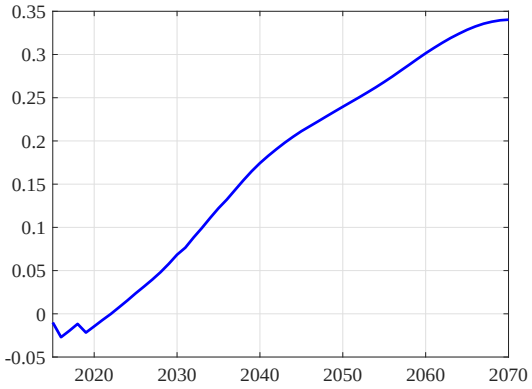


Figure 6: Lump-sum Tax (as % of Aggregate Consumption)

4.2 Policy Experiments

In this section, we consider alternative scenarios about the number of foreign workers in Japan in the future. In the first and second scenarios, we assume that the number of foreign workers increases by 100% and 200% of the level at the end of 2019 and that the rise will occur over a 10-year period. After 2030, we let the number of foreign workers remain unchanged. In the two scenarios, the skill composition of foreign workers is assumed to be the same as the current skill composition.

In the third and fourth scenario, we assume an alternative skill composition of foreign workers. More precisely, the number of foreign workers rises by 100% as in scenario 1, but we assume that all additional foreign workers are either low-skilled (scenario 3) or high-skilled (scenario 4). Finally, in scenario 5, the number of foreign workers gradually declines and reaches zero in 10 years. In each scenario, we assume that individuals learn in 2020 the new path of foreign workers and it comes as a surprise. Thereafter there is no uncertainty and the economy follows a deterministic path. Table 2 summarizes the assumptions under each of the five scenarios.

Table 2: Foreign Worker Scenarios

	Flows of Foreign Workers	Skill Composition of Foreign Workers
Scenario 1	Increase by 100% over 10 years	Low 80%, High 20%
Scenario 2	Increase by 200% over 10 years	Low 80%, High 20%
Scenario 3	Increase by 100% over 10 years	Low 100%
Scenario 4	Increase by 100% over 10 years	High 100%
Scenario 5	Decrease to zero over 10 years	Low 80%, High 20%

Effects of the scenarios on macroeconomic variables are summarized in Table 3. More foreign workers will raise the aggregate labor supply and output, as shown in the first four columns of the table. The change in the aggregate output is relatively small even though the number of foreign workers doubles or triples, since the fraction of foreign workers out of the total labor force is relatively small in the first place.

The skill composition, however, of foreign workers differs from that of Japanese workers and additional foreign workers affect the wage rates of each skill differently. A much larger fraction of foreign workers is low-skilled and the additional flows of foreign workers will lower the low-skilled wage rate. For example, low-skilled wage is 1.32 in 2050 under the baseline transition but it falls to 1.29 in scenario 1 and 1.26 in scenario 2. The wage of high-skilled workers remains almost unchanged, as also shown in Figure 7. A rise in the aggregate labor supply will make labor input more abundant relative to capital, giving a downward pressure on overall wage rates, but the relative scarcity of high-skilled labor raises the wage of high-skilled workers and the effects offset each other.

Interest rates are higher in experiments with more foreign workers as capital becomes more scarce relative to labor. Interest rate falls from 2.95% in 2020 to 1.56% in 2050 in the baseline transition, and it stays at 1.71% and 1.86% in scenarios 1 and 2, respectively, in 2050.

Table 3: Effects on Macroeconomic Variables: Foreign Worker Scenarios

	L_t	$L_{l,t}$	$L_{h,t}$	Y_t	$w_{l,t}$	$w_{h,t}$	r_t (%)	$\tau_{ls,t}$ (%)
Baseline								
2020	1.00	1.00	1.00	1.00	1.00	1.00	2.95	-1.43
2030	0.95	0.80	1.17	1.03	1.17	0.98	2.13	7.01
2040	0.86	0.64	1.21	0.96	1.27	0.94	1.61	19.03
2050	0.78	0.53	1.20	0.87	1.32	0.91	1.56	28.37
Scenario 1								
2030	0.97	0.82	1.18	1.04	1.15	0.97	2.28	5.41
2040	0.88	0.66	1.22	0.97	1.25	0.94	1.76	17.14
2050	0.80	0.55	1.22	0.88	1.29	0.91	1.71	25.66
Scenario 2								
2030	0.99	0.85	1.20	1.05	1.13	0.97	2.43	3.95
2040	0.90	0.69	1.24	0.98	1.23	0.94	1.90	15.42
2050	0.82	0.58	1.23	0.90	1.26	0.91	1.86	23.22
Scenario 3								
2030	0.97	0.83	1.17	1.04	1.14	0.98	2.27	5.53
2040	0.87	0.67	1.21	0.97	1.24	0.95	1.75	17.21
2050	0.79	0.56	1.20	0.88	1.28	0.92	1.71	25.74
Scenario 4								
2030	0.97	0.80	1.24	1.04	1.18	0.95	2.32	4.99
2040	0.88	0.64	1.28	0.97	1.28	0.92	1.78	16.88
2050	0.80	0.53	1.27	0.89	1.33	0.88	1.73	25.42
Scenario 5								
2030	0.93	0.78	1.16	1.01	1.19	0.98	1.98	8.76
2040	0.84	0.62	1.20	0.94	1.30	0.95	1.46	21.11
2050	0.76	0.51	1.19	0.86	1.35	0.91	1.40	31.37

The first six columns show the level of each variable (L_t, $L_{l,t}$, $L_{h,t}$, Y_t, $w_{l,t}$, and $w_{h,t}$ expressed in terms of the level of the same variable in 2020 in the Baseline scenario. The column r_t shows values of interest rate in each year under each scenario. The last column $\tau_{ls,t}$ shows total lump-sum taxes as a fraction of aggregate consumption in each year.

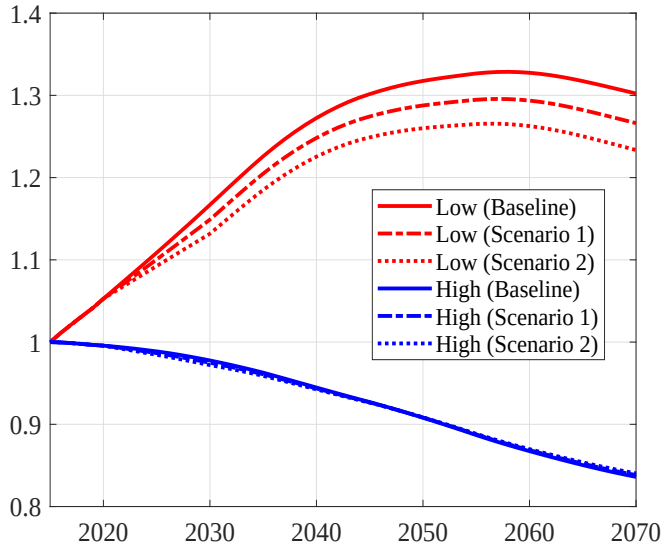


Figure 7: Wage Rates under Baseline, Scenario 1 and 2

The equilibrium lump-sum tax will decline from 28.4% of aggregate consumption in 2050 under the baseline transition to 25.7% and 23.2% under scenarios 1 and 2, respectively, suggesting that additional foreign workers will alleviate the fiscal cost of the demographic transition, though the effects are not large enough to significantly mitigate the cost even under a very optimistic scenario.

If Japan will receive more foreign workers but restrict the skill set to be low (scenario 3) or high (scenario 4), the relative wage will move in favor of skills that become more scarce, although the quantitative effects are small. When new foreign workers are all high-skilled, high-skill wage will decline more sharply over time, from 0.91 in 2050 under the baseline to 0.88 in scenario 4. Although earnings of each high-skilled workers are lower, high-skilled foreign workers contribute more to the revenues and the equilibrium lump-sum tax will be slightly lower than when additional foreign workers are all low-skilled.

If all foreign workers eventually leave Japan (scenario 5), low-skill wage will be higher (1.32 in the baseline vs 1.35 in 2050). The tax burden will rise and the lump-sum tax rate will be higher by 3 percentage points relative to the aggregate consumption (28.4% in the baseline vs 31.4% in 2050).

Welfare Effects: We evaluate welfare effects of alternative scenarios on Japanese workers and summarize the results in Table 4. In quantifying welfare effects of an alternative, we compute consumption equivalent variation (CEV), which is a required percentage change in consumption in all states of the baseline economy so that an individual will be indifferent between the baseline and an alternative scenario.[19] The first four columns

[19]For example, 1.84% under scenario 1 for a low-skilled worker aged 20 implies that this particular worker would be better off under scenario 1 than in the baseline and he needs to experience a rise in consumption by 1.84% in the baseline so he would be equally better off.

of the table shows the welfare effects on generations that are alive in 2020 and the last three columns show the effects on future generations, who will enter the economy and be economically active in different years.

Table 4: Welfare Effects: Foreign Worker Scenarios (in *CEV*, %)

	Age in 2020				Cohort entering in		
	80	60	40	20	2030	2040	2050
Scenario 1							
Low	1.41	2.41	2.43	1.84	1.68	1.75	1.94
High	0.76	1.35	1.99	2.85	3.43	4.05	4.69
Scenario 2							
Low	2.75	4.69	4.72	3.56	3.26	3.40	3.79
High	1.49	2.64	3.88	5.54	6.66	7.86	9.08
Scenario 3							
Low	1.32	2.27	1.92	0.91	0.56	0.48	0.52
High	0.72	1.36	2.38	3.55	4.27	4.97	5.72
Scenario 4							
Low	1.73	2.92	4.43	5.52	6.16	6.85	7.70
High	0.91	1.28	0.41	0.05	0.13	0.40	0.63
Scenario 5							
Low	-1.47	-2.56	-2.61	-1.96	-1.79	-1.86	-2.07
High	-0.79	-1.40	-2.09	-3.02	-3.66	-4.34	-5.05

Table 4 shows that under scenarios 1 to 4, in which Japan will receive more foreign workers, all generations experience a welfare gain relative to the baseline transition. Quantitatively, however, effects differ significantly across generations and skill types. In scenarios 1 and 2, where skill composition of foreign workers remains the same and the number of low-skilled foreign workers are four times as large as that of high-skilled, the welfare gains are larger for high-skilled individuals due to different impacts on skill-specific wage rates. Both types of workers gain from a decline in the fiscal burden and taxes but low-skilled workers also face a decline in the wage rate because low-skilled labor supply becomes more abundant relative to not only capital but also to high-skilled labor.

When new foreign workers are all high-skilled under scenario 4, the welfare gain of high-skilled workers is almost wiped out by a further decline in high-skilled wage rates. Comparing welfare effects across generations, future cohorts gain more from additional foreign workers since they will fully enjoy lower tax burden for longer periods and are able to allocate additional disposable income to consumption and life-cycle savings.

If foreign workers leave Japan and eventually disappear entirely under scenario 5, there will be a large welfare loss. Much higher tax burden to finance the demographic transition will hurt the welfare of current and future generations. As capital becomes more abundant, interest rates are lower, which add to the welfare loss of retirees in particular.

Although this may seem a very unrealistic assumption, the experiment highlights roles of foreign workers currently residing in Japan and consequences on the Japanese economy once the past trend changes its direction in the future.

4.3 Alternative Scenarios

In this section, we consider different values of elasticity of substitution between the two skill types in the production function and corresponding productivity growth rates of the skill-specific productivity. In the baseline model, we set the elasticity parameter σ to 1.4. We consider alternative values of 1.2 and 1.6 and recalibrate other parameters so that the model matches the same set of target moments. In particular, in order to match the change in the relative wage between the low- and high-skilled labor, a higher (lower) value of elasticity requires a lower (higher) growth rate of the productivity of high-skilled labor. If skills are not substitutable (low σ), a rise in the supply of high-skilled labor would imply a counter-factually large decline in high-skilled wage and a higher growth rate of high-skilled labor productivity is required to account for the difference.

As a result, more abundant supply of high-skilled labor over the coming decades will give a downward pressure on the high-skilled wage at different magnitude, but the effects are partially offset by higher growth rates of the productivity. As shown in Figure 8, the paths of low- and high-skilled wages follow the same trend as in the baseline transition. Effects of foreign workers remain the same qualitatively and mostly quantitatively as well.

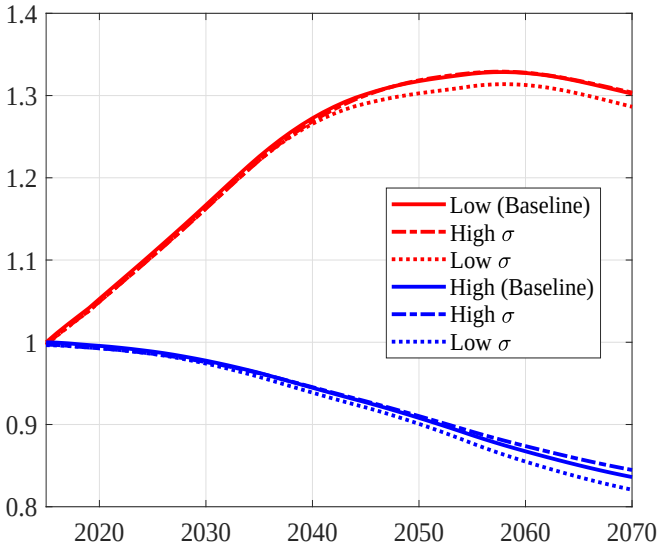


Figure 8: Wage Rates under Baseline, Low and High σ

5 Conclusion

Japan will face rapid demographic aging during the coming decades and a major fiscal challenge. A decline in the working-age population will reduce the output and tax revenues while the government faces rising expenditures to cover payments for public pension, health insurance and long-term care insurance programs. This paper studies how the presence of foreign workers affects the projections of macroeconomic and fiscal variables of Japan.

We built a general equilibrium life-cycle model of overlapping generations populated by native Japanese and foreign workers. Our results show that foreign workers help slow down the decline in labor force that Japan would face during the next decades and mitigate the fiscal pressure from the demographic aging, although effects are not large enough to wipe away fiscal concerns even under a very optimistic scenario on the inflow of foreign workers.

We also find that the size and skill composition of foreign workers will have large quantitative effects on skill-specific wages in Japan. Given a rise in college graduation rates, Japan will experience a major increase in the number of high-skilled labor force relative to the low-skilled and the skill premium, defined as the ratio of high-skilled wage to low-skilled wage, is projected to fall rapidly, even if we assume that a skill-biased productivity growth continues. Additional foreign workers, who are more likely to be low-skilled, slow down a decline in the skill premium and different effects on workers of different skills. If the skill composition of foreign workers changes and they become higher-skilled, high-skilled wage may decline even faster relative to the low-skilled.

Obviously, much remains to be seen how an inflow of foreign workers will be affected in response to the COVID-19 crisis and other changes in the economic conditions not only in Japan but also globally. Given, however, the additional public expenditures to deal with the economic contraction and a massive rise in the government debt in the aftermath of the crisis, roles of foreign workers are likely to be more important.

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