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Sagiri Kitao
Selahattin Imrohoroglu
Tomoaki Yamada

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1-7-10-703 Iidabashi, Chiyoda-ku, Tokyo 102-0072, Japan

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Sagiri Kitao
Keio University
Department of Economics
2-15-45 Mita, Minato-ku, Tokyo, Japan
sagiri.kitao@gmail.com

Selahattin Imrohoroglu
University of Southern California
Department of Business Economics and Finance
3670 Trousdale Pkwy, Los Angeles, CA 90089, United States
simrohor@marshall.usc.edu

Tomoaki Yamada
Meiji University
Department of Commerce
1 Chome-1 Kanda Surugadai, Chiyoda, Tokyo
tyamada@meiji.ac.jp

Can Guest Workers Solve Japan's Fiscal Problems?*

Selahattin İmrohoroğlu†, Sagiri Kitao‡, and Tomoaki Yamada§

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Abstract

The labor force in Japan is projected to fall from about 64 million in 2014 to near 20 million in 2100. In addition, large increases in aging related public expenditures are projected which would require unprecedented fiscal adjustments to achieve sustainability under current policies. In this paper, we develop an overlapping generations model calibrated to micro and macro data in Japan and conduct experiments with a variety of guest worker and immigration programs under different assumptions on factor prices and labor productivities. Against a baseline general equilibrium transition which relies on a consumption tax to achieve fiscal sustainability, we compute alternative transitions with guest worker programs that bring in annual flows of foreign born workers residing in Japan for 10 years with the share of guest workers in total employment in a range between 4% and 16%. Depending on the size and skill distribution of guest workers, these programs significantly mitigate Japan's fiscal imbalance problem with a relatively manageable and temporary increase in the consumption tax rate.

Keywords: Immigration, Overlapping Generations, Aging, Fiscal Sustainability.
JEL Classification: E2, E6, H5, J11, J15

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†Marshall School of Business, University of Southern California, Los Angeles, USA. selo@marshall.usc.edu.

‡Department of Economics, Keio University, Tokyo, Japan. sagiri.kitao@gmail.com.

§School of Commerce, Meiji University, Tokyo, Japan. tyamada@meiji.ac.jp.

1 Introduction

The population in Japan has already started to decline. According to recent forecasts of fertility and longevity, the population is expected to decrease from its recent high of 127.4 million in 2010 to about 50 million by 2100. In addition, the working age population is declining even faster. Due to this rapid aging, public expenditures for pensions and health are projected to require sizeable new revenues when the tax base is already shrinking. If Japan wants to avoid massive spending cuts or tax increases, it may need to 'manufacture' workers in order to minimize the impact of this secular demographic change.

One way to increase the size of the work force is to introduce a foreign worker policy. Indeed, the Japanese government announced early in 2014 that it would consider a guest worker program that would bring 200,000 foreign workers to Japan for a period of 10 years, eventually accumulating a stock of about 2 million guest workers. Can such a guest worker program solve Japan's fiscal problems? This paper investigates the effects of guest worker programs on fiscal sustainability in Japan and the welfare effects on the native Japanese individuals.

Japan has followed insular policies for centuries and relied on native born workers for their economic growth. Their post World War II growth and 'catching up' in the 1960s through 1980s have turned into the lost decades since 1990. While a large wave of globalization and capital deepening has propelled most of the Asian economies, in particular China, into faster economic growth, Japan has lost significant ground. Meanwhile, Japan is fast approaching crossroads as it seeks to find more workers to mitigate the projected decline in working age population. Additional workers would produce additional goods and services and pay more taxes to help achieve fiscal sustainability. With a male labor force participation rate among the highest in the world, additional labor supply in Japan can only come from (i) increases in the fertility rate to produce younger native born workers, (ii) increases in the female participation rates and/or increases in labor in efficiency units, and, (iii) foreign-born workers.

The fertility rate has been far below the level necessary for a stationary population and the population has been declining already. The total fertility rate in Japan between 2010 and 2015 is estimated at 1.41, much lower than 2.0 in the U.S. and well below the replacement rate that would keep the population constant. Unfortunately for Japan, the fertility rate is projected to stay significantly below 2 over the next few decades.[1]

Another potential source of additional labor supply is the pool of Japanese females. The female labor force participation (FLFP) rate has been rising over the last two decades in Japan and it is now 65.1% within the 15-64 age group, very close to the 66.1% in the U.S. It is true, however, that when older working ages are considered (65+) Japan's FLFP rate, 49%, is lower than those in France (51%), Germany (54%) and especially United States (57%), according to the World Bank data over 2010-2013. So, it may

[1]In addition, even if fertility unexpectedly rises significantly in the future, it may not help with the fiscal imbalance. Indeed, İmrohoroğlu, Kitao, and Yamada (2014) conduct an experiment in which future fertility rates are 1.68 but this leaves the fiscal imbalance nearly unchanged. The reason is that these additional native born workers broaden the tax base during their working ages but raise public expenditures during their retirement years with extra pension and health expenditures to be financed.

be possible to raise the FLFP rate in Japan further. In addition, many females are on irregular or part-time jobs that pay much less than regular jobs. Raising their human capital and hence income may make a more important contribution to solving Japan's fiscal imbalance.[2]

The third source of additional workers is to introduce a major guest worker program. Several European countries, most notably Germany, benefited immensely from significant immigration in 1960s and 1970s. The United States has received a large in-flow for more than a century and the current law specifies an annual flow of legal permanent immigration at 675,000, although there is an additional unreported or illegal flow of immigrants. The skill distribution is bi-modal; there is a significant group of highly skilled immigrants in research and development, academia, and at consulting, finance and insurance services industries, as well as a larger group of low-skilled workers in agriculture and hospitality service industries. In 2014, the share of foreign born workers in total employment in the U.S. was 16.4%.

In this paper, we develop a quantitative general equilibrium model of native and guest workers, assess the impact of various guest worker programs on the Japanese economy and evaluate the welfare effects of these programs on the native Japanese. We build a large overlapping generations model populated with individuals between 20 and 110 years old, who face longevity risk and make optimal consumption and saving decisions over the life cycle. Labor is exogenous and therefore labor income taxes are not distortionary.[3] There is a stand-in firm which maximizes its profits. The government taxes consumption and income from capital, labor, and government bonds, to finance exogenous government purchases, transfer payments, and its debt. We present results that alternatively assume that the productivity of guest workers is 50% or 100% of that of the native workers. A key assumption in our setup is that the guest workers leave after working for 10 years and therefore they do not receive pensions or significant public health transfer payments. To the best of our knowledge, the existing models of immigration including those we mention below assume that foreign born workers become identical to native born workers after one period in the model. To make contact with this literature, we also present an extended version of the model in which the foreign-born workers eventually become permanent residents after a work life of 30 years.

The model is calibrated to Japanese data; in particular, we calibrate the individuals'

[2]In United States, nearly 60% of recent university graduates are females. In some OECD countries this ratio is two-thirds. Japan is one of a few OECD countries where female graduates make up less than 50% of total university graduates; less than those in South Korea and Turkey. In addition, there is an 'M-curve' of female labor force participation over the life cycle. A typical Japanese female withdraws from the labor force upon having a child and despite re-joining the labor force later in the life cycle, the new job is typically an 'irregular' job that pays less than a regular job. Depreciation of skills and a lack of accumulating further human capital (by learning by doing or on the job training) combine to yield a much higher fractions of irregular jobs held by females than males. Another finding in İmrohoroğlu, Kitao, and Yamada (2014) is that an increase in the female labor force participation rate without an increase in the fraction of regular jobs does not broaden the tax base significantly to solve Japan's fiscal imbalance. We leave the FLFP rate and the role of human capital in producing a gender gap in regular vs irregular jobs for future research.

[3]This makes the benefits of a guest worker program conservative since such a program would lead to reductions in the required tax rates with the broadening of the tax base.

life-cycle earnings to our estimates from micro data. We assume that the debt to GDP ratio is maintained forever at its 2013 level of 130%. The baseline experiment computes the equilibrium transition from 2014 toward a final steady state in the far distant future and produces an endogenous path for the consumption tax rate that satisfies the government's budget in each period in the face of increases in public expenditures due to aging. Similar to the findings in the literature (see below) we find consumption tax rates above 35% for several decades; there is a very high cost, in terms of unprecedentedly high tax rates, of loading all of the fiscal burden on a single fiscal instrument.

When we initiate a guest worker program in which 200,000 foreign born workers are introduced into the workforce every year to leave after a 10-year tenure on the job, the consumption tax rate rises 2-3% less than that in the baseline case. If Japan adopts a larger-scale U.S.-style guest worker program which builds a stock of foreign born workers equal to 16.4% of employment and maintains this ratio, then the gains in consumption tax reduction can be as large as 10%. The experiment demonstrates how a guest worker program could contribute to achieve fiscal sustainability in Japan.

These quantitative results depend on two forces that go in the same direction and necessitate very large fiscal adjustments in Japan. The first is aging-related; the combination of shrinking tax base and increased public pension and health expenditures. This is essentially the accounting result of the increase in the old-age dependency ratio. In addition, there is a second mechanism, familiar in general equilibrium models, and, this second force is the increase in the equilibrium wage rate arising from the increase in the time path of the capital-labor ratio. The labor supply is falling monotonically from 2014 through post-2100. The capital stock, on the other hand, rises for a while as the extended retirement years compel individuals to raise their private saving. The reduction in the number of savers and increase in the number of spenders eventually puts an end in this process and the capital stock eventually falls along the transition. As a result, the capital labor ratio in Japan rises significantly until about 2050, and then falls, but it converges to a level still much higher than that in 2014. With the wage rate following a similar qualitative path, and pensiona tied partially to wages, this delivers added expenditures that the Japanese government must finance.

In our partial equilibrium exercise, we turn off this second mechanism and even without guest workers or immigration, the consumption tax rate needed to achieve fiscal sustainability is around today's levels in Scandinavian countries such as Denmark, Finland, Norway and Sweden, at 25%. In other words, if Japan could implement policies that mitigate the run up in wages over the next few decades produced by the predicted increase in the capital labor ratio, then the fiscal adjustments need to finance aging-related public expenditures would be much more manageable.

Of course, any immigration or guest worker policy program faces political, societal and technological challenges, some of which may be specific to Japan. An immigration policy, as opposed to a guest worker program, requires planning for and financing of additional old age pensions and public health expenditures. Clearly this would raise the overall fiscal burden and possibly outweigh the contributions to the tax base during working ages over the life cycle. A guest worker program, on the other hand, introduces difficulties in the termination of the finite working age stay in Japan, requiring assurances

and controls to keep the 'guest' feature of the program in place. We do not wish to minimize the practical, technological, and societal challenges posed by immigration or guest worker programs. Instead, this paper focues on the opportunities that a guest worker policy can provide for Japan. A strong foreign-born worker policy could significantly help Japan achieve fiscal sustainability.

The paper is organized as follows. Section 2 presents a brief literature review relevant to our work, 3 describes our economic model, Section 4 provides the details of our calibration strategy, Section 5 presents our quantitative findings, Section 6 presents some additional exercises and Section 7 gives our concluding remarks.

2 Related Literature

Our paper builds on and contributes to two strands of literature. First, there is a large literature on measuring the size of adjustments Japan needs to bring about fiscal sustainability in the face of the projected aging related public expenditures. Doi, Hoshi, and Okimoto (2011) estimate the tax revenue as a fraction of GDP required to sustain the debt at the 2010 level; they find that revenue has to go up by 7-14% of GDP, from 33% in 2010. Hansen and İmrohoroğlu (2015) use a one-sector neoclassical growth model and measure the needed consumption tax rate that achieves fiscal sustainability to be about 50%, unless there is a significant spending cut. Braun and Joines (2015) and Kitao (2015a) employ large scale overlapping generations models and calculate tax rate increases of similar size. Reforms of health insurance co-pay for the retirees or extensions of the normal retirement age seem to contain the required increases in tax rates.[4]

Second, we are contributing to the literature on immigration and its impact on public finances. An earlier study by Storesletten (2000) uses a general equilibrium model with overlapping generations, calibrated to the U.S. economy and argues that a large immigration policy (about 1.6 million annual flow starting in 2000) of high and medium skilled immigrants could resolve the fiscal problems. Auerbach and Oreopoulos (1999) and Lee and Miller (2000) also find large gains from immigration for the U.S. Storesletten (2003) uses an accounting model for Sweden and calculates the net public gain of a new immigrant as the discounted value of future tax payments minus transfers and additional government consumption, and finds the potential gains to be large, about $20,000 per new immigrant.[5]

Among the immigration studies for Japan, however, Fehr et al. (2004) are less enthusiastic. Fehr et al. (2004) develop a three-region overlapping generations model for U.S., Japan and European Union in which immigrants (i) broaden the tax base but lower the real wage (dampening the initial beneficial effect), (ii) accumulate the capital they arrive with, raising wages, and, (iii) require public expenditures like natives as they be-

[4]Earlier and other contributors to this literature are Broda and Weinstein (2005), Doi (2008), İmrohoroğlu and Sudo (2011a), İmrohoroğlu and Sudo (2011b), Hoshi and Ito (2014), Hsu and Yamada (2015), and Kitao (2015b).

[5]A recent survey by Preston (2014) reviews various approaches to measuring the impact of immigration, evaluating the mechanisms in accounting models, or, static or dynamic behavioral economic models.

come identical to natives after one period. Their baseline experiment calls for an annual flow of 54,000 immigrants (with the same amount of capital and children as their native born counterparts), and an alternative of 108,000 of only high-skilled immigrants.[6] Their overall conclusion is that there are small welfare effects and that the impact is "too little too late".

Shimasawa and Oguro (2010) use a 16-country/region overlapping generations model in which immigrants cannot be distinguished from natives upon entry. Like Fehr et al. (2004) and other studies, this assumption makes their productivity the same as their native counterparts subject to being in the same skill category, and, makes them eligible for pensions and public health insurances.[7] Their baseline immigration policy brings in an annual flow of 150,000 immigrants and the foreign born population eventually reaches 37% of the Japanese population by 2100.[8] Despite this large immigrant population, there are little gains on the fiscal front. The debt to GDP ratio by 2050 is 699% compared to the baseline case of zero immigration value of 719%. When a consumption tax rate is raised and set at 30% (in their scenario 8) under this high immigration assumption, the gains are much larger and the debt to GDP ratio declines to 234% in 2050. Overall, Shimasawa and Oguro (2010) conclude that immigration alone cannot alleviate the fiscal burden.

3 Model

The economy consists of overlapping generations of individuals. We denote time as t, age of an individual as j. We will first describe our benchmark model without foreign workers and introduce them in the model in Section 5, where we discuss guest worker policies.

3.1 Demographics

Individuals enter the economy at age $j = 1$ and can live up to J years. Life-time is uncertain and agents of age j at time t face a conditional probability of $s_{j,t}$ to survive to age $j+1$ at time $t+1$. $s_{J,t} = 0$ for all t. The size of a new cohort entering the economy grows at rate γ_t. We denote by $n_{j,t}$ the number of individuals of age j at time t.

[6] Fehr et al. (2004) maintain a consumption tax rate of 5%, use a normal retirement age of 60, which has since been changed to 65, and include a strong bequest motive.

[7] In addition, Lagakos et al. (2014) document that returns to potential experience among U.S. immigrants are higher on average for workers coming from rich countries than for those coming from poor countries, making it unlikely that foreign born workers would become like native workers soon after they enter the host country.

[8] In contrast, our guest worker policies keep the foreign born share of employment at 4% to 16.4%, depending on the particular experiment. In Section 6.2, we simulate an extended guest worker program, in which guest workers stay longer and constitute a larger fraction of the workforce comparable to that of Shimasawa and Oguro (2010).

3.2 Endowment, skills and earnings

Labor supply is exogenously determined in the model and we denote by $\Lambda_{j,t} \in [0,1]$, the employment rate of age j individuals at time t. Earnings of working individuals at age $j < j^R$ at time t are given as $y_{j,t} = \eta_j w_t$. η_j denotes age-specific productivity which evolves deterministically and w_t is the market wage at time t. Average earnings of an age$-j$ individual net of labor income taxes at $\tau_{l,t}$ and payroll taxes at $\tau_{p,t}$ are denoted as

$$\widetilde{y}_{j,t} = (1 - \tau_{l,t} - \tau_{p,t}) y_{j,t} \Lambda_{j,t}$$

3.3 Individuals' problem

The lifetime utility function of an individual who enters the economy at age $j = 1$ as an adult is given by

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

where $c_{j,t+j-1}$ is consumption at age j and time $t+j-1$, $S_{j,t+j-1}$ denotes unconditional probability that an individual born in at time t survives $j-1$ periods up to age j at time $t+j-1$. That is, $S_{j,t+j-1} = \prod_{k=1}^{j-1} s_{k,t+k-1}$. The subjective discount factor is denoted by β and the coefficient of relative risk aversion is given by θ.

The budget constraint of an individual in each period is given as

$$c_{j,t}(1 + \tau_{c,t}) + s_{j,t} a_{j+1,t+1} = \widetilde{y}_{j,t} + tr_t + p_{j,t} + R_t a_{j,t} \tag{2}$$

where R_t is the after-tax gross return factor on individuals' savings defined in Section 3.5, and $\tau_{c,t}$ is the consumption tax rate. Individuals can buy and accumulate one-period riskless assets which consist of a combination of investment in physical capital and holdings of government bonds. We assume that there are annuity markets to cover the event of early death with the actuarially fair price $s_{j,t}$. The assets of the deceased are distributed equally to individuals of the same cohort.[9] The individuals receive non-pension net, lump-sum transfer payments tr_t from the government (net of lump sum taxes) and also collect pension benefits $p_{j,t}$ after retirement $j \geq j^R$.

3.4 Technology

Firms produce output Y_t using aggregate capital K_t, labor supply L_t and productive technology Z_t according to a constant returns to scale technology

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

α is capital's share of output and capital depreciates at constant rate $\delta \in (0,1)$. The productivity Z_t grows at rate λ_t. The rental price of capital $r_{k,t}$ and wage rate w_t are

[9] As in Attanasio, Kitao, and Violante (2007), we assume an annuity market rather than unintended or accidental bequests. This assumption eliminates accidental bequests from the model and simplifies the computation of equilibrium transitions.

determined competitively and equated to the marginal product of each factor and defined as follows.

$$r_{k,t} = \alpha Z_t \left(\frac{K_t}{L_t}\right)^{\alpha-1} - \delta, \tag{3}$$

$$w_t = (1-\alpha) Z_t \left(\frac{K_t}{L_t}\right)^{\alpha}. \tag{4}$$

3.5 Government and fiscal policies

The government raises revenues through taxation and issuance of one-period real debt to finance public consumption, transfers to individuals as well as debt repayment and interest payments on outstanding debt. The government also runs the public pension scheme and provides pension benefits to retirees.

Government budget: In each period the government finances its total expenditures G_t, total net (non-pension) transfers to individuals TR_t, total pension benefits to retirees P_t and the cost of debt servicing through taxation T_t, and issuance of new debt B_{t+1}. The government budget constraint is given as follows.

$$B_{t+1} = (1 + r_{b,t})B_t + G_t + P_t + TR_t - T_t. \tag{5}$$

Here $(1 + r_{b,t})B_t$ is the principal and interest payments on the stock of government debt. We assume that the government issues one-period bonds at real interest rate $r_{b,t}$.

We distinguish between $r_{b,t}$, the interest rate paid on the government debt, and $r_{k,t}$, return to physical capital rented to firms. This allows us to capture the level of interest rate paid by the government and approximate the total interest expenses of the government. As in Braun and Joines (2015) and Kitao (2015a), we assume that individuals allocate an exogenous fraction ϕ_t of their saving to government debt and a fraction $(1-\phi_t)$ to firms' physical capital.[10] After-tax gross return factor on individuals' asset holdings is given as $R_t = 1 + (1-\tau_{k,t})r_{k,t}(1-\phi_t) + (1-\tau_{b,t})r_{b,t}\phi_t$.

The government revenues and spendings are defined as follows.

$$\begin{aligned}
T_t &= \tau_{c,t}\sum_j c_{j,t}n_{j,t} + [\tau_{k,t}r_{k,t}(1-\phi_t) + \tau_{b,t}r_{b,t}\phi_t]\sum_j a_{j,t}n_{j,t} + \sum_j (\tau_{l,t} + \tau_{p,t})y_{j,t}\Lambda_{j,t}n_{j,t},\\
G_t &= \sum_j g_{j,t}n_{j,t},\\
P_t &= \sum_j p_{j,t}n_{j,t},\\
TR_t &= tr_t \sum_j n_{j,t}.
\end{aligned}$$

[10] This amounts to assuming that government bonds crowd out private investment. In particular, a \$1 allocation of assets into government bonds reduces private investment by $\phi/(1-\phi)$.

T_t represents taxes on three sources of revenues; consumption at the proportional rate $\tau_{c,t}$, income from asset holdings at a combination of $\tau_{k,t}$ and $\tau_{b,t}$, and labor income at $\tau_{l,t}$ and $\tau_{p,t}$. $g_{j,t}$ denotes exogenous per-capita government purchases for individuals of age j at time t. $p_{j,t}$ is per-capita pension payments to retirees at age j at time t, and tr_t is per-capita, age-independent, net, non-pension transfers at time t.

Pension benefits: Pension benefits $p_{j,t}$ mimic the current Japanese public pension system in which the benefit depends on past earnings and are given by the formula

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

Cumulated past gross earnings $W_{j,t}$ are computed recursively using

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

where j^R is the normal retirement age at which individuals start to receive public pensions. κ_t represents the replacement rate, which is time-dependent to calibrate recent public pension reforms.

3.6 Definition of equilibrium

Given a sequence of exogenous demographic parameters $\{\gamma_t, s_{j,t}, n_{j,t}\}$, government policy variables $\{g_{j,t}, p_{j,t}, tr_t, \tau_{k,t}, \tau_{b,t}, \tau_{l,t}, \tau_{p,t}\}$, and interest rates on the government debt and asset allocation rule $\{r_{b,t}, \phi_t\}$, a competitive equilibrium consists of sequences of individuals' consumption and asset holding choices $\{c_{j,t}, a_{j+1,t+1}\}$, factor prices $\{r_{k,t}, w_t\}$, and consumption tax rates $\{\tau_{c,t}\}$ that satisfy the following conditions:

1. Individuals' allocations $\{c_{j,t}, a_{j+1,t+1}\}$ maximize the objective function (1) subject to a sequence of budget constraints (2).

2. Factor prices are determined competitively as in equations (3) and (4).

3. The capital, bond and labor markets clear:

$$\begin{aligned} K_t &= (1 - \phi_t) \sum_j a_{j,t} n_{j,t}, \\ B_t &= \phi_t \sum_j a_{j,t} n_{j,t}, \\ L_t &= \sum_j \eta_j \Lambda_{j,t} n_{j,t}. \end{aligned}$$

4. The goods market clears:

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

   where $C_t = \sum_j c_{j,t} n_{j,t}$ is aggregate consumption.

5. The consumption tax rates $\{\tau_{c,t}\}$ satisfy the government budget constraint (5).

4 Calibration

The frequency of the model is annual. We calibrate parameters of the model in two steps. The first set of parameters are calibrated based on the data and set independently from the model's equilibrium. The second set of the parameters are determined within the model so that it matches a target moment for each parameter in equilibrium.

As we discuss more in section 5, we first compute what we call as "the initial steady state" which represents features of the Japanese economy prior to 2014. Starting in 2014, we compute the transition dynamics to a final steady state, in which the economy follows a balanced growth path under the demographics that are projected for the long-run. Note that since the demographics in 2014 are far from stationary, we use the actual age-distribution of the population in 2014 in computing aggregate statistics and the government budget for 2014.

Table 1 summarizes the calibrated parameters.

4.1 Demographics, preferences and earnings

We assume that age-specific survival rates $s_{j,t}$ follow the projection of the National Institute of Population and Social Security Research in Japan (IPSS) from 2014 to 2060, the last year for which official projections are available. They are assumed to stay constant after 2060. The growth rate of a new cohort γ_t is based on the fertility projection of the IPSS, which implies the average annual cohort growth rate of -1.24% over the period of 2014 to 2080. Thereafter we assume that the growth rate will gradually increase and converge to 0% by 2150.

Risk aversion parameter θ is set at 2.0. Subjective discount factor β is set so that the model matches the capital-output ratio of 2.5 as estimated by Hansen and İmrohoroğlu (2015).

For the age-specific productivity η_j, we use estimates of life-cycle earnings of male workers in the Statistical Survey of Actual Status for Salary in Private Sector (SSPS) as it covers a wide range of employed workers.[11] Participation rates are estimated from the Labor Force Survey (LFS) to be consistent with the earnings profile. In particular, as the SSPS covers employees including part-time job workers, non-regular workers and contract job workers, we include them in the labor force participation.

4.2 Technology

The growth rate of the productivity, λ_t, is set at 1.5%, which implies per-capita output growth of about 1% along the balanced growth path.[12]

The level of initial productivity Z_0 is set for normalization so that the average earnings (age 20-64) is 1.0 in the initial steady state of the model. The depreciation rate δ is set at 0.0821, computed following the methodology of Hayashi and Prescott (2002), using the

[11] We also examined the earnings profile using the Basic Survey on Wage Structure (BSWS) and it was slightly higher than the estimates by the SSPS because the BSWS drops all employees working in small establishments with less than 5 persons.

[12] The growth of per-capita output is computed as $(1+\lambda)^{1-\alpha} = 1.0093$.

data between 1981 and 2013. The capital share is set at 0.3794, based on the aggregate data (SNA, System of National Accounts) during the same period.

4.3 Government

In order to satisfy the period budget constraint (5), at least one of the policy parameter must be determined in the model's equilibrium. As we discuss below, we calibrate all the parameters to the data in the initial steady state except for the lump-sum transfer, which is determined in equilibrium. When we compute the transition dynamics, we assume that the lump-sum transfer will remain constant, only adjusted for the growth of the economy and use the consumption tax $\tau_{c,t}$ to satisfy the budget constraint each period.

Labor income tax τ_l is set at 18%, based on the estimates of the effective labor income tax rate by Gunji and Miyazaki (2011) at 33% in 2007 net of pension premium 15% in the same year. The premium for the employment based pension (*kosei nenkin*) is 17.12% of earnings in 2014, rising 0.353% annually to 18.3% in 2019. We set the payroll tax τ_p at 18% throughout the transition. Capital income tax τ_k is set at 35%, based on the method of Hayashi and Prescott (2002) as updated by Hansen and İmrohoroğlu (2015). The interest paid on government debt is taxed at rate τ_b, 20%.

Consumption tax τ_c is set at 8% in the initial steady state. As discussed above, the tax rate is determined endogenously during the transition to achieve the government budget balance and used as an indicator to represent the cost of demographic transition, fiscal cost or benefit of alternative policies that will be discussed in section 5.

Per-capita government purchases $g_{j,t}$ are age-dependent and represent the sum of age-independent component $\tilde{g}_t$ and medical expenditures $m_{j,t}$ covered by the government for an individual of age j at time t. Therefore we have $g_{j,t} = m_{j,t} + \tilde{g}_t$. For the medical component $m_{j,t}$, we use the gross medical expenditure data of the Ministry of Health, Labour and Welfare (MHLW) for health care and long-term care and the age-dependent co-pay rates for each type of care to compute the payment made by the government.[13] The age-independent government purchases per capita $\tilde{g}_t$ are calibrated in the initial steady state so that the model matches the ratio $G/Y = 0.18$ in 2013 and remains constant during the transition.

Total expenditures for pension benefits represent 10.6% of GDP in 2013. We set the replacement rate κ_t to match this ratio in the initial steady state. The pension reform signed into law in 2004 will reduce the replacement rate of public pension benefits over the next few decades through the adjustment according to the "macroeconomic slide" if successfully implemented. According to the official projections (*zaisei kensho*) of 2014, the replacement rate will decline by approximately by 20% when the adjustment is completed in 30 years. We embed the reduction in benefits that is expected in the coming decades by reducing the replacement rate κ_t by 20% from the initial level over the first 30 years of the transition. The replacement rate remains constant thereafter.

The net government debt to GDP ratio was 130% in 2013 and we set the level of the debt B_t to match the ratio each year. The interest rate on the government debt is set

[13] See Kitao (2015a) for more details of the two insurance programs.

at 1%, the average real interest rate on the Japanese government debt.[14]

Table 1: Parameters of the Model

Parameter	Description	Values/source
Demographics		
$\{s_{j,t}\}_{j=1}^{J}$	conditional survival probabilities	IPSS (2012)
γ_t	cohort growth rate	IPSS (2012)
J	maximum age	91 (110 years old)
Preferences		
β	subjective discount factor	1.0162 ($K/Y = 2.5$)
θ	risk aversion	2.0
Labor market		
$\{\Lambda_{j,t}\}_{j=1}^{J}$	participation rates	LFS
$\{\eta_{j,t}\}_{j=1}^{J}$	productivity	SSPS
Technology		
Z_t	TFP level	normalization
λ_t	TFP growth rate	1.5%
α	capital share	0.3794
δ	capital depreciation rate	0.821
Government		
τ_l	labor income tax	18%
τ_p	payroll tax	18%
τ_c	consumption tax	8% (in 2013)
τ_a	capital income tax	35%
τ_b	tax on gov. bond return	20%
tr_t	net transfers	see text
$\{m_{j,t}\}_{j=1}^{J}$	medical expenditures	see text
$\{g_{j,t}\}_{j=1}^{J}$	government purchases	see text ($G/Y = 0.18$)
κ_t	pension replacement rate	0.476 (in 2013, $P/Y = 0.106$)
B_t/Y_t	net debt to GDP ratio	130% (2013)
r_b	int. on government bond	1.0%

5 Numerical results and policy experiments

Our baseline case is an economy without guest workers and the government uses the consumption tax rate $\tau_{c,t}$ to satisfy its budget. In other words, the consumption tax rate is endogenously calculated each year while the population ages, public expenditures rise and the debt to GDP ratio stays at 130%.

Against this baseline transition, we introduce guest worker programs that differ along certain dimensions such as the number of guest workers and their relative productivities, and evaluate how alternative policies affect the path of the Japanese economy. In

[14]The average number of years to maturity of existing Japanese bonds is 7 years and the interest rate on 7 year government debt is 1%.

particular, the fiscal impact of guest workers is reflected in the change in equilibrium consumption tax rates, which are used as a measure of the benefits from the temporary inclusion of foreign-born workers in the economy. Finally, we measure the welfare effects of guest worker programs on the native Japanese workers, both alive at the time of the policy change and future generations.

5.1 Guest worker programs

We consider guest worker programs that consist of two important components: i) their number and age distribution, and, ii) their productivities relative to the native-born workers.

Data on foreign-born workers in Japan along these two dimensions seem to suggest a typical foreign worker at age 40 with a productivity at 50% of that of his native counterpart.[15] In order to check the sensitivity of our findings on the assumed productivity of foreigners, we also consider cases in which guest workers are just as productive as the native workers. Therefore, we assume that foreign workers enter at age 35, work for 10 years and leave before reaching 45. We consider three values for the number of foreign workers. First, we assume an inflow of 100,000 or 200,000 workers per year. The 200,000 annual flow and a 10-year stay are broadly consistent with the early 2014 announcement by the Japanese government about the number and duration of their initial exploration for a guest worker program. We also consider a smaller scale entry at 100,000 foreign born workers per year. Second, we consider a larger-scale U.S.-style guest worker program which gradually builds a stock of foreign-born workers to the level seen in the U.S. economy in 2014.

In all the economies with guest workers, we assume the following.

- Guest workers pay τ_l personal income tax on earnings and τ_c on consumption, at the same rates as the native Japanese.
- Guest workers do not pay the pension premium τ_p and they do not receive pension benefits.
- Guest workers consume 50% of earnings (net of the consumption tax), a propensity to consume in line with the native workers.
- Guest workers do not save domestically and instead send their net earnings that are not consumed back to their home economies (or simply hold them until they return to their countries), and therefore are not invested in the capital stock in Japan.
- The government incurs medical expenditures $g^*_{j,t}$ for each guest worker of age j, that are paid from by general taxes collected from all workers.
  - We assume $g^*_{j,t}$ consists of 50% of medical expenditures $m_{j,t}$ incurred for each native person of age j.

[15] See, for example, "The Survey on the Way of Working among Foreigners" (in Japanese) by the Japan Institute for Labour Policy and Training (2011).

We consider six guest worker programs using combinations of two parameters, the number and productivity of workers. Experiments 1 and 3 assume an annual in-flow of 100,000 guest workers whereas Experiments 2 and 4 allow for 200,000 guest workers. In addition, Experiments 1, 2 and 5 assume that the productivity of guest workers is 50% of that of native-born workers, and, Experiments 3, 4 and 6 assume that guest workers are just as productive as the average native-born workers. In experiments 5 and 6, we assume an annual inflow of foreign-born guest workers such that the share of guest workers in total employment rises to and is maintained at 16.4%, the same percentage as the 2014 share of foreign-born workers in the U.S.

We would like to emphasize that foreign-born workers are quite distinct from their native-born Japanese counterparts in key dimensions. In particular, guest workers are not eligible for pensions and they do not stay long enough to require significant public health expenditures. The key elements of the experiments are summarized below in table 2.

Table 2: Six Alternative Guest Worker Policies

	Annual Flow of Foreign-Born Workers	Their Relative Skill Level
Experiment 1	100,000	50%
Experiment 2	200,000	50%
Experiment 3	100,000	100%
Experiment 4	200,000	100%
Experiment 5	s.t. 16.4% are foreign	50%
Experiment 6	s.t. 16.4% are foreign	100%

In Figure 1, we show the time paths for the stock of foreign born workers in the economy as well as the ratio of guest workers to total employment (including the guest workers).

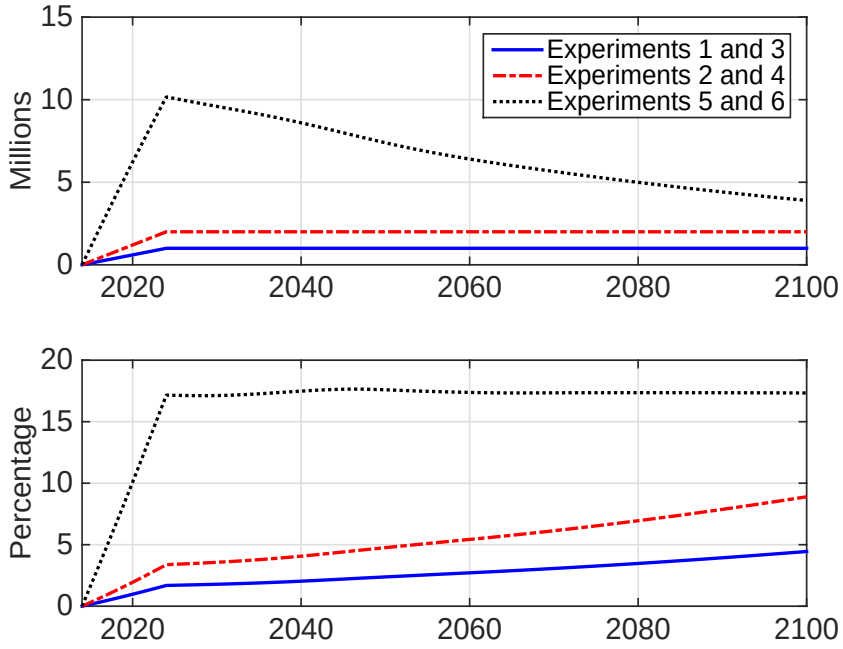


Figure 1: Foreign Born Workers: Number and Share

According to the first frame in Figure 1, the stock of guest workers is built in 10 years to 1 million, 2 million, and 16.4% of total employment (which is declining over time as the labor force shrinks), respectively. The second frame displays the foreign workers' share of employment. By 2100, these are 4.4%, 8.8%, and 16.4%, respectively. In the steady state, the shares are 7.4%, 14.8%, and 16.4%, respectively. Note that the two-way 'revolving door' nature of our guest worker experiments keeps the share of foreign born workers relatively low despite very large flows in Experiments 2, 4, 5, and 6. In contrast, existing studies we are aware of assume that guest workers become exactly like native workers upon entry into the native economy and therefore even moderately small annual flows accumulate into significant shares for foreign born workers. For example, the main experiment (scenario 2) in Shimasawa and Oguro (2010) allow for an annual flow of 150,000 foreign born workers and the share of foreign born workers in total population rises to 37% in 2100.

5.1.1 The first four guest worker programs

First, we will describe the findings from Experiments 1-4 because these seem to be fairly close to those under discussion in the public sphere. Later, we will turn our attention to Experiments 5 and 6 which are designed to highlight the two key components of a successful guest worker program.

Experiments 1 and 2: guest workers at 50% productivity of native workers In our baseline simulations, the size of the economy and the tax base shrink over time as working age population declines due to the retirement of baby boom generations and

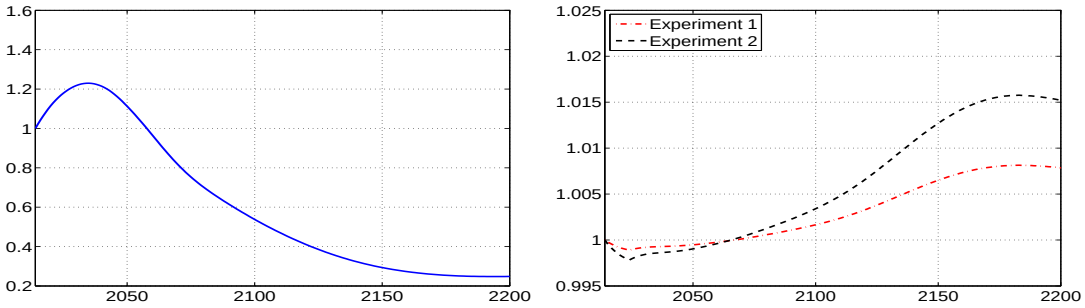
low fertility rates. In addition, the age related public expenditures such as pensions and health expenditures rise, which requires significant increases in the consumption tax rate to finance the spending driven by the demographic shift (as will be shown in Figure 4). Implementing a guest worker program mitigates the decline in the total labor input and slows down the fall in the tax base. As a result, a smaller increase in the consumption tax rate is now sufficient to finance age related public spending. Our model provides a quantitative assessment of how a guest worker policy can help Japan achieve fiscal sustainability in the next few decades.

We begin by describing the impact of guest workers on selected macroeconomic indicators. The left panels of Figure 2 display the time paths of detrended capital, labor, and output from 2014 towards the steady state for the baseline economy. The right panels are the paths under Experiments 1 and 2, expressed as ratios to the baseline counterparts. The labor input declines monotonically in the baseline simulations because of the decline in the working age population. This decline is mitigated under Experiments 1 and 2 thanks to the inflow of guest workers and their labor supply.

The capital stock rises for the first few decades as individuals live longer and need to save more for a longer period of retirement. The decline in the population offsets the increase in aggregate capital as it reduces the number of savers and this effect starts to dominate in 2030s in the baseline model. In economies with guest workers, the return to capital is higher than that in the baseline economy as discussed below and the capital stock is higher. The difference, however, is quantitatively small, about 1.5% of the baseline level in the long-run under Experiment 2 with a larger number of guest workers.

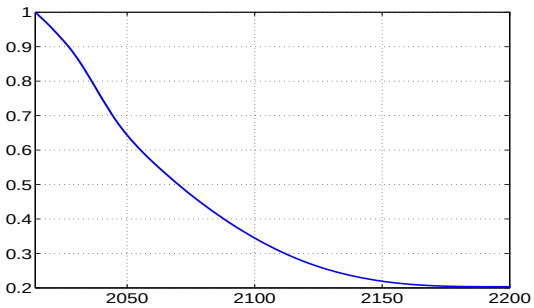
Output is mostly flat in the first 2-3 decades as the increase in the capital stock counteracts the decline in the labor input but then falls rapidly as both inputs decline over time.[16] Output differences caused by the guest worker programs are small in the beginning, less than 1% during the initial 10 years in both experiments, but rising to about 2.8% and 5.5%, respectively, in the long run.

[16]Note that when the TFP growth rate is used to produce the level of output, it grows slightly over time as the assumed TFP growth rate consistent with a balanced growth rate of 1.5% is slightly greater than the average decline of about 1.4% in the labor input.

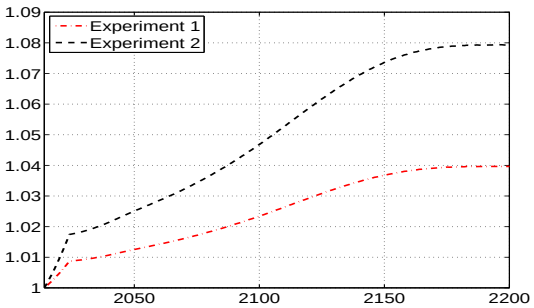


(a) Capital: baseline

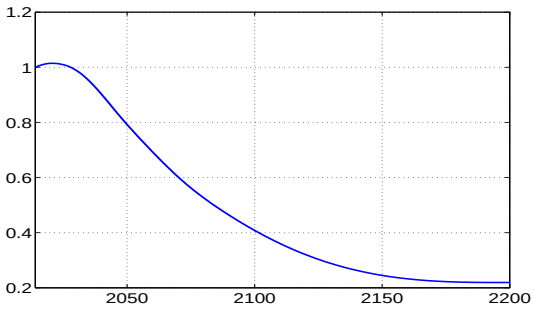
(b) Change in capital: Exp 1 and 2



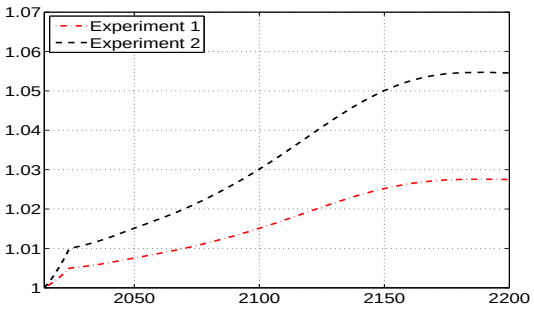
(c) Labor: baseline



(d) Change in labor: Exp 1 and 2



(e) Output: baseline



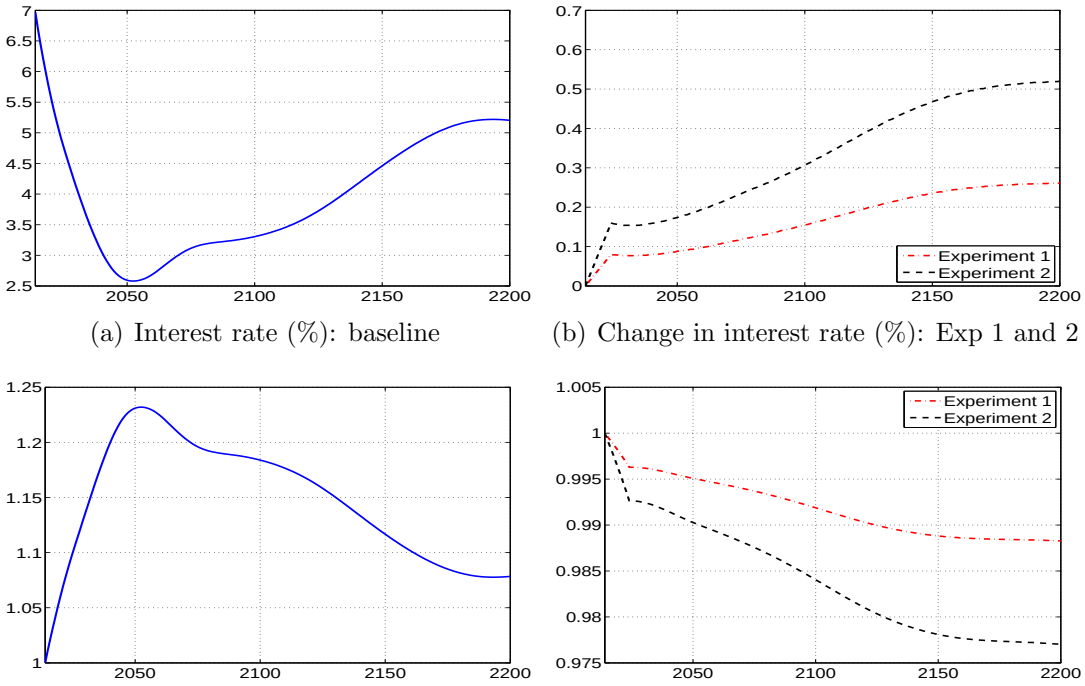
(f) Change in output: Exp 1 and 2

Figure 2: Capital, Labor and Output. Right panels show the change in aggregate variables in Experiment 1 and 2 expressed as a ratio to the baseline.

As the aggregate capital rises and labor supply falls during the initial decades, the capital labor ratio rises rapidly early on. As shown in Figure 3, the interest rate will fall and the wage rate will rise during this period. Thereafter, the decline in capital dominates the fall in labor supply and the interest rate will rise and wage will decline gradually.[17]

Under the guest worker policies, the wage rate will always be lower than that in the baseline transition as labor is less scarce with more workers. The magnitude of the difference, however, is very small in the two experiments.

[17]We assume that the decline in the wage rate is not sufficient to entice the guest workers to return to their home economies.



(a) Interest rate (%): baseline

(b) Change in interest rate (%): Exp 1 and 2

(c) Wage rate: baseline

(d) Change in wage rate: Exp 1 and 2

Figure 3: Factor Prices. Right panels show the change in factor prices in Experiment 1 and 2 relative to the baseline, in percentage point difference in (b) and the ratio of the wages to the baseline in (d).

Figure 4 shows the time paths of the consumption tax rate under the baseline transition and Experiments 1 and 2. The differences across the three transitions are fairly small, especially in the first few decades, indicating the relatively small contribution from the implementation of the guest worker programs. After 2050, the difference increases somewhat and remains between 2 to 3 percentage points in Experiment 2.

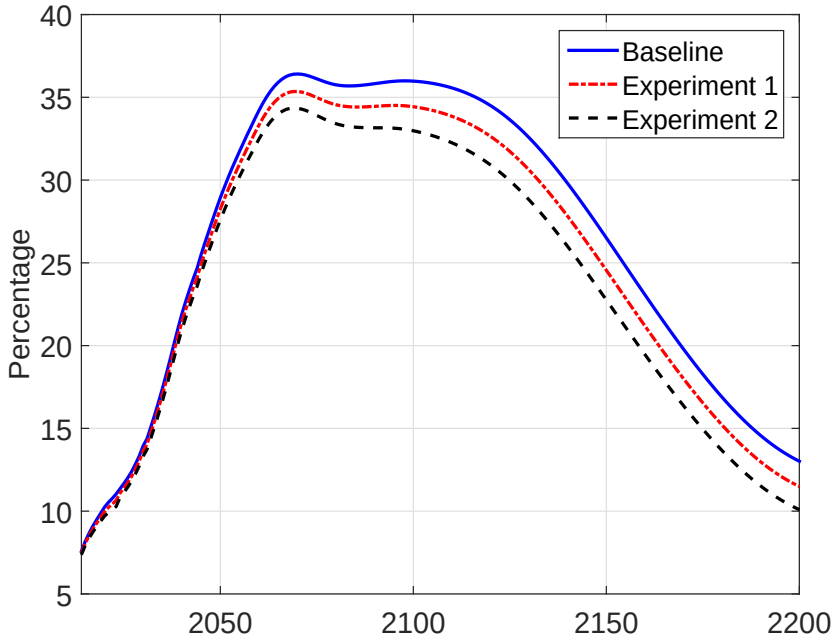
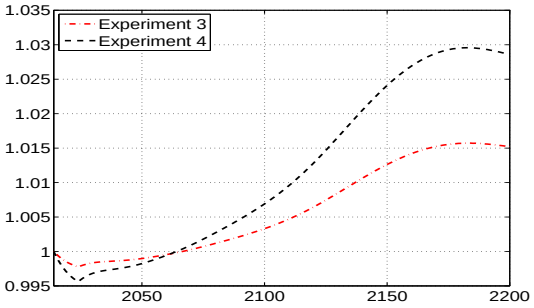


Figure 4: Consumption Tax Rate

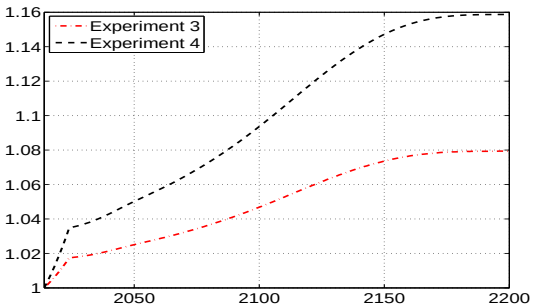
Experiments 3 and 4: more productive guest workers Now we discuss the impact of the two guest worker programs in which the productivities of foreign-born workers are identical to those of native Japanese workers. In the previous calculations above, we assumed that foreign-born workers were half as productive as their native counterparts.[18] In the experiments below, we assume that guest workers are identical to the Japanese workers in productivity over their working lives in Japan. Perhaps this can be interpreted as choosing a more high-skill biased guest worker program.

Figure 5 displays the effects on the economy from these skill-biased guest worker programs, expressed as the ratio to the level of variables in the baseline model with only native workers. The effects are similar to those under Experiments 1 and 2 examined above, but the magnitudes of the effects are significantly larger, especially in the long run. For example, output is more than 10% higher in the long run with the addition of guest workers that are twice as productive as those in Experiment 2, where the effect was about 5.5%.

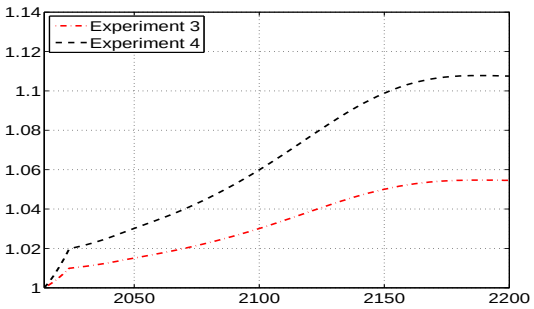
[18]In the U.S., the ratio of median weekly earnings of foreign-born workers to that of native-born workers is 80%, according to the CPS in 2014.



(a) Capital



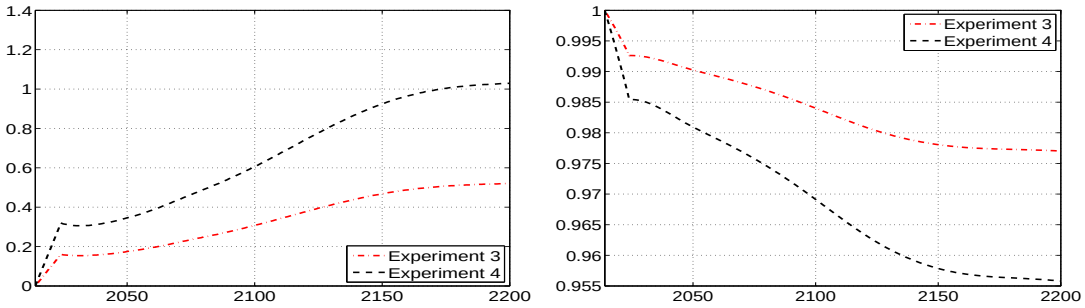
(b) Labor



(c) Output

Figure 5: Capital, Labor and Output in Experiments 3 and 4. Panels show the change in aggregate variables in experiments expressed as a ratio to the baseline.

The change in the capital labor ratio is more pronounced and this can be seen as larger effects on factor prices in Figure 6. Note that the labor input in the production function is in efficiency units and with foreign-born workers twice as productive in Experiments 3 and 4 relative to those in Experiments 1 and 2, the paths of the capital labor ratio are visibly lower than that under the baseline economy. This results in higher returns to capital and lower wage rates with larger and skill-biased guest worker programs compared to those in Experiments 1 and 2.



(a) Interest rate (%-difference) (b) Wage rate

Figure 6: Factor Prices in Experiment 3 and 4. Panels show the change in factor prices in experiments relative to the baseline, in percentage point difference in interest rate and the ratio of the wages to the baseline.

The effects on the consumption tax rate in Experiments 3 and 4 are much larger due to our assumption that the productivity of guest workers are higher than that in Experiments 1 and 2 and the same as that of native-born workers at each age. This leads to more significant broadening of the tax base and therefore allows the government to limit the increase in the consumption tax to maintain fiscal sustainability. Figure 7 indicates a significant reduction in the consumption tax required to finance the increasing public expenditures. The impact of a larger tax base, either through a bigger guest worker program, or, targeting more productive guest workers, is summarized in Table 3.

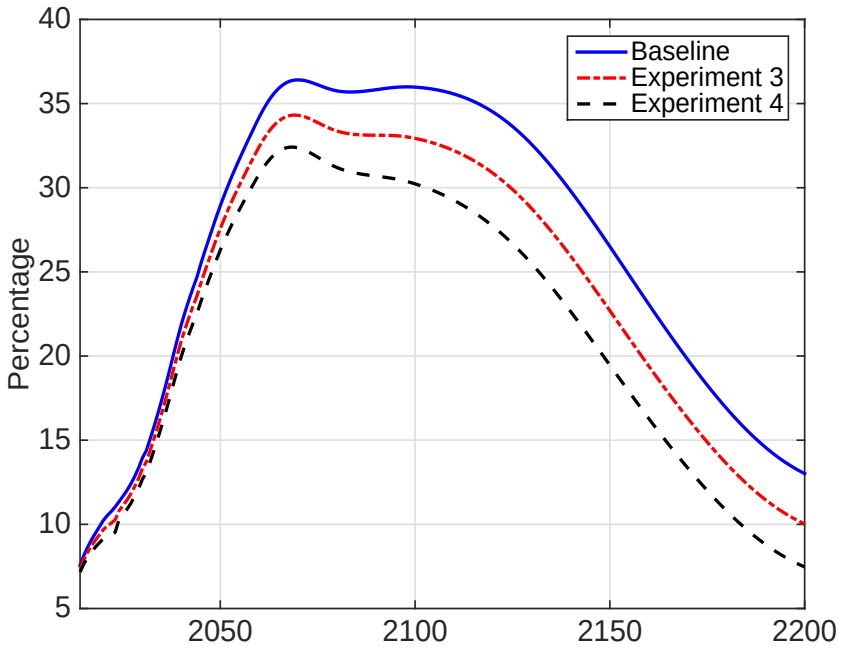


Figure 7: Consumption Tax Rate

As shown in Table 3, Experiment 4 provides the largest relief on the government budget, producing a consumption tax rate that is lower than that in the baseline case by two percentage points in 2040 and by 5.5 percentage points in 2100. The difference remains above 5 percentage points throughout the transition after 2100.

The fact that the consumption tax rises less than that in the baseline under the guest worker program described by Experiment 4 implies that the taxes are less distortionary on the saving decisions of individuals. In a model with endogenous labor supply, the gain from this particular policy is likely to be even larger because the consumption tax would distort work decisions less in that case.

In the long run, the consumption tax rate falls to 11.73% in the baseline case, and much lower in the guest worker experiments, due to our assumption that demographics become stationary eventually at an old age dependency ratio which is much lower than that in 2100 but still higher than that in 2014. In the steady state, Experiment 4 delivers a consumption tax rate which is more than 5 percentage points lower than that in the baseline case and lower than the actual consumption tax rate in 2014.

Table 3: Consumption Tax Rate under Alternative Guest Worker Policies

	Baseline	Exp 1	Exp 2	Exp 3	Exp 4
2015	8.17	8.05	7.92	7.92	7.67
2020	10.24	9.97	9.70	9.69	9.15
2030	13.95	13.63	13.32	13.30	12.68
2040	21.88	21.40	20.93	20.92	19.99
2050	28.94	28.26	27.60	27.57	26.29
2060	34.20	33.32	32.47	32.45	30.82
2070	36.41	35.35	34.33	34.30	32.37
2080	35.75	34.55	33.40	33.37	31.20
2100	35.98	34.43	32.98	32.93	30.23
∞	11.73	10.27	8.92	8.86	6.39

5.1.2 Turning American: A U.S.-style guest worker program

In this subsection we conduct an experiment modeled after the current U.S. immigration environment. According to the Bureau of Labor Statistics "Foreign-Born Workers: Labor Force Characteristics – 2013" (published on May 22, 2014), there are 25.3 million foreign-born workers in the U.S. that constitute about 16% of the labor force. They include naturalized citizens, legal permanent residents, temporary migrants (including H-1B workers and students), refugees, asylum seekers, and unauthorized immigrants (to the extent that they are counted in the Current Population Survey).

The exercises we conduct in this section take the current (as of the end of 2014) employment of 64 million in Japan and gradually add a flow of foreign-born workers who remain and work in Japan for 10 years so that the eventual stock of foreign-born workers is at 16.4% which would be 10.5 million in 2014.[19] This would require an annual flow of

[19]The ratio is obtained as the number of employed immigrants in 2013 to the total employment during

about 1 million workers, 5 times as large as what the Abe government announced in early 2014. However, given the projected decline in working age population and employment in Japan, we gradually reduce the annual flow of guest workers to keep the share of foreign-born workers at 16.4% of the total employment in steady state. The productivities of the guest workers will be assumed to be 50% or 100% of those of the native workers.

Clearly, this would broaden the tax base significantly more than the guest worker programs presented above. How much would it improve the fiscal balance? Figure 8 shows the time path of the consumption tax rate under these two U.S.-style guest worker programs and the benchmark path with no guest workers.

Even with the productivities of guest workers at 50% of those of the Japanese workers, the large influx of workers raises the tax base significantly and allows for a smaller increase in the consumption tax rate. This is especially true under the assumption that the foreign-born workers have the same productivity as the native-born workers. In this case, the resulting consumption tax rate is much lower than that in the benchmark case and temporarily rises to levels similar to those in some European economies (about 25%) before declining to a level lower than the current 8% consumption tax rate. In other words, a guest worker program alone can nearly solve Japan's fiscal problems if the program is large and the guest workers are sufficiently skilled.

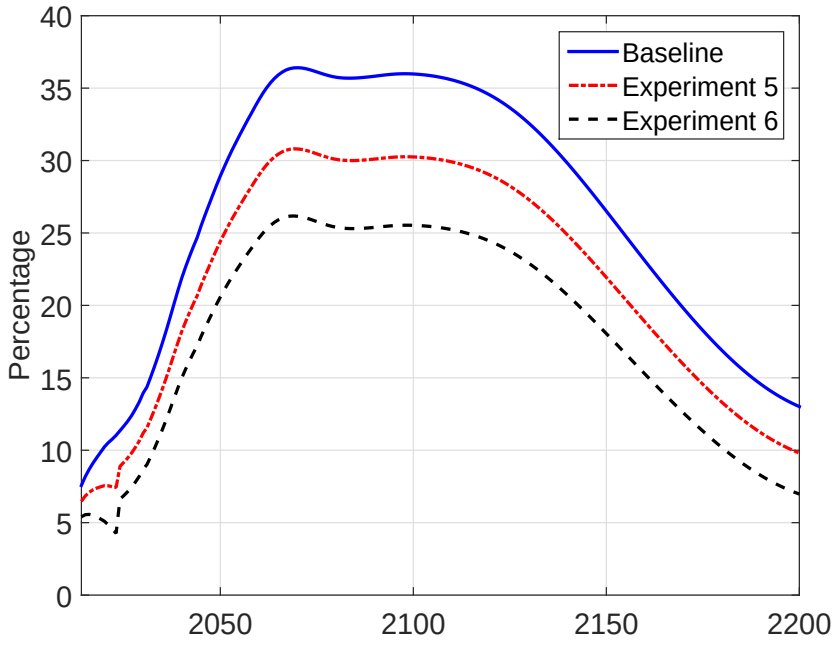


Figure 8: Consumption Tax Rate

Table 4 displays a few snapshots of the tax rate over time for experiments with U.S.-style guest workers. Even if we assume guest workers' productivities are 50% of the Japanese, the increase in the consumption tax rate is significantly more subdued relative to the baseline case. With the assumption of 100% productivity, the tax rate is

the same year in the U.S.

lower by more than 10 percentage points at the peak. It suggests that a policy to bring foreign workers for a limited duration could significantly mitigate the fiscal cost of the demographic transition, depending on the size and productivity of guest workers.

Table 4: Consumption Tax Rate under U.S.-Style Guest Worker Programs

	Baseline	Exp 5	Exp 6
2015	8.17	6.84	5.55
2020	10.24	7.56	5.09
2030	13.95	11.18	8.68
2040	21.88	18.20	14.99
2050	28.94	24.42	20.58
2060	34.20	29.00	24.65
2070	36.41	30.80	26.15
2080	35.75	30.08	25.40
2100	35.98	30.25	25.50
∞	11.73	8.65	5.92

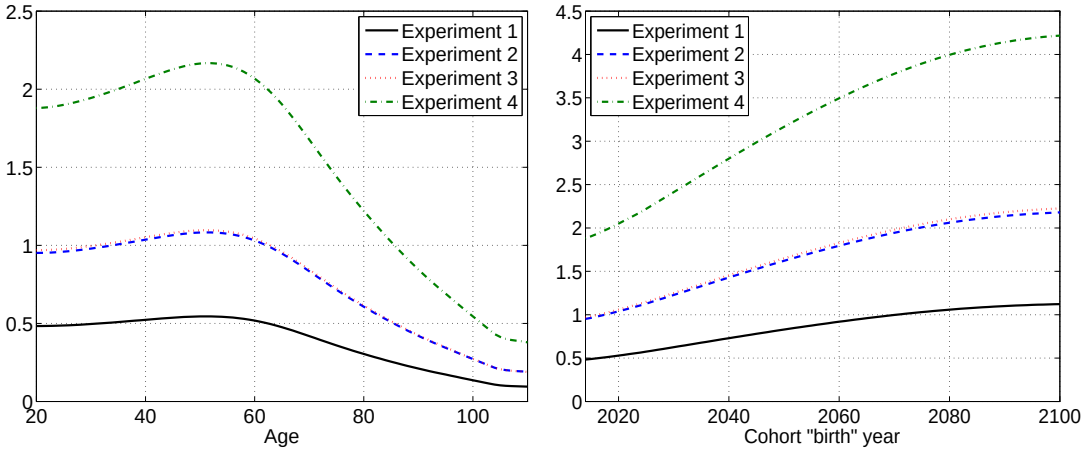
5.2 Welfare analysis

In this subsection, we study welfare effects of the guest worker programs on the Japanese individuals that belong to different cohorts. First, in order to assess the welfare effects on current generations that are already economically active (above age 20) in 2014, the first year of the transition, we compute the consumption equivalent variation (CEV) for individuals at each age. It represents a percentage change in consumption for the remainder of each individual's life which will make him indifferent between the baseline economy and the alternative economy under a particular guest worker policy. The CEV of 1%, for example, implies that individuals are better off if a guest worker program is introduced and his life-time utility for the remaining years of his life would be the same in the baseline economy if his consumption in each period were raised by 1%. For the generations that will enter the economy after 2014, we compute the CEV in a similar way, as a percentage increase in consumption that is needed to equalize the life-time utility between the baseline and an experiment, evaluated at the time of his entry to the economy.

Figure 9(a) shows the welfare effects in CEV from the first four guest worker programs on the generations alive in 2014 and Figure 9(b) shows the CEV for future generations by the "birth" year of their entry to the economy at the age of 20. The welfare effects are determined by changes in the paths of three factors relative to the baseline simulations, (1) consumption taxes, (2) return to labor supply (wage) and (3) return to savings (interest rate). The net gain on each individuals is determined by the combination of the changes in the three factors that they will face at different stages of their life cycles.

As shown in Figure 9(a), all four guest worker programs yield welfare gains for the native born workers at all ages. Wages are lower by the introduction of guest workers as labor becomes less scarce, but working-age individuals experience welfare gains as

the negative effects are offset by benefits of lower consumption taxes and higher interest rate. The gains are smaller for old individuals at the time of the reform. Although they benefit from higher return on their savings and lower consumption taxes, the effects are much smaller during the initial decades of the transition as we saw above and many of them will not survive until when the difference grows more significantly. Welfare gains are larger for future generations that will enter the economy later in the century, as shown in Figure 9(b), as they will fully enjoy the large decline in consumption taxes when the economy has a larger number of guest workers in stock. The largest welfare gain is achieved under Experiment 4, in which working-age individuals in 2014 will experience about 2% of welfare gains in consumption equivalence and future generations will enjoy 2-4% of gains. Experiments 2 and 3 generate almost identical welfare benefits for Japanese workers because they lead to nearly identical expansions in the tax base and similar paths of factor prices.

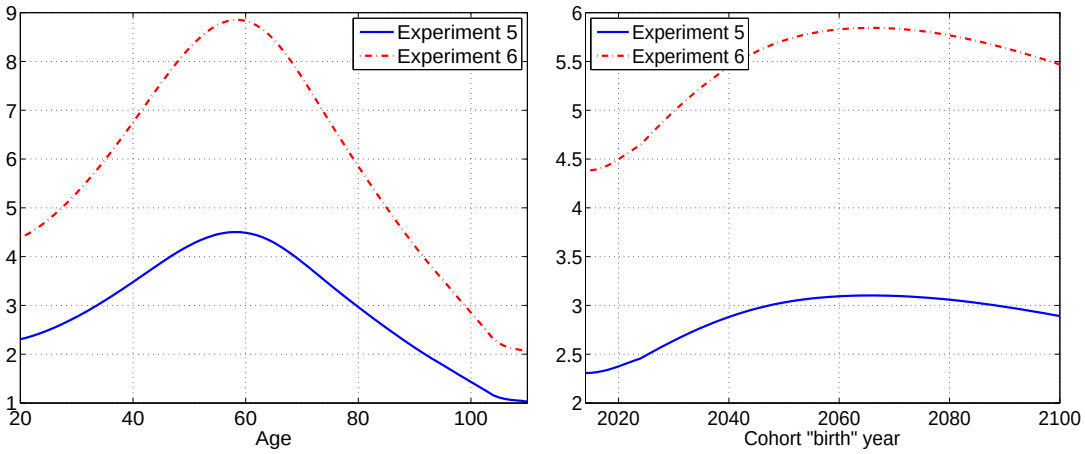


(a) Welfare gains of current generations

(b) Welfare gains of future generations

Figure 9: Welfare Effects of Experiments 1-4 (% in Consumption Equivalent Variation)

Figure 10(a) shows the welfare gains from the U.S.-style guest worker programs on the cohorts alive in 2014. In these experiments, the movement of factor prices are more significant and younger individuals will have lower welfare gains than those at around age 60 who are close to the retirement, since they will experience a large drop in wages during the transition. The gains, however, are larger in magnitude compared to other four experiments, where age-20 individuals had a welfare gain of less than 2% of consumption. In Experiments 5 and 6, age-20 individuals experience a welfare gain of 2.2% and 4.4% in CEV, respectively. Future generations will gain more because the decline in the wage rate will eventually stabilize and the consumption tax will be much lower than in the baseline economy, as shown in Figure 10(b).



(a) Welfare gains of current generations (b) Welfare gains of future generations

Figure 10: Welfare Effects of Experiments 5 and 6

6 Extensions

In this section we present two additional exercises. In the first, we will simulate the model under the assumption that factor prices remain the same as in the initial year. The exercise is to isolate and understand the effects of endogenous transitions of interest rate and wage rate. In the second, we simulate a policy in which the Japanese government allow guest workers to stay much longer than 10 years that we assumed above; a policy to treat foreign workers more like permanent residents or immigrants.

6.1 Partial equilibrium analysis: effects of factor price adjustments

In our baseline general equilibrium (GE) model, the factor prices are determined endogenously in each period according to their marginal productivities. The time paths of these prices depend on the time path of the capital-labor ratio. The wage rate follows a time path similar to that of the capital-labor ratio where as the return to capital follows an opposite path. According to Figure 3(c), the wage rate rises by about 23% from 2015 to 2050 and then falls to a level above its 2014 level, which is exactly what the capital-labor ratio does. The main reason for the rise in the capital-labor ratio is the exogenous decline in the labor input driven by the shrinking labor force and the increase in the life cycle saving motive as the life expectancy rises. After 2050, the capital stock starts to fall as the fraction of non-saving elderly increases significantly and the decline in the labor force continues. The return to capital falls from about 7% in 2014 to about 2.5% in 2050 and then rises eventually to about 5%. The increase in the wage rate from 2015 to 2050 raises the tax base along the way but it also increases the pensions to be paid out post-2050. After 2050, the tax base starts to shrink but the higher pension payments

persist for a while, requiring a high consumption tax rate to achieve fiscal sustainability, as shown in Table 3.

In order to isolate the effects associated with price adjustments, we now consider a scenario in which prices are fixed at the levels of the initial year, 2014, throughout the transition. In particular, we assume a small open economy, where the return to capital is determined at an exogenous level and the level of domestic capital is determined to be consistent with the "world" interest rate. Put differently, we allow for capital inflows and outflows consistent with time-invariant factor prices in a small open economy, which we label as our partial equilibrium (PE) model.

Table 5 summarizes the path of consumption taxes under the baseline model (both GE and PE variants) without guest workers and the four scenarios of introducing guest workers as studied above, but this time under PE. The equilibrium consumption tax rates are significantly lower in the baseline model PE where prices are fixed. Since wages are kept lower than those in the general equilibrium model, wages and therefore pension expenditures are lower, which mitigates the need to raise consumption taxes. Higher interest rates under the partial equilibrium assumption imply a lower level of capital stock and output in our model. Since we assumed and set the government debt as a fixed percentage of GDP, it also reduces the level of the debt and the cost of servicing it, contributing to a lower consumption tax to finance the demographic transition.

It is important to emphasize that the looming fiscal adjustments arise from two sources. First, the exogenous demographics of a rapidly aging society lead to an economy in which there are "too few" workers to pay for the pensions and health expenses of "too many" retirees. In addition, there is a second, endogenous force in general equilibrium. This mechanism is the increase in the wage rate in response to the predicted increase in the capital-labor ratio in Japan, until about 2050. The labor supply is projected to decline monotonically post-2100. The capital stock, on the other hand, is predicted to have an inverted-U shape, rising for 10-20 years with the stronger life cycle saving motive on the part of the workers facing extended retirement lives. But as the dependency ratio keeps rising, the capital stock eventually starts to call with the diminished number of savers as opposed to dissavers. The combination of movements in the capital stock and labor supply leads to an inverted-U shape in the capital-labor ratio that tops out around 2050 and converges to a level still much higher than that in 2014.

To be more concrete, the capital-labor ratio rises 73% from 2014 to 2050 and then falls after 2050 but it is still 56% higher in 2100 than its level in 2014. The impact on the wage rate is an increase of 23% by 2050 and the leveling off results in a wage still 18% higher in 2100 than its level in 2014. Since pensions are partially tied to wages, this general equilibrium effect adds significantly to the fiscal burden already created by the "numbers game" of an older society. Our partial equilibrium exercise turns this second channel off and our results suggest that this effect is quantitatively quite large.

Table 5: Consumption Tax Rate under Partial Equilibrium

	Baseline		PE Experiments			
	GE	PE	Exp 1	Exp 2	Exp 3	Exp 4
2015	8.17	11.35	11.10	10.86	10.86	10.38
2020	10.24	12.96	12.56	12.17	12.16	11.38
2030	13.95	14.93	14.63	14.34	14.32	13.74
2040	21.88	19.76	19.41	19.06	19.04	18.34
2050	28.94	22.71	22.29	21.89	21.87	21.06
2060	34.20	24.83	24.36	23.90	23.88	22.96
2070	36.41	25.55	25.01	24.48	24.45	23.41
2080	35.75	24.65	24.04	23.45	23.42	22.27
2100	35.98	24.69	23.91	23.16	23.13	21.67
∞	11.73	9.15	8.16	7.23	7.17	5.41

Although the level of consumption taxes are significantly lower for these reasons, the effects of the guest worker policies are qualitatively the same. The effects are also similar quantitatively, though the fiscal savings through the introduction of guest workers are somewhat smaller since the tax contributions of guest workers are smaller with a lower market wage rate under PE.

6.2 An extended guest worker program: "immigration"

In the guest worker experiments studied above, we assume that foreigners arriving in Japan are required to return in 10 years. In this section, we run the experiments assuming that the Japanese government allows foreigners to stay much longer and they eventually become permanent residents. We continue to let foreign-born workers arrive in Japan at the age of 35. Instead of having them leave in 10 years, we assume that they do not return to their home countries and live in Japan up to the male life-expectancy, which we set to 70.[20] We assume that they will follow the same pattern of labor force participation by age as the Japanese natives for the remainder of their life.

We maintain the assumption that they pay the labor income and consumption taxes, but do not pay the pension premia nor receive benefits. The government pays 50% of the medical expenditures incurred for each native person. As before, we abstract from the effects of children of foreign workers.[21]

The paths of the consumption taxes are summarized in Table 6. Compared to the consumption tax rates under the 10-year guest worker programs presented in Table 3, the tax rates are not very different during the initial few decades. Once, however, the initial

[20]We set the life-expectancy to 70, taking into account the range of male life-expectancies of major countries that have foreign workers in Japan, such as China (74), Brazil (70) and the Philippines (65).

[21]If we allow for the possibility of foreigners having children and assume that their offsprings are identical to the native Japanese economically, then it is equivalent to increasing fertility rates. The effects of such experiments are studied in more detail in İmrohoroğlu, Kitao, and Yamada (2014).

waves of guest workers reach the 10th anniversary and stay in Japan beyond 10 years, the difference becomes larger since the stock of foreigner-born workers continues to rise and they contribute to the budget through the payment of labor income and consumption taxes. By 2100, the consumption tax rates would be lower by 3 to 10 percentage points compared to the 10-year guest worker programs. We note, however, that we abstracted from the children of those foreigners and that they could potentially raise the required consumption taxes in the long-run if they become entitled to public transfers in their adulthood including pensions and health insurance benefits. In addition, this policy may face other political and social issues that have to be overcome to a greater degree than the fixed-duration guest worker programs. Nevertheless, the results presented in this extended analysis demonstrate the significant fiscal gains that would be realized through a more aggressive immigration program.

Table 6: Consumption Tax Rate under Extended Guest Worker (Immigration) Program

	Baseline	Exp 1	Exp 2	Exp 3	Exp 4
2015	8.17	8.07	7.96	7.96	7.75
2020	10.24	10.01	9.77	9.77	9.29
2030	13.95	13.31	12.68	12.66	11.45
2040	21.88	20.61	19.41	19.35	17.10
2050	28.94	27.12	25.45	25.29	22.20
2060	34.20	31.82	29.68	29.50	25.62
2070	36.41	33.52	30.97	30.75	26.22
2080	35.75	32.46	29.59	29.35	24.36
2100	35.98	31.77	28.23	27.93	22.00
∞	11.73	7.91	4.84	4.43	-0.53

7 Conclusion

The Japanese economy is seen as struggling, due to little growth since 1990, and diminishing, because the working age population has started to decline rapidly. Projections of future fertility rates and survival probabilities indicate a severe reduction in both total and working age population. Among the options to mitigate the effects of this demographic transition in Japan is a new immigration policy. In this paper, we construct a general equilibrium model and evaluate various guest worker programs. The two key aspects of a successful program that helps achieve fiscal sustainability are (i) the size of the guest worker or immigration program as this directly increases the tax base, (ii) the skill level of the guest workers and immigrants.

A guest worker program that brings 200,000 foreign born and unskilled workers to Japan for 10 years allows a smaller increase in the consumption tax rate, by 3 percentage points, than that in the baseline cse. If the program targets skilled guest workers so that their mean earnings equal those of native born workers, then the gains are more than 5 percentage in consumption taxes. In addition, there are significant welfare gains for

all native born workers, about 2% of consumption each year for working age workers but smaller gains for retirees in the case of high-skilled guest worker policy. Gains are larger for future generations, exceeding 4% of consumption in the long-run, because of the smaller consumption tax rate increases needed to finance rising public expenditures due to demographic aging. A larger-scale U.S.-style guest worker program brings the foreign born workers' share in total employment to 16.4% in 10 years and maintains this ratio forever. The benefits are huge: the consumption tax is now significantly lower by 5 to 10 percentage points, relative to baseline transition. The welfare gains are even larger: 2 to 9% of consumption. Finally, if the Japanese government manages to prevent the increase in the capital-labor ratio between now and 2050 (as in our partial equilibrium case) and thereby prevents the buildup of pension payments, or, it starts a larger immigration program (as in the extended immigration case), then the needed increase in the consumption tax rate to achieve fiscal sustainability is very small. There are clear and substantial economic benefits from a guest worker or immigration program, especially one that targets high-skilled workers.

The political economy of a guest worker or immigration program, however, is less clear and often a sensitive topic to be discussed. Historically, Japan has been insular concerning immigration. Given the projected increases in public expenditures caused by aging, our quantitative results suggest that a guest worker program ought to be one of the policy options on the table more open to discussion.

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A Computation of equilibrium

Denote the net-of-taxes gross interest rate as

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

From the FOC with respect to asset holdings next period, we obtain

$$\frac{c_{j+1,t+1}}{c_{j,t}} = \left[\beta \frac{1+\tau_{c,t}}{1+\tau_{c,t+1}} R_{t+1}\right]^{1/\theta} \equiv g_{t+1}, \tag{6}$$

which is the optimal growth rate of consumption between any age j and $j+1$ and between time t and $t+1$. Iterating on (6), we obtain

$$c_{j+1,t+j} = c_{1,t} \prod_{k=1}^{j} g_{t+k}. \tag{7}$$

The discounted present value of the total (gross of taxes) lifetime consumption of an individual of age 1 at time t can be expressed as

$$\bar{c}_{1,t} = c_{1,t} \left[(1+\tau_{c,t}) + \sum_{j=1}^{J-1} (1+\tau_{c,t+j}) \prod_{k=1}^{j} \frac{s_{k,t+k-1}}{R_{t+k}} g_{t+k}\right]. \tag{8}$$

Denote by $\widetilde{x}_{j,t}$ earnings of an individual of age j at time t net of transfers, lump-sum taxes, and pensions, that is,

$$\widetilde{x}_{j,t} = \widetilde{y}_{j,t} + tr_t + p_{j,t}.$$

The discounted present value of the total (net of taxes) lifetime earnings of an age-1 individual at time t is

$$\bar{x}_{1,t} = \widetilde{x}_{1,t} + \sum_{j=1}^{J-1} \left(\prod_{k=1}^{j} \frac{s_{k,t+k-1}}{R_{t+k}}\right) \widetilde{x}_{j+1,t+j}. \tag{9}$$

Since individual optimization requires $\bar{c}_{1,t} = \bar{x}_{1,t}$, from (8) and (9),

$$c_{1,t} = \frac{\bar{x}_{1,t}}{\left[(1+\tau_{c,t}) + \sum_{j=1}^{J-1}(1+\tau_{c,t+j}) \prod_{k=1}^{j} \frac{s_{k,t+k-1}}{R_{t+k}} g_{t+k}\right]}.$$

The path of the individual's consumption $\{c_{j,t+j-1}\}_{j=1}^{J}$ is computed from (7) and the assets at each age are computed recursively by the flow budget constraint (2).