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The Impact of Immigrants' Entries on Destination Countries' Economies

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Abstract

Whether immigration brings benefit or harm has always been controversial. In this paper, I develop a Real Business Cycle model with a search-based labor market to examine how an unexpected influx of immigrants impacts destination economies. I divide households and firms into two types, namely natives and immigrants, and conduct a general equilibrium analysis. The simulated results suggest that even though natives face a temporary rise in unemployment after the shock, recovery occurs quickly, and levels of aggregate output and consumption become higher.

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1 Introduction

In 2015, the European Refugee Crisis broke out and the number of asylum applicants exceeded 1.25 million, almost doubling the previous peak which occurred in the 1990s (Pew Research Center, 2016). Similarly in the US, in 2016, the foreign-born population reached a record of 43.7 million, accounting for 13.5 percent of the nation's population. This percentage was very close to the historic high of 14.8 percent in the 1890s, while the absolute number was already a new record (Pew Research Center, 2018b). As massive volume of immigration floods into these countries, media has reported that some natives become more and more concerned about potential rise in their unemployment and reduction in their welfare. Meanwhile, intellectual talents are also brought in and always welcomed as they bring and develop cutting-edge technology. So overall, how does immigration impact destination economies? In this paper, I investigate this question.

Specifically, I explore how an unexpected influx of immigrants affect the nation's production, consumption and investment, in addition to its employment level and job matching. I derive a Dynamic Stochastic General Equilibrium (DSGE) model with a search-based labor market. I label households and firms as natives or immigrants, and examine how the economy fluctuates when a shock occurs. From the simulated results, employment, vacancies and job matches for natives all fall temporarily after a shock of immigrant population, but recover quickly. In addition, output and consumption remain positively impacted in the long run. Overall, in contrast to conventional wisdom, immigration stimulates the economy and improves households' welfare.

The rest of the paper is organized as follows. Section 2 reviews recent studies on relation between immigration and national economies. Section 3 lays out the model and its associated Social Planner Problem. Section 4 parameterizes the model based on the US historical data. Section 5 discusses the simulated results, especially interaction between different variables when given a shock. Section 6 concludes the paper.

2 Literature Review

Most existing literature examines the economic impact of immigration from a microeconomic perspective, which has been surveyed extensively by Manacorda, Manning, and Wadsworth (2012) and Card and Peri (2016). However, research from a macroeconomic perspective is sparse.

Early studies implement neo-classical growth models. Palivos and Yip (2010) analyze the welfare effect and the income distribution effect of illegal immigration. They contrast the effect of immigration on skilled and unskilled labor. More recently, Kiguchi and Mountford (2013) build a model with a production function with constant elasticity of substitution (CES). They conclude that characterizing immigrants and capital as complements to skilled domestic labor and substitutes for each other can produce responses closer to the reality than a skill-neutral shock. Their finding provides support to a key microeconometric result that immigrant labor is a much closer substitute for native unskilled labor than native skilled labor (Ottaviano and Peri, 2012; Manacorda et al., 2012).

Recently, studies have implemented search models in their analyses. By incorporating search and matching frictions into the labor market, these studies are able to capture unemployment and job search costs which are missing in growth models. Liu (2010) allows competition between domestic workers and illegal immigrants and finds similar results as Palivos and Yip (2010) who use a growth model. Chassamboulli and Palivos (2013) allow for skill heterogeneity among natives but assume all immigrants to be low-skilled. After examining data from Greece, they conclude that an influx of unskilled immigrants help skilled native workers gain in wages and employment but bring an ambiguous result to unskilled native workers. Building on this model Chassamboulli and Palivos (2014) add a component of capital-skill complementarity to the model and examine data from the US. They find increases in unskilled workers' wages, their employment and skilled workers employment but uncertainty in skilled workers' wages.

In sum, most literature that investigates relation between immigration and a nation's economy distinguishes between high-skilled and low-skilled workers, and focuses on implications of natives' wages, employment and welfare. However, both growth models and search models have drawbacks. The popular approach of building a search model derives only a partial equilibrium, leaving some important stylized facts, such as consumption and investment, out of discussion. On the other hand, for a growth model, although it reveals a general equilibrium, it does not capture several important elements in the labor market such as unemployment, vacancies and job search costs. Compared with these two model types, a DSGE model is able to reveal a comprehensive picture of the economy, not only including labor market factors such as unemployment, but also other macroeconomic measures such as consumption and productivity. Unfortunately, the literature that utilizes a DSGE model to analyze the effect of immigration on a nation's economy is extremely sparse.

One study that analyzes the economy of New Zealand using a DSGE model is Smith and Thoenissen (2018). To reflect New Zealand's economy, they separate the housing sector, which involves residential investment, from the rest of the goods market. They find that immigration shocks account for a considerable proportion of the variability of per capita GDP. Such shocks are not key drivers but important for the components of per capita GDP.

Another study, which is the closest with mine, is Kiguchi and Mountford (2017). They implement a DSGE model with a search-based labor market. They divide unemployed workers into those with a high or a low job matching probability, and assume that migrants enter the labor market as unemployed workers with a low matching probability. They find a temporary increase in unemployment as a result of an immigration shock and verify that this increase matches the post-war US data.

While these two recent studies do utilize DSGE models to analyze immigration, neither of them nor the previous studies that implement growth or search models treat native and immigrant workers as having the same capacity. However, in reality, especially more recently, more and more immigrants are highly-educated or able to access the same level of technology as natives (Pew Research Center, 2018a). Hence, it is worthwhile and valid to examine a scenario where natives and immigrants have no skill difference. In this paper, I seek to unify the working capacity of natives and immigrants, and therefore, only differentiate labor based on their immigration status. I make two contributions to the literature. First, this paper adds to the minimal amount of literature that utilizes DSGE models to analyze immigration. Second, I eliminate the assumption that immigrants are low-skilled or disadvantaged.

3 Theory

The model economy is based on the Real Business Cycle model with a search-based labor market developed by Merz (1995). Variables and their descriptions are listed in Table 1. The model has an infinite number of households and firms. Each household hosts one worker and each firm employs one worker at maximum. In each period, unemployed workers and firms with vacancies attempt to match with each other in the labor market.

I divide households into two types using subscript $j \in \{D, F\}$, where D stands for natives (domestic workers) and F stands for immigrants (foreign workers).

Each firm can hire one worker at maximum, and hire only natives (D) or only immigrants (F). This assumption partly follows the reality that some positions only hire natives while others hire both natives and immigrants. Since the domestic population remains stable and constant in the model, I simplify the second group as firms only hiring immigrants. Even though the assumption omits the potential of natives directly competing with immigrants, it does differentiate between the matching processes for workers with different immigration status. Hence, it is able to reveal fluctuation brought by immigration. Consequently, the economy has two separate labor markets, respectively for natives and for immigrants. Unemployed natives only seek vacancies targeted at natives, and unemployed immigrants only seek vacancies targeted at immigrants.

3.1 Labor Supply

In each period, N_{jt} denotes employment of each household type. The labor force of natives is normalized to 1. Q_t denotes the labor force of immigrants, as an unexpected increase or decrease of immigrants would shift the measurement above or below its steady state, which is normalized as 1. Then unemployment is derived as $(1 - N_{Dt})$ for natives and $(Q_t - N_{Ft})$ for immigrants. Each unemployed worker spends a cost of $c_0 > 0$ in one period to perform the searching process.

In each period t, every employee faces an exogenous probability of $\psi \in [0, 1]$ to lose the job and begin searching for employment in period $t + 1$. If an unemployed worker matches successfully with a firm in period t, this agent starts working in period $t + 1$.

3.2 Labor Demand

Similar to workers, firms engage in a search process for matching and operating. In every period, firms post job vacancies V_{Dt} for natives, V_{Ft} for immigrants and pay an exogenous cost a per vacancy. However, the matching attempt is not guaranteed to be successful. If a firm finds or maintains a match in period t, it operates in period $t + 1$. Otherwise, it shuts down and produces nothing in period $t + 1$. A firm that employs one worker in period t also faces a probability of ψ to lose the worker in period $t + 1$.

3.3 Matching

The number of matches M_{jt} is determined by firms' vacancies V_{jt} and the unemployed population of natives $(1 - N_{Dt})$ or of immigrants $(Q_t - N_{Ft})$ as follows:

$$M_{Dt} = V_{Dt}^{1-\lambda}(1 - N_{Dt})^{\lambda} \text{ for natives} \tag{1}$$

$$M_{Ft} = V_{Ft}^{1-\lambda}(Q_t - N_{Ft})^{\lambda} \text{ for immigrants,} \tag{2}$$

where $\lambda \in (0, 1)$ is the matching elasticity of unemployment, and $(1 - \lambda)$ is the matching elasticity of vacancies. Since the sum of two elasticities equals 1, the matching function inherits constant returns to scale (CRS).

3.4 Social Planner Problem

Since there exists no distortion in the environment, I characterize the economy into a Social Planner Problem. The social planner chooses the set $\{C_{jt}, X_t, N_{jt+1}, K_{j,t+1}, V_{jt}\}_{t=0}^{\infty}$ to maximize consumers' lifetime utility function, which is characterized as follows:

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big(\log C_{Dt} - \frac{N_{Dt}^{1-\chi}}{1-\chi} + \log C_{Ft} - \frac{N_{Ft}^{1-\chi}}{1-\chi} \Big), \tag{3}$$

where $\beta \in (0,1)$ is the discount rate, $1/\chi$ is the Frisch elasticity, C_{jt} denotes consumption, N_{jt} denotes employment and E_0 is the expectations operator given information known at period 0. The maximization is subject to the following five sets of constraints.

First, all households manage investment decisions collectively subject to the law of motion for capital:

$$K_{t+1} = (1-\delta)K_t + X_t, \tag{4}$$

where δ is the exogenous depreciation rate of capital, K_t denotes capital and X_t denotes investment.

Next, the labor market follows the matching functions (Equations 1 and 2) and laws of motion for labor:

$$N_{D,t+1} = (1-\psi)N_{Dt} + M_{Dt} \tag{5}$$

$$N_{F,t+1} = (1-\psi)N_{Ft} + M_{Ft}, \tag{6}$$

where ψ is the exogenous job separation rate as explained in Sections 3.1 and 3.2, and M_{jt} denotes the number of matches.

The production process involves complementary labor employment of natives N_{Dt} and immigrants N_{Ft} as follows:

$$Y_t = z_t K_t^{\alpha} N_{Dt}^{\phi} N_{Ft}^{1-\alpha-\phi}, \tag{7}$$

where z_t is total factor productivity (TFP), and $\alpha, \phi \in (0,1)$ are respectively the production elasticity of capital and the production elasticity of domestic labor. The exponent $(1-\alpha-\phi)$ is the production elasticity of foreign labor. The sum of three elasticities equals 1, which indicates CRS in production.

Lastly, aggregate feasibility is

$$Y_t = C_{Dt} + C_{Ft} + X_t + aV_{Dt} + aV_{Ft} + c_0(1 - N_{Dt}) + c_0(Q_t - N_{Ft}) \tag{8}$$

which shows that output is spent on consumption, investment, vacancy posting and job searching in each period.

There are two exogenous state variables in the model, namely TFP (z_t) and the labor force of immigrants (Q_t), both assumed to follow AR(1) stochastic processes. TFP z_t follows

$$\log z_{t+1} = (1 - \rho_z) \log z + \rho_z \log z_t + \epsilon_{zt}. \tag{9}$$

The labor force of immigrants Q_t follows

$$\log Q_{t+1} = (1 - \rho_Q) \log Q + \rho_Q \log Q_t + \epsilon_{Qt}. \tag{10}$$

Variables without time subscripts, namely z in Equation 9 and Q in Equation 10, denote steady state values, which are normalized as 1. Parameters ρ_z and ρ_Q are autocorrelation coefficients that control how much contribution of steady state values and this period's values have to the next periods' values. Both ϵ_{zt} and ϵ_{Qt} are unanticipated shocks and have a mean of 0. Both error terms are normally distributed: $\epsilon_z \sim N(0, \sigma_z^2)$ and $\epsilon_i \sim N(0, \sigma_Q^2)$.

Summing up, the social planner solves the following constraint optimization problem to maximize all consumers' utility. According to the First Welfare Theorem (FWT) and the Second Welfare Theorem (SWT), the optimal allocation determined by the social planner is equivalent to a competitive equilibrium.

$$
\begin{aligned}
\mathcal{L} =& E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ \log C_{Dt} - \frac{N_{Dt}^{1-\chi}}{1-\chi} + \log C_{Ft} - \frac{N_{Ft}^{1-\chi}}{1-\chi} \\
&+ \kappa_t [z_t K_t^{\alpha} N_{Dt}^{\phi} N_{Ft}^{1-\alpha-\phi} - (C_{Dt} + C_{Ft} + X_t + aV_{Dt} + aV_{Ft} + c_0(1-N_{Dt}) + c_0(Q_t - N_{Ft}))] \\
&+ \mu_t [(1-\delta)K_t + X_t - K_{t+1}] \\
&+ \sigma_{Dt} [(1-\psi)N_{Dt} + M_{Dt} - N_{Dt+1}\Big] + \sigma_{Ft}\Big[(1-\psi)N_{Ft} + M_{Ft} - N_{Ft+1}] \\
&+ \xi_{Dt}[V_{Dt}^{1-\lambda}(1-N_{Dt})^{\lambda} - M_{Dt}] + \xi_{Ft}[V_{Ft}^{1-\lambda}(Q_t - N_{Ft})^{\lambda} - M_{Ft}]\Big\}
\end{aligned}
$$

In the system, κ_t, μ_t, σ_{Dt}, σ_{Ft}, ξ_{Dt} and ξ_{Ft} denote Lagrangian multipliers.

3.5 Equilibrium Conditions

The model economy's reduced system of equilibrium conditions is written as follows:

$$\mu_t = C_{Dt}^{-1} \tag{11.1}$$

$$\mu_t = C_{Ft}^{-1} \tag{11.2}$$

$$a\mu_t = \sigma_{Dt}(1-\lambda)V_{Dt}^{-\lambda}(1-N_{Dt})^{\lambda} \tag{11.3}$$

$$a\mu_t = \sigma_{Ft}(1-\lambda)V_{Ft}^{-\lambda}(Q_t - N_{Ft})^{\lambda} \tag{11.4}$$

$$\mu_t = \beta E_t \mu_{t+1}(1 - \delta + \alpha K_{t+1}^{\alpha-1} N_{Dt+1}^{\phi} N_{Ft+1}^{1-\alpha-\phi}) \tag{11.5}$$

$$
\begin{aligned}
\sigma_{Dt} = \beta E_t[&-N_{Dt+1}^{-\chi} + \mu_{t+1}(c_0 + \phi K_{t+1}^{\alpha} N_{Dt+1}^{\phi-1} N_{Ft+1}^{1-\alpha-\phi}) \\
&+ \sigma_{Dt+1}(1 - \psi - \lambda V_{Dt+1}^{1-\lambda}(1-N_{Dt+1})^{\lambda-1}]
\end{aligned} \tag{11.6}
$$

$$
\begin{aligned}
\sigma_{Ft} = \beta E_t[&-N_{Ft+1}^{-\chi} + \mu_{t+1}(c_0 + (1-\alpha-\phi) K_{t+1}^{\alpha} N_{Dt+1}^{\phi} N_{Ft+1}^{-\alpha-\phi}) \\
&+ \sigma_{Ft+1}(1 - \psi - \lambda V_{Ft+1}^{1-\lambda}(Q_{t+1}-N_{Ft+1})^{\lambda-1}]
\end{aligned} \tag{11.7}
$$

$$Y_t = C_{Dt} + C_{Ft} + X_t + aV_{Dt} + aV_{Ft} + c_0(1-N_{Dt}) + c_0(Q_t - N_{Ft}) \tag{11.8}$$

$$Y_t = z_t K_t^{\alpha} N_{Dt}^{\phi} N_{Ft}^{1-\alpha-\phi} \tag{11.9}$$

$$K_{t+1} = (1-\delta)K_t + X_t \tag{11.10}$$

$$N_{D,t+1} = (1-\psi)N_{Dt} + M_{Dt} \tag{11.11}$$

$$N_{F,t+1} = (1-\psi)N_{Ft} + M_{Ft} \tag{11.12}$$

$$M_{Dt} = V_{Dt}^{1-\lambda}(1-N_{Dt})^{\lambda} \tag{11.13}$$

$$M_{Ft} = V_{Ft}^{1-\lambda}(Q_t - N_{Ft})^{\lambda} \tag{11.14}$$

$$\log z_{t+1} = (1-\rho_z)\log z + \rho_z \log z_t + \epsilon_{zt} \tag{11.15}$$

$$\log Q_{t+1} = (1-\rho_Q)\log Q + \rho_Q \log Q_t + \epsilon_{Qt} \tag{11.16}$$

Equation (11.1) to Equation (11.4) are intratemporal conditions that inform allocation decisions on consumption, vacancies and employment in the same periods. Equations (11.5), (11.6) and (11.7) are intertemporal conditions that inform decisions on consumption, capital stock, employment and vacancies between periods. All other equations are the same as described in Sections 3.3 and 3.4. As μ_t equals κ_t, σ_{Dt} equals ξ_{Dt}, and σ_{Ft} equals ξ_{Ft}, the system has three Lagrange multipliers left, respectively μ_t, σ_{Dt} and σ_{Ft}. More details regarding the derivation of the reduced system are noted in Appendix B.

4 Parameterization

I follow previous research and parameterize the model based on empirical findings from the US historical data. Let Φ denote the set of all parameters as listed below. Table 2 summarizes parameter values and definitions.

$$\Phi = \{\alpha, \beta, \delta, \lambda, \phi, \psi, \chi, a, c_0, \rho_z, \rho_Q, \sigma_z, \sigma_Q\}$$

Most parameters follow Merz (1995). The parameter $\alpha = 0.36$ represents the capital income share and $\beta = 0.99$ is the discount factor over time. The parameter $\lambda = 0.40$ measures the elasticity of matches and is consistent with Blanchard and Diamond (1989). The job separation rate $\psi = 0.07$ is the probability of a worker losing its current job in one period. The inverse of the Frisch elasticity $\chi = -0.8$ shows how consumer's utility is influenced by the amount of work. The unit cost of a vacancy post $a = 0.05$ matches the average rate of vacancy duration in van Ours and Ridder (1992). The cost of job search by a single unemployed worker $c_0 = 0.005$ generates an equilibrium unemployment level of 6.4 percent, close to the historical average level and the average level after the Great Recession in the US.

The capital depreciation rate $\delta = 0.059$ is in accordance with Nadiri and Prucha (1996), who estimate the depreciation rate of physical capital in the US total manufacturing sector. The production elasticity of domestic labor ϕ is set as 0.32 to create equal influences on output from native and immigrant workers. Section 5.2 illustrates sensitivity analysis of ϕ and Table 3 shows steady state values corresponding to different values of ϕ.

Altering the parameters associated with stochastic processes $\{\rho_z, \rho_Q, \sigma_z, \sigma_Q\}$ would not modify the model's qualitative results. However, quantitatively, $\rho_z = 0.95$ and $\rho_Q = 0.75$ affect how long the impact of a shock would dissipate. The larger the parameter value is, the longer it takes for the effects to dissipate. The parameter ρ_z follows Merz (1995) and ρ_Q follows Kiguchi and Mountford (2017). Without loss of generality, my goal is to measure the impact of a 1 percent deviation from the steady state of TFP and immigrant population. Given this goal, I set $\sigma_z = \sigma_Q = 0.01$ so that simulated 1 standard deviation shocks match 1 percent shocks to corresponding variables.

5 Results

In this section, I present simulated results of the parameterized model. First, I present Impulse Response Functions (IRFs), which show how each variable responds to a 1 percent shock of TFP or immigration population over 40 periods. Second, I run a steady state analysis which serves as a robustness check. Since I manually set the production elasticity of domestic labor ϕ as 0.32, I tweak ϕ slightly in both directions and verify that the consequent steady state values would not fluctuate dramatically.

5.1 Impulse Response Functions

As an initial pass, I first implement a TFP shock and examine the behavior of variables. Then I implement an immigration shock, which is the main interest of this study, and investigate how the economy responds.

5.1.1 TFP

Since two groups contribute equally to production (i.e. $\phi = 1 - \alpha - \phi$ in Equation 7) and behave identically, each group's corresponding variables are affected exactly in the same way when a TFP shock occurs (Figure 1). Output, investment and capital stock give the most significant responses. Output peaks in the second period after the shock occurs, experiencing 2.7 percent above the steady state value. Most increase in output gets transferred into investment, peaking also in the second period at 1.83 percent above steady state. Both variables slowly fall toward steady state after the peak, but still remain positively affected after 40 periods.

Unlike output and investment which increase sharply right after the shock, capital stock rises steadily over the first 16 periods and then begin to fall. This incident is largely due to the vast amount of investment in those first periods is able to recover depreciation and even leaves extra amount into capital stock. Similarly, consumption slowly rises after the shock and achieves its maximum in the 11th to 14th periods. To explain the behavioral difference between consumption and investment, one possibility could be that when TFP drives productivity high and produces extra output, households first focus on investing these output into production to keep productivity high in the future periods, and then slowly increase their consumption to enjoy the extra wealth.

Even though magnitudes of their responses are relatively small, labor, matches and vacancies reach their heights in period 1, and then drop to levels below steady state. Together with consumption slowly rising and always staying positive, these phenomena show that after the TFP shock generates high levels of employment and produces at an excessive level, the economy reduces working overall and households still benefit from high output produced in previous periods.

5.1.2 Immigrant Population

When an immigrant influx arrives unexpectedly, two groups react differently. Vacancies for immigrants drop sharply to -0.38 percent below steady state in period 2. Matches follow the same pattern with a smaller magnitude of -0.09 percent. Both drops are resulted from the sudden population influx and the employment booming right afterwards. On the other hand, vacancies for natives react much more slowly and remain positively impacted for 6 periods, responding to the temporarily increased productivity. Around the same time when vacancies for natives drop to negative, native employment also runs below steady state to accommodate vast production generated by immigrants.

Output, investment and capital stock increase after the shock as more matches for immigrants are made and thus, productivity rises and generates additional output. Unlike output and capital shock, which remain positively impacted after 40 periods, investment goes below steady state in period 14. I attribute this adjustment to the economy balancing the excessive usage of labor in production. As a result of increasing output, consumption of each household type increases identically, since two types of households value consumption at the same level.

Overall, even though employment, vacancies and matches experience some negative influences, their fluctuations are generally small and recover quickly. In addition, output, consumption and capital stock are positively impacted all the time after the shock, representing positive benefits in general to the economy.

5.2 Sensitivity Analysis

I list steady state values associated with $\phi = \{0.30, 0.32, 0.34, 0.36\}$ in Table 3. Steady state values of variable pairs are symmetric around $\phi = 0.32$. For example, compared with $\phi = 0.30$, steady state values when $\phi = 0.34$ are absolutely identical except the group names are flipped.

As ϕ gets farther away from 0.32, output, capital stock, consumption and investment decrease. This is due to the distortion of symmetry between exponents ϕ and $(1 - \alpha - \phi)$ turning the economy less productive than when two exponents equal. At the same time, when compared between $\phi = \{0.32, 0.34, 0.36\}$, employment, vacancies and matches favor natives more and more as ϕ gets larger, because natives become weighted more and more importantly in the process of production.

Since steady state values do not change dramatically, and all behavior of the two groups other than production is identical, I don't expect simulation results alter considerably when the parameter ϕ is slightly adjusted.

6 Conclusion

This paper develops a DSGE model with a search-based labor market to explore the impact of immigrants on destination countries' economies. Based on the simulations, although employment, vacancies and matches drop below steady state after the shock, they recover to the steady state quickly. In addition, output, consumption and capital stock stay positively influenced even after 40 periods. Overall, immigration benefits the economy and increases households' welfare.

Due to my simplified assumptions of how agents interact, there are several limitations. First, I assume homogeneous consumers value consumption and leisure in the same way across different household types. It would be worthwhile to explore results from different preferences. Second, vacancies target only natives or immigrants in the model, lacking dynamics between the two labor forces. Finally, each worker in either labor force is forced to spend an equal amount of efforts looking for a job. The model would inherit more heterogeneity if endogenous search efforts are admitted.

The proposed model aims to characterize immigration in a macroeconomic context and examine its impact on the destination country's economy. In addition to allow for more heterogeneity in existing variables, further research could incorporate skill heterogeneity and capital-skill complementarity into the model. Furthermore, to improve accuracy and precision, further research could calibrate parameters based on recent real-world data. It would be an interesting expansion to utilize data from different immigrant-receiving countries for mechanism comparison between economies.

References

Blanchard and Diamond. The aggregate matching function. Working Paper 3175, National Bureau of Economic Research, November 1989.

Card and Peri. Immigration economics by george j. borjas: A review essay. *Journal of Economic Literature*, 54(4):1333–1349, 2016.

Chassamboulli and Palivos. The impact of immigration on the employment and wages of native workers. *Journal of Macroeconomics*, 38(A):19–34, December 2013.

Chassamboulli and Palivos. A search-equilibrium approach to the effects of immigration on labor market outcomes. *International Economic Review*, 55(1):111–129, 2014.

Kiguchi and Mountford. The macroeconomics of immigration. MPRA Paper 45517, University Library of Munich, Germany, March 2013. URL `https://ideas.repec.org/p/pra/mprapa/45517.html`.

Kiguchi and Mountford. Immigration and unemployment: A macroeconomic approach. *Macroeconomic Dynamics*, pages 1–27, 2017. doi: 10.1017/S1365100517000244.

Liu. On the macroeconomic and welfare effects of illegal immigration. *Journal of Economic Dynamics and Control*, 34(12):2547–2567, 2010.

Manacorda, Manning, and Wadsworth. The impact of immigration on the structure of wages: Theory and evidence from britain. *Journal of the European Economic Association*, 10(1):120–151, February 2012.

Merz. Search in the labor market and the real business cycle. *Journal of Monetary Economics*, 36(2):269–300, November 1995.

Nadiri and Prucha. Estimation of the depreciation rate of physical and r&d capital in the u.s. total manufacturing sector. *Economic Inquiry*, 34(1):43–56, January 1996.

Ottaviano and Peri. Rethinking the effect of immigration on wages. *Journal of the European Economic Association*, 10(1):152–197, February 2012.

Palivos and Yip. Illegal immigration in a heterogeneous labor market. *Journal of Economics*, 101(1):21–47, September 2010.

Pew Research Center. Number of asylum seekers in europe surges to record 1.3 million in 2015, 2016. URL https://www.pewglobal.org/2016/08/02/number-of-refugees-to-europe-surges-to-record-1-3-million-in-2015/.

Pew Research Center. Facts on u.s. immigrants, 2016, 2018a. URL https://www.pewhispanic.org/2018/09/14/facts-on-u-s-immigrants/.

Pew Research Center. Key findings about u.s. immigrants, 2018b. URL https://www.pewresearch.org/fact-tank/2018/11/30/key-findings-about-u-s-immigrants/.

Smith and Thoenissen. Migration and business cycle dynamics. Cama working papers, Centre for Applied Macroeconomic Analysis, Crawford School of Public Policy, The Australian National University, May 2018. URL https://EconPapers.repec.org/RePEc:een:camaaa:2018-20.

van Ours and Ridder. Vacancies and the recruitment of new employees. *Journal of Labor Economics*, 10(2):138–155, April 1992.

A Tables and Figures

Table 1: Variable Descriptions

Variable	Description
Y	Output
K	Capital Stock
C_D	Consumption of Natives
C_F	Consumption of Immigrants
X	Investment
N_D	Employment of Natives
N_F	Employment of Immigrants
V_D	Vacancies for Natives
V_F	Vacancies for Immigrants
M_D	Matches of Natives
M_F	Matches of Immigrants
z	Total Factor Productivity (TFP)
Q	Population of Immigrants

Table 2: Calibrated Parameters

Parameter	Description	Value
α	Capital Income Share	0.36
β	Discount Factor	0.99
δ	Capital Depreciation Rate	0.059
λ	Matching Function Parameter	0.40
ϕ	Production Elasticity of Domestic Labor	0.32
ψ	Job Separation Rate	0.07
χ	Inverse of Frisch Elasticity	-0.8
a	Unit Cost of Vacancy Post	0.05
c_0	Unit Cost of Job Search	0.005
ρ_z	Autocorrelation Coefficient of z_t	0.95
ρ_Q	Autocorrelation Coefficient of Q_t	0.75
σ_z	Standard Deviation of ϵ_z	0.01
σ_Q	Standard Deviation of ϵ_Q	0.01

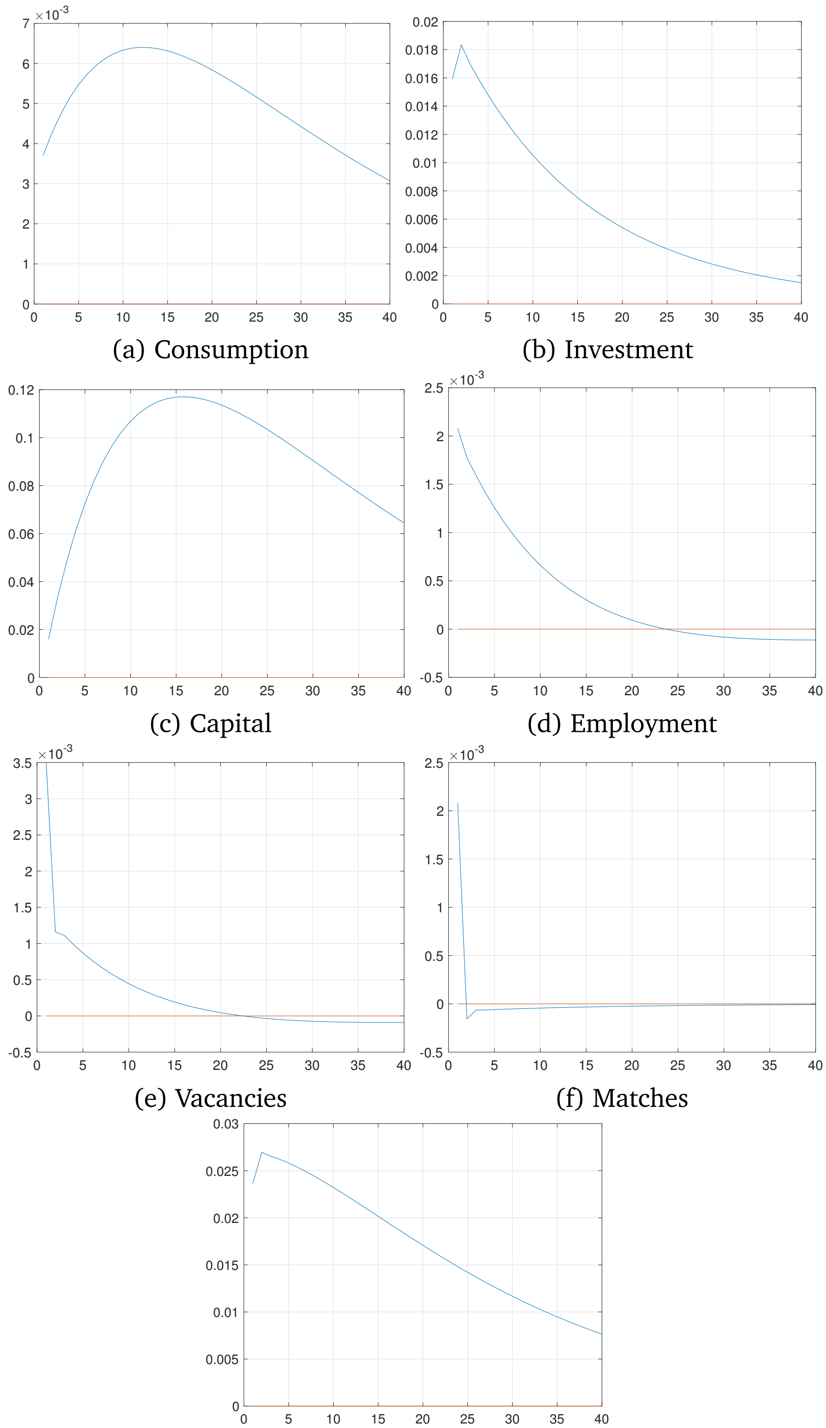
Notes: The parameter values are calibrated in Section 4. Sensitivity analysis for parameter ϕ is written in Section 5.2.

Table 3: Steady State Values

Variable	$\phi = 0.30$	$\phi = 0.32$	$\phi = 0.34$	$\phi = 0.36$
Y	2.361	2.367	2.361	2.346
K	12.302	12.333	12.302	12.223
C_D	0.814	0.816	0.814	0.809
C_F	0.814	0.816	0.814	0.809
X	0.726	0.728	0.726	0.721
N_D	0.912	0.936	0.952	0.962
N_F	0.952	0.936	0.912	0.884
V_D	0.052	0.066	0.083	0.100
V_F	0.083	0.066	0.052	0.041
M_D	0.064	0.065	0.067	0.067
M_F	0.067	0.065	0.064	0.062
z	1.000	1.000	1.000	1.000
Q	1.000	1.000	1.000	1.000

Notes: Sensitivity analysis for parameter ϕ is shown in Section 5.2.

Figure 1: Impulse Response Functions Associated with ϵ_z



(a) Consumption

(b) Investment

(c) Capital

(d) Employment

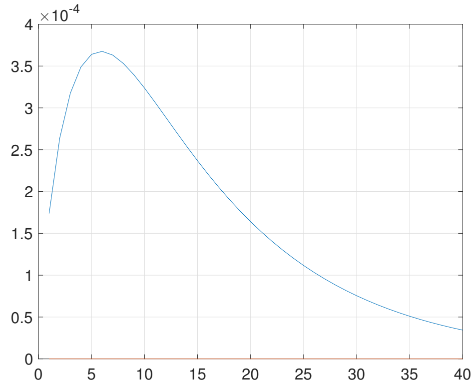
(e) Vacancies

(f) Matches

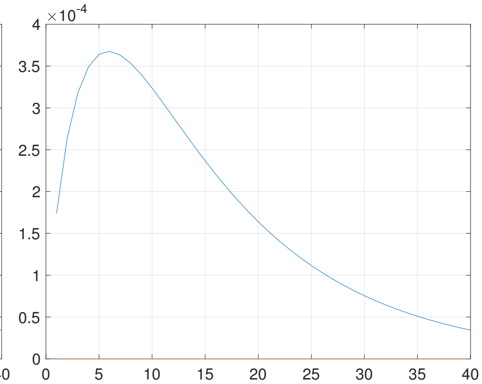
(g) Output

Notes: The impulse responses are associated with 1 percent deviation shock to TFP. The y-axes measure the percent deviations from the steady state. The x-axes indicate time periods from the initial shock.

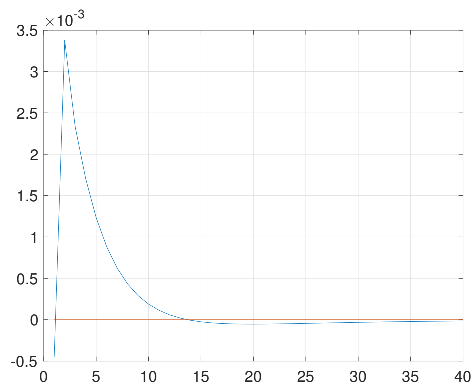
Figure 2: Impulse Response Functions Associated with ϵ_Q



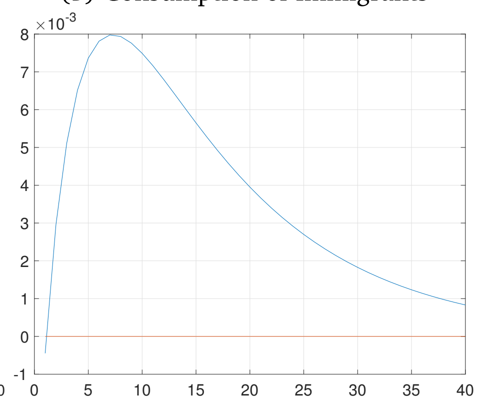
(a) Consumption of Natives



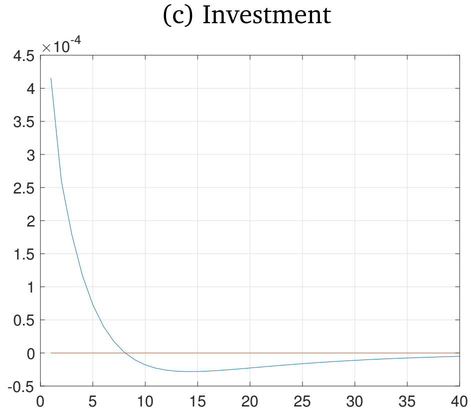
(b) Consumption of Immigrants



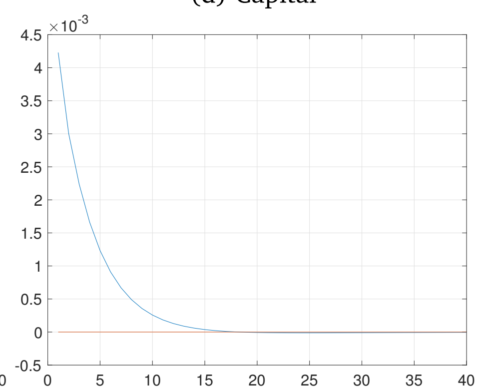
(c) Investment



(d) Capital



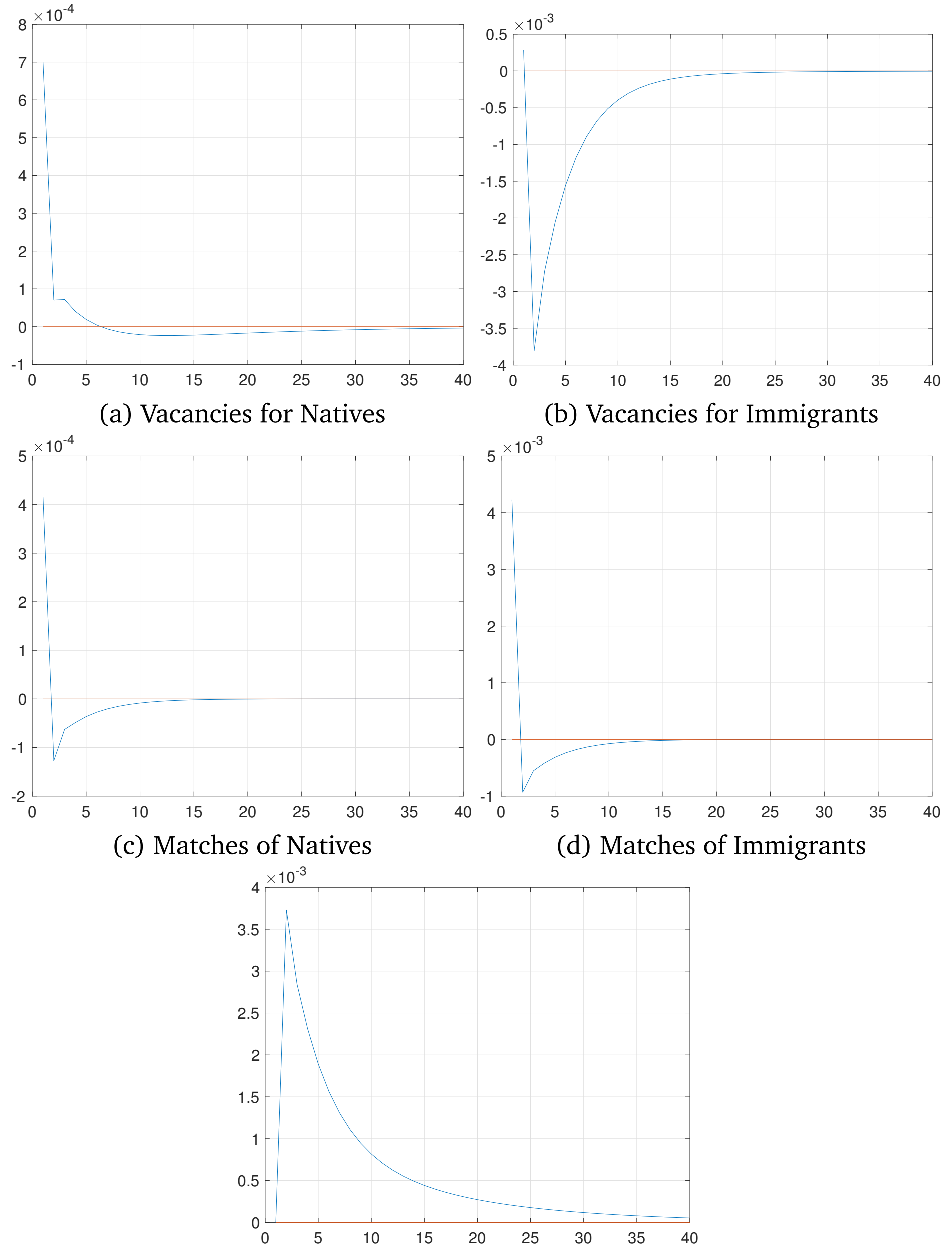
(e) Employment of Natives



(f) Employment of Immigrants

Notes: The impulse responses are associated with 1 percent deviation shock to the immigrant population. The y-axes measure the percent deviations from the steady state. The x-axes indicate time periods from the initial shock.

Figure 3: Impulse Response Functions Associated with ϵ_Q (cont.)



(a) Vacancies for Natives

(b) Vacancies for Immigrants

(c) Matches of Natives

(d) Matches of Immigrants

(e) Output

Notes: The impulse responses are associated with 1 percent deviation shock to the immigrant population. The y-axes measure the percent deviations from the steady state. The x-axes indicate time periods from the initial shock.

B Derivation of Equilibrium Conditions

After securing the Lagrangian, I take first-order conditions (FOCs) with respect to all variables, and rearrange them into equilibrium conditions. The FOCs are shown as follows, where variables in front of colons denote which variable the FOC is with respect to:

$$C_{Dt} : \kappa_t = C_{Dt}^{-1} \tag{B.1}$$

$$C_{Ft} : \kappa_t = C_{Ft}^{-1} \tag{B.2}$$

$$X_t : \kappa_t = \mu_t \tag{B.3}$$

$$M_{Dt} : \sigma_{Dt} = \xi_{Dt} \tag{B.4}$$

$$M_{Ft} : \sigma_{Ft} = \xi_{Ft} \tag{B.5}$$

$$V_{Dt} : a\kappa_t = \xi_{Dt}(1-\lambda)V_{Dt}^{-\lambda}(1-N_{Dt})^{\lambda} \tag{B.6}$$

$$V_{Ft} : a\kappa_t = \xi_{Ft}(1-\lambda)V_{Ft}^{-\lambda}(Q_t-N_{Ft})^{\lambda} \tag{B.7}$$

$$K_{t+1} : \mu_t = \beta E_t[\mu_{t+1}(1-\delta) + \kappa_{t+1}(\alpha z_{t+1}K_{t+1}^{\alpha-1}N_{Dt+1}^{\phi}N_{Ft+1}^{1-\alpha-\phi})] \tag{B.8}$$

$$\begin{aligned} N_{Dt+1} : \sigma_{Dt} = \beta E_t[&-N_{Dt+1}^{-\chi} + \kappa_{t+1}(c_0 + \phi z_{t+1}K_{t+1}^{\alpha}N_{Dt+1}^{\phi-1}N_{Ft+1}^{1-\alpha-\phi}) \\ &+ \sigma_{Dt+1}(1-\psi) - \xi_{Dt+1}(\lambda V_{Dt+1}^{1-\lambda}(1-N_{Dt+1})^{\lambda-1})] \end{aligned} \tag{B.9}$$

$$\begin{aligned} N_{Ft+1} : \sigma_{Ft} = \beta E_t[&-N_{Ft+1}^{-\chi} + \kappa_{t+1}(c_0 + (1-\alpha-\phi)z_{t+1}K_{t+1}^{\alpha}N_{Dt+1}^{\phi}N_{Ft+1}^{-\alpha-\phi}) \\ &+ \sigma_{Ft+1}(1-\psi) - \xi_{Ft+1}(\lambda V_{Ft+1}^{1-\lambda}(Q_{t+1}-N_{Ft+1})^{\lambda-1}] \end{aligned} \tag{B.10}$$

$$\begin{aligned} \kappa_t : z_tK_t^{\alpha}N_{Dt}^{\phi}N_{Ft}^{1-\alpha-\phi} = &\ C_{Dt} + C_{Ft} + X_t + aV_{Dt} + aV_{Ft} \\ &+ c_0(1-N_{Dt}) + c_0(Q_t - N_{Ft}) \end{aligned} \tag{B.11}$$

$$\mu_t : K_{t+1} = (1-\delta)K_t + X_t \tag{B.12}$$

$$\sigma_{Dt} : N_{D,t+1} = (1-\psi)N_{Dt} + M_{Dt} \tag{B.13}$$

$$\sigma_{Ft} : N_{F,t+1} = (1-\psi)N_{Ft} + M_{Ft} \tag{B.14}$$

$$\xi_{Dt} : M_{Dt} = V_{Dt}^{1-\lambda}(1-N_{Dt})^{\lambda} \tag{B.15}$$

$$\xi_{Ft} : M_{Ft} = V_{Ft}^{1-\lambda}(Q_t-N_{Ft})^{\lambda} \tag{B.16}$$