The Dynamic Effects of Changes to Japanese Immigration Policy *

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Abstract

This paper uses a single-sector dynamic stochastic general equilibrium (DSGE) model with heterogeneous households to analyze Japanese immigration policy. We examine the effects on output, consumption, factor prices, and utility. We do this for both steady states and for transition paths. We find that: 1) Aggregate output, investment, and consumption in Japan are likely to rise with any sort of loosening of immigration restrictions. 2) Allowing more skilled immigration generates greater aggregate changes. 3) Increasing (decreasing) skilled immigration relative to unskilled immigration drives down (up) skilled wages, consumption, and utility. 4) The effects of changes to immigration policy are small when compared to the changes that occur naturally due to business cycle fluctuations.

keywords: labor migration, factor mobility, dynamic general equilibrium, Japan, immigration

JEL classification: F15, F22, F42

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1 Introduction and Literature Review

Immigration issues create tough political problems for policy makers. Confronting the question of whether to allow workers from low wage countries to migrate to high wage countries generates constant domestic and international political debate. Western Europeans struggle with the optimal number of workers from Eastern Europe, North Africa, and the Middle East. Americans confront issues of immigration from Mexico and other parts of Latin America, as well as from China and other countries in Asia.

While immigration issues have not loomed so large in Japan, its aging population and low birthrates have led to debate on the wisdom of allowing more foreign workers into the country. Such immigration would likely help Japanese firms and capital owners but could also hurt Japanese workers.

Japan has, until very recently, strictly limited immigration. Currently Japanese immigration law favors skilled workers and those with Japanese ancestry. This stems from concerns with possible links between low wage workers and crime. There is no consensus at the current time on whether immigration restrictions should be eased or not. Advocates of the status quo argue that available jobs can largely be filled by Japanese workers.[1] Advocates of increased immigration argue that Japan's demographics demand an increase in immigration to fill job openings and support an increasingly older population.

In June, 2018 the Japanese government announced plans to allow increased employment of foreign workers. While avoiding permanent immigration, the change would allow up to 500,000 foreigners to live and work

[1] For example, see Ogawa (2004).

in Japan for up to five years. This change seeks to fill unskilled jobs in which domestic workers have little interest. New immigrants are expected to make up for employment shortfalls in nursing care, construction, agriculture, lodging, and shipbuilding[2].

Some observers of Japan's immigration policy argue that, rather than increases or decreases in immigration quotas, the government needs to focus on consistent enforcement of a simple set of immigration rules. [3]

In this paper, we examine the effects of broad changes to immigration policy in Japan. We build and calibrate a single-sector dynamic stochastic general equilibrium (DSGE) model and consider changes in the supply of both unskilled and skilled labor. We are interested in the effects these policy changes will induce on the welfare of existing domestic workers and on aggregate output, consumption, and other key measures of economic activity.

We find that immigration raises overall consumption per capita (including the immigrants as a class) by the largest amount when the share of skilled labor in immigration is highest. This finding provides some support for the government's policy of favoring skilled immigration, though our analysis implies that unskilled immigration can also help the economy.

This paper is not the first to examine these issues using formal models. Goto (1998) builds and calibrates a small open computable general equilibrium (CGE) model for Japan. He groups goods into three categories: exportable, importable, and non-traded. Rather than aggregating into a single final good, he allows each of these to enter the utility function separately. Since the model is not explicitly dynamic, he holds capital in each production

[2]See Shigeta (2018)
[3]See Kuwahara (2004) and Tezuka (2004).

sector constant. Labor, however, is homogeneous and mobile across sectors. Goto examines the effects of several shocks having to do with changes in trade and international prices. His most interesting result is that small amounts of labor immigration reduce welfare, while sufficiently large amounts may improve welfare.[4]

Choi (2004) builds a static general equilibrium model of the South Korean economy. His model is similar in spirit to ours but has important differences. He allows for imperfect competition in intermediate goods which are produced using sectorally-mobile capital and skilled labor that is specific to that particular intermediate good. Final goods are perfectly competitive and produced with capital and unskilled labor. Choi focuses on the welfare effects of easing immigration restrictions and is concerned primarily with behavior in the short run as a result of business cycle movements. He reports the effects of various business cycle shocks to the economy on welfare and wage inequality. The result most relevant is that immigration biased towards skilled labor yields the greatest welfare gains.

Dekle (2004) uses a modified Ramsey growth model to assess how allowing 400,000 immigrants per year from 2000 to 2040 would affect the fiscal strain imposed by Japan's aging population. (This article does not explore other immigration scenarios.) This article finds that allowing such a large number of immigrants would boost GDP 50% by 2040 but would not do much to

[4]This result comes the fact that his model has trade barriers. Immigration with trade barriers can lower welfare if those immigrants work in the trade protected sector, since that can reduce imports and thus tariff revenues. While immigrants certainly bring gains to the economy, it turns out that the reduced tariff revenue effect dominates with small numbers of immigrants. As the amount of immigrants increases, their positive effect increases while the negative tariff effect does not change much. So, beyond a certain point, a larger number of immigrants benefits the nation, even with trade barriers.

relieve the fiscal strain of Japan's aging. Those immigrants would only cut the tax rate needed to fund 2040 Social Security from 49% to 45%.

Shimasawa and Oguro (2010) construct a multi-sector CGE model with overlapping generations (OLG) and consider the dynamic effects of both increased immigration and an increase in the consumption tax for Japan. They find "...that substantially increased inflows of working-age immigrants would alleviate the need for future fiscal reform and also help to dramatically reduce the public pension burden on the working generations." Their model includes demographic dynamics within each of the sixteen countries in the model and derives a world general equilibrium, rather than making a small open economy assumption with a single country.

Imrohoroglu et al. (2017) also use an OLG model to analyze how expanded immigration can help alleviate Japan's fiscal burden caused by a shrinking population. Their model, like ours, is a one-sector macro model for Japan only. Their OLG framework allows them to give a realistic and insightful assessment of the welfare and fiscal impacts of expanding Japanese immigration. They simulate various versions of guest worker programs, as well as a boost in permanent immigration. Their model, though, only has one type of labor, thus preventing them from analyzing how allowing different skill mixes of immigrants would affect Japan. They do shed some light on this by considering two scenarios for the productivities of immigrants: half as productive as natives and equally productive. The former scenario resembles low-skilled immigration only, while the latter, high-skilled immigration only. They cannot, though, assess different skill mixes of immigrants. They acknowledge in footnote 14 that allowing for different skill levels would be an important next step. Our model does just that.

In contrast to the literature mentioned above, this paper uses the tools of dynamic stochastic general equilibrium (DSGE) modeling. It is similar in spirit to Phillips (2012), which modeled immigration in South Korea. That model, though, considered many intermediate sectors and did not allow for international borrowing and lending.

In this paper, we focus on the long-run transition to a new steady state equilibrium. Business cycle movements are important only because they add uncertainty and volatility to this transition. By incorporating these shocks, though, we are able to present not only impulse responses of key variables to immigration shocks but also derive confidence bands about these responses.

Section 2 below presents the model and shows how it can be rendered stationary and suitable for finding a steady state. In Section 3, we discuss calibration of the model. In Section 4, we discuss possible policy changes and resulting steady states. Our policies differ in the mix of skilled and unskilled workers that are allowed to immigrate. We simulate the various policy options and derive both smooth transition paths as well as paths with confidence bands for the key variables considered. Section 5 concludes the paper.

2 The Model

We construct a small open economy single sector DSGE model. Our model allows for a single final good (Y) which is used for consumption (C) and investment in capital goods. This final good is produced using capital (K)

and two types of labor: skilled (L_S) and unskilled (L_U). Both types of labor are supplied in fixed endowments. Physical capital is non-traded and accumulates optimally over time. Households may save or borrow internationally, and the balance of payments sums to zero each period.

2.1 Households

There are four types of representative households: skilled and unskilled domestic households, and skilled and unskilled immigrant households. Domestic households have access to savings and credit markets, while immigrant households do not and must consume whatever they earn from wages each period.

We first discuss the decision problem for the domestic skilled household. The analysis for the domestic unskilled household is analogous, as mentioned below. Each period, the domestic skilled household maximizes utility, supplies capital and labor, and saves by holding physical capital and real savings assets. They solve the Bellman equation below, subject to the budget constraint in (2.1).[5]

$$V(K_S, B_S; \Theta) = \max_{K'_S, B'_S} L_{SD} \frac{C_{SD}^{1-\gamma} - 1}{1-\gamma} + \beta E\{V(B'_S; \Theta')\}$$

$$C_{SD} = w_S + (1 + r - \delta)\frac{K_S}{L_{SD}} + (1 + s_S)\frac{B_S}{L_{SD}} - \frac{K'_S}{L_{SD}} - \frac{B'_S}{L_{SD}} \tag{2.1}$$

In these equations, K is holdings of physical capital, B is holdings of real

[5]When $\gamma = 1$, we use the limiting case, and let the utility of consumption be $\ln C_{SD}$.

financial assets, and Θ is an information set which includes: w_S, the wage for skilled labor, r, the gross return on capital, and s_S, the return on savings for a skilled worker. L_{SD} is the total number skilled domestic workers, and C_{SD} is consumption per household member. We use a constant relative risk aversion utility function, with risk parameter γ. β is the subjective discount factor, and δ is the rate of capital depreciation. A prime denotes next period's value.

The Euler equations are:

$$C_{SD}^{-\gamma} = \beta E\{{C'_{SD}}^{-\gamma}(1 + r' - \delta)\} \tag{2.2}$$

$$C_{SD}^{-\gamma} = \beta E\{{C'_{SD}}^{-\gamma}(1 + s'_S)\} \tag{2.3}$$

The equivalent equations for the unskilled domestic household are shown below.

$$C_{UD} = w_U + (1 + r - \delta)\frac{K_U}{L_{UD}} + (1 + s_U)\frac{B_U}{L_{UD}} - \frac{K'_U}{L_{UD}} - \frac{B'_U}{L_{UD}} \tag{2.4}$$

$$C_{UD}^{-\gamma} = \beta E\{{C'_{UD}}^{-\gamma}(1 + r' - \delta)\} \tag{2.5}$$

$$C_{UD}^{-\gamma} = \beta E\{{C'_{UD}}^{-\gamma}(1 + s'_S)\} \tag{2.6}$$

Immigrant housholds are hand-to-mouth consumers and their behavior is described by the two budget constraints below.

$$C_{SI} = w_S \tag{2.7}$$

$$C_{UI} = w_U \tag{2.8}$$

2.2 Firms

Production is given by equation (2.9).

$$Y = \left[aK^{\frac{b-1}{b}} + (1-a)W^{\frac{b-1}{b}}\right]^{\frac{b}{b-1}} \tag{2.9}$$

Final good producers maximize profit from hiring capital and both types of labor and selling the final good, as shown in the profit equation below.

$$\underset{K,N_S,N_U}{\text{Max}} \ \Pi = \left[aK^{\frac{b-1}{b}} + (1-a)W^{\frac{b-1}{b}}\right]^{\frac{b}{b-1}} - rK - w_S N_S - w_U N_U$$

with N_S and N_U denoting the demands for skilled and unskilled labor and,

$$W = e^{z+gt}\left[c(fN_S)^{\frac{d-1}{d}} + (1-c)N_U^{\frac{d-1}{d}}\right]^{\frac{d}{d-1}} \tag{2.10}$$

where z is a stochastic deviation from trend to labor-augmenting productivity, and gt is the long-run trend in that productivity, with g denoting the constant trend growth rate.

We use a CES production function that has nested in it a CES labor aggregate. Here, W is a composite labor input, and technology is labor augmenting. f is the relative productivity of skilled labor over unskilled labor.

The first-order conditions reduce to equations (2.11) through (2.13).

$$r = a(\tfrac{Y}{K})^{1/b} \tag{2.11}$$

$$w_S = f(1-a)(\tfrac{Y}{W})^{1/b} c(\tfrac{W}{N_S})^{1/d} e^{gt+z} \tag{2.12}$$

$$w_U = (1-a)(\tfrac{Y}{W})^{1/b}(1-c)(\tfrac{W}{N_U})^{1/d} e^{gt+z} \tag{2.13}$$

2.3 Financial Sector

Banks extend loans or accept deposits from domestic households. These funds are used to purchase foreign capital which returns a rate of s. As in Schmitt-Grohe and Uribe (2003), we assume that banks limit the amount of credit available by charging a higher interest rate the more a household has borrowed and offering a lower rate the more it has saved relative to some target amount. We let this target vary according to household labor income. This gives us a unique allocation of assets between the two types of domestic households. We show this with the following returns functions.

$$s_S = \bar{s}^* - \nu \frac{B_S}{w_S} \tag{2.14}$$

$$s_U = \bar{s}^* - \nu \frac{B_U}{w_U} \tag{2.15}$$

where $\bar{s}^*$ is a fixed foreign rate of return, and ν is the responsiveness of household interest rates to debt.

For simplicity, we assume that banks are foreign-owned, which means that any profits have no wealth effects on Japanese households.

2.4 Market Clearing

All markets must clear and this imposes additional restrictions on the model. Physical capital and labor are not traded internationally.

The capital markets clear as shown below.

$$K_S + K_U = K \tag{2.16}$$

$$B_S + B_U = B \tag{2.17}$$

The labor market clearing conditions are that labor demand equal the number of workers for each type.

$$N_S = L_{SD} + L_{SI} \tag{2.18}$$

$$N_U = L_{UD} + L_{UI} \tag{2.19}$$

The balance-of-payments condition is (2.20).

$$X + sB + (B - B') = 0 \tag{2.20}$$

The first two terms are the current account (net exports plus net factor income) and the last term is the capital account (net change in holdings of international assets).

Equations (2.1) through (2.20) are a system of dynamic equations that define the behavior of the economy over time.

2.5 Exogenous Shock Process

We assume that deviations of labor-augmenting technology from the long-run growth rate of g follow an autoregressive process.

$$z' = \rho z + \varepsilon;\ \varepsilon \sim iid(0, \sigma^2) \tag{2.21}$$

2.6 A Stationary Version

We can render the model stationary by redefining variables. Equation (2.10) shows that technology is growing with a trend growth rate of g. Hence we can transform all growing non-utility variables $(K, B, F, w_U, w_S, Y, C, X\ )$ by dividing them by e^{gt}. We denote transformed variables by placing a carat over them.

This transformed system of equations is given in Appendix A2 by (A.1) through (A.20).

3 Calibration

Equations (A.1) through (A.20) are a stationary system. We can find the steady state of this system by replacing the variables in these equations with their steady state values. These will depend on the parameter values chosen. Our parameters are: β, δ, γ, g, a, b, c, d, f, L_{SD}, L_{UD}, L_{SI}, L_{UI}, $\bar{s}^*$ and ν. We explain our choice of parameter values below.

Our model is simulated with one period corresponding to one quarter of calendar time. This means that while we quote annual rates for variables like the depreciation rate (δ), and the subjective rate of time preference (β, we actual use the quarterly equivalents during our simulations.

The annual depreciation rate δ is set to 11.31%, the average of the implied rate consistent with a capital stock measure constructed by the perpetual inventory method from IMF real investment data and a direct measure of Japanese capital from the Federal Reserve Economic Database. We use the period 1995 to 2014.

γ is the coefficient of relative risk aversion. We set this to 2.5, a value often used in the business cycle literature.

The annual growth rate of technology, g, is set to zero, which is the average value for the growth of TFP in Japan over the period 2000 to 2014.[6]

The average international real interest rate ($\bar{s}^*$) is set to .6043%. This is the average value of the real return on five-year inflation-indexed bond in U.S. for the period 2003 to 2016. We use an annual subjective discount factor (β) of .9940 that is consistent with the steady state version of (2.6); i.e. $\beta = 1/(1 + \bar{s}^*)$.

We set a, the capital share in national income, to .38, the average post-war value. c is the share of skilled worker's total compensation in total labor compensation for 2014. This data come from Japanese Ministry of Health, Labor and Welfare.

Based on the findings of Pessoa et al. (2005) and Behar (2010), we set the elasticities of substitution, b and d, to 0.7 and 2.0, respectively.

f is the relative effectiveness of skilled workers. We choose this by taking the ratio of total compensation per skilled worker and dividing it by the

[6]This means that our system is stationary without adjustment. We have allowed for the possibility of positive growth in theory, even though it turns out to be unnecessary for the period over which we simulate.

total compensation per unskilled worker. This value is 3.24 in the 2014 data. $f = 1.817$ sets the steady state ratio of skilled to unskilled wages to this value.

We set the total number of workers in the baseline to one. Relative amounts of unskilled labor and skilled labor (L_{SD} and L_{UD}) are obtained using data from the Japanese Ministry of Health, Labor and Welfare for 2014. We use the percent of the workforce ages 15 or older with an advanced education[7] as our measure of of skilled labor. This percentage is 23.25%. The baseline values of L_{SI} and L_{UI} are set to values that yield the same skilled to unskilled ratio as the rest of the population and that give a foreign population of 1.24%. These values change as immigration policy changes.

The parameter ν is set to .81 so that the ratio of $\bar{B}$ to $\bar{Y}$ equals the average value of -6.51% over the period 1980 - 2015,

The values of all baseline parameters adjusted to their quarterly values where applicable are reported in Table 1.

Table 1: Summary of Baseline Parameters Adjusted to Quarterly Values

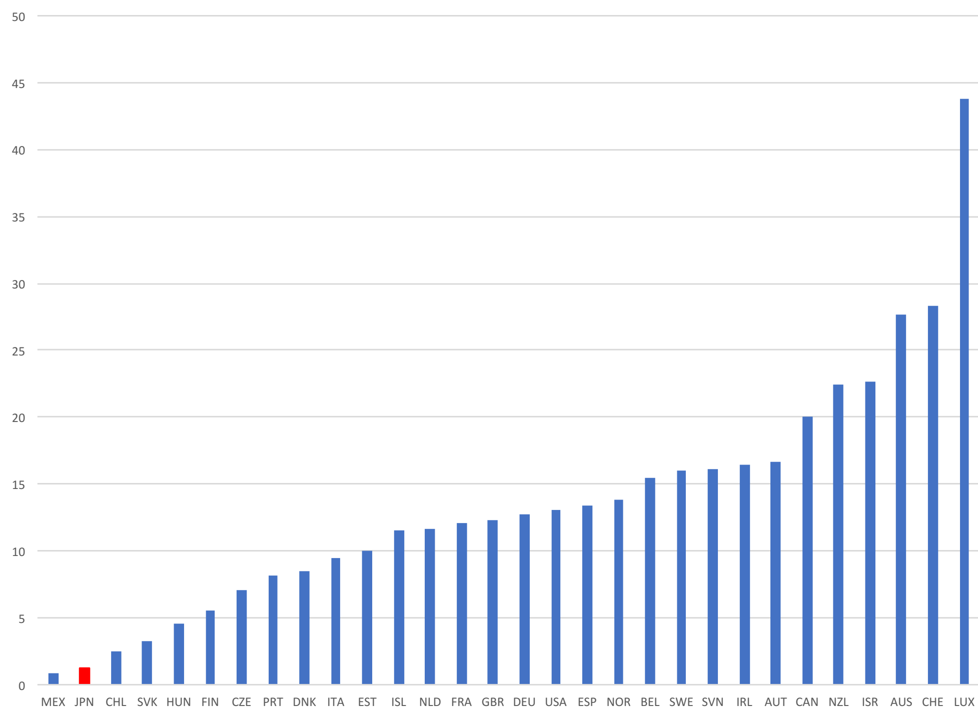
β	0.9985	a	0.38	L_{SD}	0.2296
δ	0.0283	b	0.7	L_{UD}	0.7580
g	0	c	0.4952	L_{SI}	0.0029
ν	0.81	d	2.0	L_{UI}	0.0095
f	1.187	$\bar{s}^*$	0.001511	γ	2.5

[7]Defined as graduates of universities, versus graduates from junior high schools, senior high schools, and higher professional schools or junior colleges.

4 Policy Experiments

We use the model to simulate how expanded immigration would affect the Japanese economy. We allow for expansions of unskilled immigration, skilled immigration, or mixtures of the two, as described below.

Figure 1: Foreign Population as a Percentage of the Total Population, 2000



Sources: OECD and Statistics Japan

As Figure 1 shows, the percentage of foreign residents to the total population is quite low in Japan compared to other developed countries. This number was 1.24% in 2013 and is around 2% as of 2018. By contrast, it was 13.08% for the United States, 12.04% in France, 12.78% for Germany and 12.26% in Great Britain. We consider a change in immigration policy that raises the percentage from its current value to 5%. This is about half of the normal value for other large developed economies. This corresponds to new immigration equal to 3.76% of the existing population. The policies we consider differ only in the mix of labor types allowed to immigrate.

i. We first consider a case (UN) where only unskilled labor is allowed to immigrate.

ii. Secondly, we consider a case (PR) where both skilled and unskilled labor are allowed to immigrate in the same proportions as the current labor force.

iii. Third, we consider a case (EQ) where both types of labor can immigrate, but skilled labor is given a priority. We allow equal numbers of workers of both types to enter the country, but since there are more unskilled workers in the workforce already, this leads to smaller percentage increases for unskilled labor.

iv. A fourth scenario (SK) is to allow only skilled labor into a country.

4.1 Steady States

The steady state values for the baseline case and the four different immigration cases are presented in Table 2. Several interesting patterns emerge from this table. First, greater increases in skilled immigration lead to greater increases in capital and output. The ranking from lowest to highest is: 1) unskilled only, 2) proportional, 3) equal, and 4) skilled only.

Second, as the mix of immigration moves from unskilled to skilled labor, skilled wages fall and unskilled wages rise, as one would expect. This also causes consumption by skilled labor to fall, while that of unskilled labor rises as skilled immigration becomes more predominant. This is true for both consumption by domestic and foreign households.

Finally, welfare (as measured by utility levels) rises for unskilled households and falls for skilled households as the mix of new immigrants becomes more skilled.[8] Again this is for both domestic and foreign households. We include the weighted average utility over our four household types (denoted $\bar{U}$) as a rough measure of overall welfare gains or losses. These gains are largest for skilled immigration.

All these results are for the steady state, to which the economy will trend in the long-run. However, the long-run can be very far in the future and policy makers may well be interested in changes in output, consumption, and wages along the transition path to this new steady state.

We now turn to these transition paths.

[8] Since utility is not bounded below at zero, percent changes are meaningless. We report simple differences instead.

Table 2: Steady State Changes Relative to Baseline
5% Immigrants

Variable	UN	PR	EQ	SK
K	2.821%	3.787%	5.395%	**6.665%**
Y	2.821%	3.787%	5.395%	**6.665%**
w_S	**1.401%**	-0.040%	-2.087%	-4.179%
w_U	-0.995%	0.029%	1.576%	**3.279%**
C_{SD}	**1.715%**	0.392%	-1.486%	-3.440%
C_{UD}	-1.276%	-0.328%	1.112%	**2.734%**
C_{SI}	**1.401%**	-0.040%	-2.087%	-4.179%
C_{UI}	-0.995%	0.029%	1.576%	**3.279%**
U_{SD}	**0.0048**	0.0011	-0.0043	-0.0102
U_{UD}	-0.0220	-0.0056	0.0186	**0.0448**
U_{SI}	**0.0040**	-0.0001	-0.0063	-0.0129
U_{UI}	-0.0172	0.0005	0.0263	**0.0536**
$\bar{U}$	-0.0340	-0.0131	0.0168	**0.0494**

UN - unskilled only immigration
PR - proportional immigration
EQ - Equal amounts of immigration
SK - skilled only immigration.
Note: bold text indicates the highest increase across policies.

4.2 Transition Paths

We approximate the policy functions for our model using standard linearization techniques like those from Uhlig (1999) and Christiano (2002). Our endogenous state variables are the set of capital stocks and of savings held by domestic households: $\mathbf{X}_t = \{K_S, K_U, B_S, B_U\}$. Our set of exogenous state variables is denoted $\mathbf{Z}_t$. Following the discussion in section 2, we let this be a shock to productivity (z) with the law of motion given in (2.21).

Linearization leads to an approximate policy function of the following form, which can be used to simulate the model over time if a law of motion for $\mathbf{Z}_t$ is specified.

$$\mathbf{X}_{t+1} - \bar{\mathbf{X}} = \mathbf{P}(\mathbf{X}_t - \bar{\mathbf{X}}) + \mathbf{Q}(\mathbf{Z}_t - \bar{\mathbf{Z}}) \tag{4.1}$$

where a bar over a variable set indicates the steady state values of that set. $\mathbf{P}$ and $\mathbf{Q}$ are linear coefficient matrices. In our case $\mathbf{P}$ is a 4×4 matrix, since $\mathbf{X}_t$ is a 4×1 vector. $\mathbf{Q}$ will be a $4 \times n_z$ matrix, where n_z is the number of terms in $\mathbf{Z}_t$.

4.2.1 Expected Transition Paths

To examine the transition of our model economy from the current steady state to a new one, we assume our economy is initially in the baseline steady state, where the economy remains until something changes. When policy is changed in some period t_0, the economy will slowly converge to the new steady state.

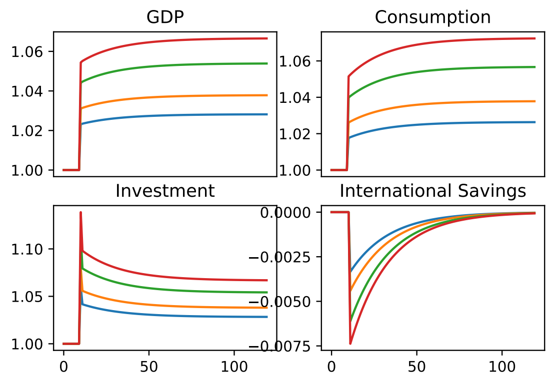
We first simulate this with no aggregate shocks by setting $\mathbf{Z}_t$ equal to zero in all periods in equation (4.1). We consider a change in policy that occurs in period 10. This gives a lag of two and a half years between the announcement of a policy change and the actual change in policy. Since we start off in the steady state for the baseline, we remain there until period 10. The simulation then converges over time from period 10 onward to the new steady state associated with the changed immigration policy.

Figure 2 panel 1 shows the transition paths of GDP, private consumption, investment, and the international financial account over each scenario. Panel 2 shows the transition paths of factor prices. Panel 3 shows utilities for the four types of households. In the case of all variables except international savings, we show the values over time relative to the initial steady state. With international savings, since the values can be positive or negative, we show the actual values over time.

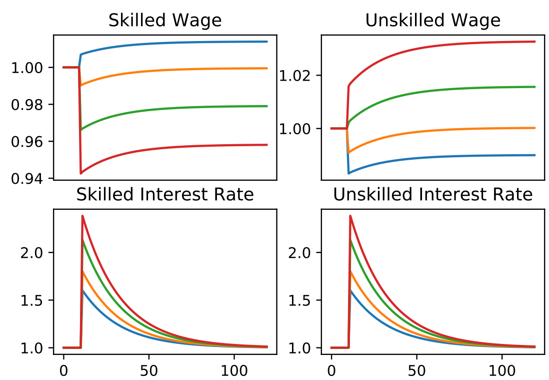
We find the same general patterns along the transition paths as we do in the steady states. That is, the larger effects come from allowing greater proportions of skilled immigrants.

Figure 2: Transition Paths for Aggregate Variables
5% Immigrants Policy

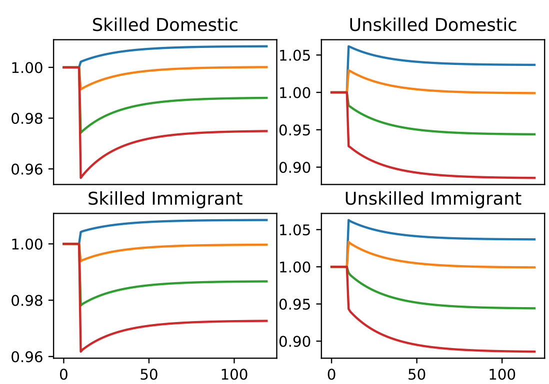
Aggregates



Factor Prices



Utility Levels



UN - blue, PR - orange, EQ - green, SK - red

4.2.2 Transition Paths with Aggregate Shocks

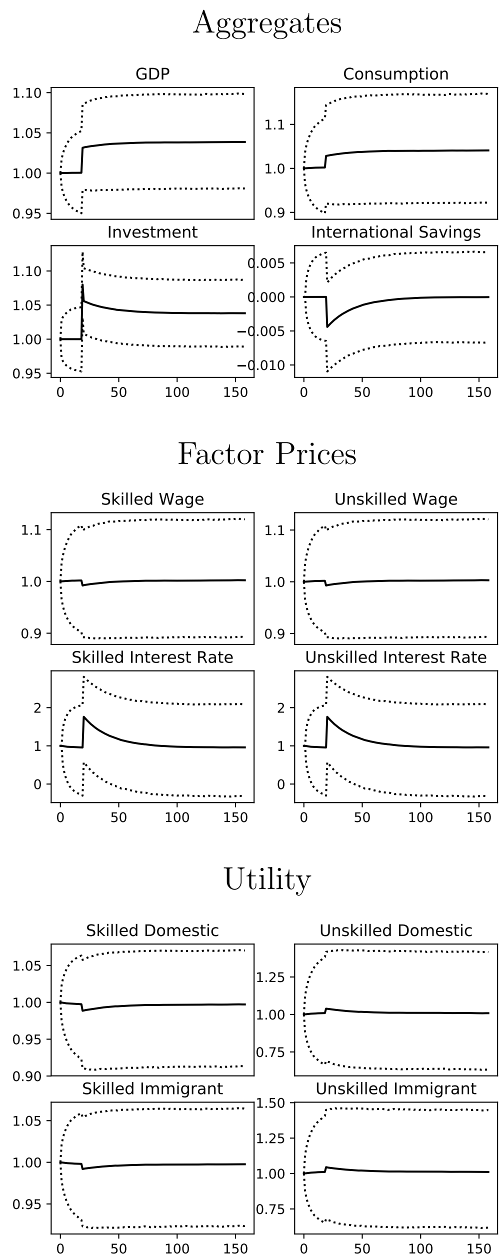
Figure 2 shows the path of variables in the face of an unexpected policy change with no aggregate shocks. It is useful for comparison purposes to see how large the variable changes caused by policy are relative to the changes due to natural fluctuations in the business cycle. To examine this question we simulate our model with a series of random draws to the $\mathbf{Z}_t$ process in equation (4.1) (which corresponds to z in section 2).

We consider a change in immigration policy that occurs suddenly and unexpectedly in five years. We simulate our model economy for 40 years and perform 100,000 simulations. For each period in our 100,000 simulations we sort each variable in the model from highest to lowest across all the simulations. We then take the 5% and 95% values along with the averages over the simulations and plot these for selected variables in Figure 3.

That figure shows the results for a proportional increase in skilled and unskilled immigration; the policy most closely in line with the Japanese government's recent proposal. Similar figures for our other three policies are presented in Appendix A3.

All these figures illustrate a common pattern; the effects of immigration reform, even when implemented suddenly and unexpectedly, are small relative to the movement due to the business cycle. Only in the case of investment does the expected path (solid line) even approach the original 90% confidence bands when the reform occurs. For each of these variables, the estimated interval in the long run includes the original value, meaning that we cannot predict with 90% confidence whether the immigration policies simulated will cause any of these variables to go up or down in a world with shocks. We conclude that the effects of loosening immigration restrictions are likely to be unnoticeable against this backdrop. This is particularly true for wages and utility.

Figure 3: Transition Paths for Aggregate Variables
with 90% Confidence Bands
5% Proportional Immigration
100,000 simulations



5 Conclusion

In this paper we constructed a single sector dynamic general equilibrium model for a trading economy in order to examine the dynamic effect of changes to immigration policy. We solved and calibrated our model using data from Japan. We considered four immigration policies, relating to the mix of skilled and unskilled immigration allowed: unskilled immigrants only, proportional increases in both types, equal increases in the number of each type, and skilled immigrants only. We then examined the effects of these policies on output, consumption, factor prices, and utility. We reported steady state changes, as well as the time paths leading to those steady states without shocks to the economy. We also imposed random shocks on the economy to simulate business cycle fluctuations and to get a sense for likely ranges for key variables in a world with such fluctuations.

From these policy experiments, we learn the following:

1) Aggregate output, investment, and consumption in Japan are likely to rise with loosening of immigration restrictions.

2) Allowing more skilled immigration generates greater aggregate changes.

3) Increasing (decreasing) skilled immigration relative to unskilled immigration drives down (up) skilled wages, consumption, and utility.

4) The effects of changes to immigration policy are small when compared to the changes that occur naturally due to business cycle fluctuations. As a result, this analysis implies that it will be hard to detect the effects of immigration policy changes, even ones large enough to expand the

immigrant share to 5% of the population. Also, the longer it takes to phase in such policies, the harder it will be to detect their effects.

APPENDICES

A1 Derivation of Factor Price Equations

In this appendix we derive equations (2.11) - (2.13).

Recall that:

$$\Pi = \left[aK^{\frac{b-1}{b}} + (1-a)W^{\frac{b-1}{b}}\right]^{\frac{b}{b-1}} - rK - w_U N_U - w_S N_S$$

$$W = e^{gt+z}\left[c(fN_S)^{\frac{d-1}{d}} + (1-c)(N_U)^{\frac{d-1}{d}}\right]^{\frac{d}{d-1}}$$

Define the following as equation (2.9).

$$Y = (aK^{\frac{b-1}{b}} + (1-a)W^{\frac{b-1}{b}})^{\frac{b}{b-1}}$$

Differentiating Π with respect to K and setting this to zero:

$$\begin{aligned}
&\frac{b}{b-1}\left[aK^{\frac{b-1}{b}} + (1-a)W^{\frac{b-1}{b}}\right]^{\frac{b}{b-1}-1}\frac{b-1}{b}aK^{\frac{b-1}{b}-1} - r = 0\\
&\left[aK^{\frac{b-1}{b}} + (1-a)W^{\frac{b-1}{b}}\right]^{\frac{1}{b-1}} aK^{-\frac{1}{b}} - r = 0\\
&Y^{\frac{1}{b}}aK^{-\frac{1}{b}} - r = 0\\
&r = a\left(\frac{Y}{K}\right)^{1/b} \qquad\qquad (A.1)\\
&r = a\left(\frac{Ye^{gt}}{Ke^{gt}}\right)^{1/b}\\
&r = a\left(\frac{\hat{Y}}{\hat{K}}\right)^{1/b}
\end{aligned}$$

Differentiating Π with respect to N_U and setting this to zero:

$$
\begin{aligned}
&\frac{b}{b-1}\left[aK^{\frac{b-1}{b}}+(1-a)W^{\frac{b-1}{b}}\right]^{\frac{b}{b-1}-1}\frac{b-1}{b}(1-a)W^{\frac{b-1}{b}-1}\frac{\partial W}{\partial N_U}-w_U=0\\
&(1-a)\left(\frac{Y}{W}\right)^{1/b}e^{gt+z}\frac{d}{d-1}\left[c(fN_S)^{\frac{d-1}{d}}+(1-c)(N_U)^{\frac{d-1}{d}}\right]^{\frac{d}{d-1}-1}\\
&\quad\times\frac{d-1}{d}(1-c)(N_U)^{\frac{d-1}{d}-1}-w_U=0\\
&(1-a)\left(\frac{Y}{W}\right)^{1/b}e^{gt+z}\left[c(fN_S)^{\frac{d-1}{d}}+(1-c)(N_U)^{\frac{d-1}{d}}\right]^{\frac{1}{d-1}}\\
&\quad\times(1-c)(N_U)^{-\frac{1}{d}}-w_U=0\\
&(1-a)\left(\frac{Y}{W}\right)^{1/b}e^{(gt+z)(1-\frac{1}{d})}W^{\frac{1}{d}}(1-c)(N_U)^{-\frac{1}{d}}-w_U=0\\
&(1-a)\left(\frac{Y}{W}\right)^{1/b}(1-c)\left(\frac{W}{N_U}\right)^{1/d}e^{(gt+z)(1-\frac{1}{d})}-w_U=0\\
&\frac{w_U}{e^{gt}}=(1-a)\left(\frac{Y}{W}\right)^{1/b}(1-c)\left(\frac{W}{e^{gt}N_U}\right)^{1/d}e^{z(1-\frac{1}{d})}=0\\
&\frac{w_U}{e^{gt}}=(1-a)\left(\frac{Ye^{gt}}{We^{gt}}\right)^{1/b}(1-c)\left(\frac{W}{N_U}\right)^{1/d}e^{z(1-\frac{1}{d})}=0\\
&\hat{w}_U=(1-a)\left(\frac{\hat{Y}}{\hat{W}}\right)^{1/b}(1-c)\left(\frac{\hat{W}}{N_U}\right)^{1/d}e^{z(1-\frac{1}{d})}=0
\end{aligned}
\tag{A.2}
$$

Similarly, differentiating Π with respect to N_S and setting this to zero yields:

$$\begin{aligned}\frac{w_S}{e^{gt}} &= f(1-a)\left(\frac{Y}{W}\right)^{1/b} c\left(\frac{W}{e^{gt}N_S}\right)^{1/d} e^{z(1-\frac{1}{d})} = 0 \\ \hat{w}_S &= f(1-a)\left(\frac{\hat{Y}}{\hat{W}}\right)^{1/b} c\left(\frac{\hat{W}}{N_S}\right)^{1/d} e^{z(1-\frac{1}{d})} = 0\end{aligned} \tag{A.3}$$

A2 The Stationary Model

$$\hat{K}_S + \hat{K}_U = \hat{K} \tag{A.1}$$

$$\hat{B}_S + \hat{B}_U = \hat{B} \tag{A.2}$$

$$N_S = L_{SD} + L_{SI} \tag{A.3}$$

$$N_U = L_{UD} + L_{UI} \tag{A.4}$$

$$\hat{W} = e^z \left[c(fN_S)^{\frac{d-1}{d}} + (1-c){N_U}^{\frac{d-1}{d}} \right]^{\frac{d}{d-1}} \tag{A.5}$$

$$\hat{Y} = \left[a\hat{K}^{\frac{b-1}{b}} + (1-a)\hat{W}^{\frac{b-1}{b}} \right]^{\frac{b}{b-1}} \tag{A.6}$$

$$\hat{X} = \hat{B}'(1+g) - (1+s)\hat{B} \tag{A.7}$$

$$r = a(\tfrac{\hat{Y}}{\hat{K}})^{1/b} \tag{A.8}$$

$$\hat{w_S} = f(1-a)(\tfrac{\hat{Y}}{\hat{W}})^{1/b} c(\tfrac{\hat{W}}{N_S})^{1/d} e^{z(1-\frac{1}{d})} \tag{A.9}$$

$$\hat{w_U} = (1-a)(\tfrac{\hat{Y}}{\hat{W}})^{1/b} (1-c)(\tfrac{\hat{W}}{N_U})^{1/d} e^{z(1-\frac{1}{d})} \tag{A.10}$$

$$s_S = s - \nu \frac{\hat{B}_S}{\hat{w}_S} \tag{A.11}$$

$$s_U = s - \nu \frac{\hat{B}_U}{\hat{w}_U} \tag{A.12}$$

$$\hat{C}_{SD} = \hat{w}_S + (1+r-\delta)\frac{\hat{K}_S}{L_{SD}} - \frac{\hat{K}'_S}{L_{UD}}(1+g) \tag{A.13}$$

$$\hat{C}_{UD} = \hat{w}_U + (1+r-\delta)\frac{\hat{K}_U}{L_{UD}} - \frac{\hat{K}'_U}{L_{UD}}(1+g) \tag{A.14}$$

$$\hat{C}_{SI} = \hat{w}_S \tag{A.15}$$

$$\hat{C}_{UID} = \hat{w}_U \tag{A.16}$$

$$\hat{C}_{SD}^{-\gamma} = \beta E\{[\hat{C}'_{SD}(1+g)]^{-\gamma}(1+r'-\delta)\} \tag{A.17}$$

$$\hat{C}_{UD}^{-\gamma} = \beta E\{[\hat{C}'_{UD}(1+g)]^{-\gamma}(1+r'-\delta)\} \tag{A.18}$$

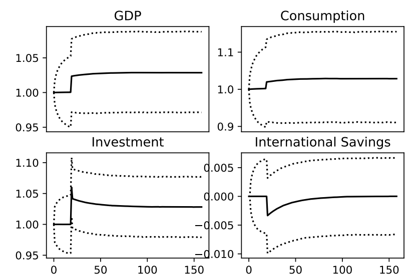
$$\hat{C}_{SD}^{-\gamma} = \beta E\{[\hat{C}'_{SD}(1+g)]^{-\gamma}(1+s'_S)\} \tag{A.19}$$

$$\hat{C}_{UD}^{-\gamma} = \beta E\{[\hat{C}'_{UD}(1+g)]^{-\gamma}(1+s'_S)\} \tag{A.20}$$

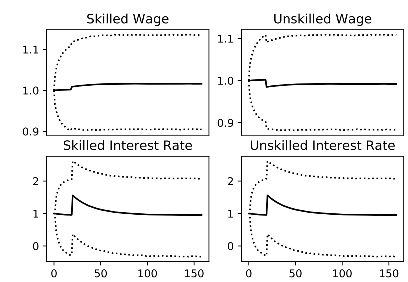
A3 Confidence Bands for Remaining Policies

Figure A.1: Unskilled Immigration

Aggregates



Factor Prices



Utility

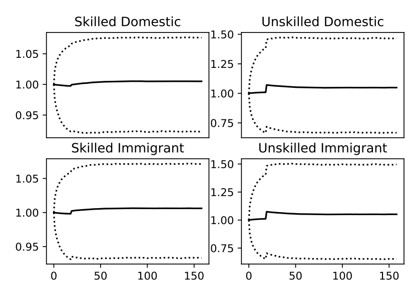
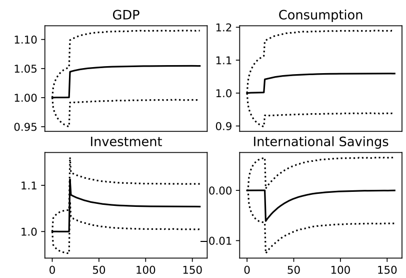


Figure A.2: Equal Immigration

Aggregates



Factor Prices

Utility

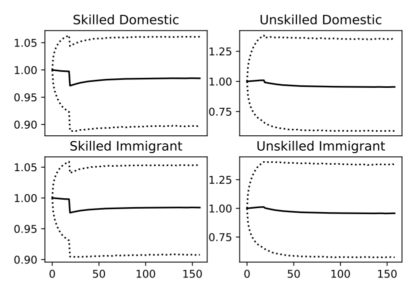
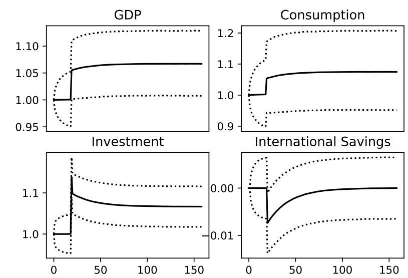


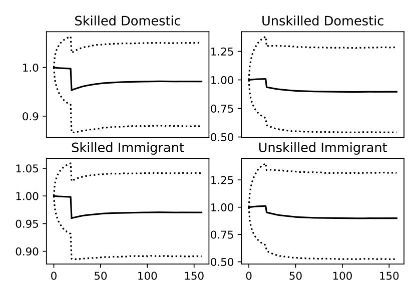
Figure A.3: Skilled Immigration

Aggregates



Factor Prices

Utility



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