Immigration and Economic Growth: Do Origin and Destination Matter?

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Abstract

This paper assesses the heterogeneous effects of immigration on economic growth depending on both the origin and the destination countries. Following the development of a simple growth model augmented by the embodied human capital of immigrants, we estimate the growth equation using a gravity-style instrument variable approach and the dynamic system-GMM estimator. We find that immigration from developed economies positively affects the economic growth of the host countries. Furthermore, the growth-enhancing effect of immigration is significantly larger when immigration flows from developed to developing economies than when it does to those that include both developed and developing economies. We interpret these results as evidence of immigrants from developed countries bringing with them – upon entry – their advanced knowledge on technology and institutions into the developing countries that host them.

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1. Introduction

Immigration is a political topic that has yet to be resolved in many countries throughout the world. An important reason behind the conflicting arguments on immigration is that there is no consensus on the effect of immigration on the economy of the destination country. Economists are divided on whether or not immigrants contribute to the economic growth of the host country. According to the neo-classical growth model, immigrant inflow leads to a decrease in the long-run economic growth per capita through the capital dilution effect. The augmented Solow growth model of Mankiw, Romer, and Weil (1992) is based on this view. In contrast, several economic models on immigration pioneered by Dolado, Goria, and Ichino (1994) suggest that immigration increases the stock of human capital in the host country, because the migrants bring with them existing human capital (represented by education) upon entry, thereby facilitating the growth of the host country. Using a two-country version of the quality ladders endogenous growth model, Lundborg and Segerstrom (2000, 2002) develop a theoretical model to predict the positive impact of immigration on the growth of the host country through higher spending on R&D by firms facing lower wages due to immigrants.[1]

Given such differences in theoretical predictions, the relationship between immigration and growth is largely an empirical issue. Some empirical works on the relationship between immigration and growth look at general immigration without cosidering the channel of immigration through which growth is affected (Felbermayr, Hiller, and Sala, 2008; Bellini, Ottaviano, Pinelli, and Prarolo 2009; Ortega and Peri 2009). In contrast, a few studies investigate the impact of immigration on growth in the receiving country by focusing on education achievements of the immigrants (Dolado, Goria, and Ichino 1994; Orefice, 2011).

A major challenge to empirical studies is dealing with the endogenous nature of immigration to growth. Dolado, Goria, and Ichino (1994) attempt to avoid the endogeneity problem using lagged

[1] In spite of the positive impacts of immigration on growth, they suggest that immigration decreases the welfare of workers in the host country if its R&D sector is already large.

variables, and find that the negative impacts of migration on growth in OECD countries decrease by more than half due to the high human capital of immigrants entering these countries. Two recent studies attempt to address endogeneity in a systematic way. Using data from 14 OECD countries as host countries, Ortega and Peri (2009) apply a two-step estimation, in which the first step is to estimate the gravity equation of immigration and then find the positive impacts of the inflow of immigrants on employment and investment. Orefice (2011) uses data from 24 OECD host countries and apply an instrument variable approach based on bilateral immigration flows that are determined by bilateral aid, the stock of existing immigrants, and geographical variables. Unlike Ortega and Peri (2009), he finds that the overall effect of migration on the per capita GDP of the host countries is negative despite some positive effects of highly educated migrants on per capita GDP.

These conflicting findings suggest the need to employ a more focused approach. Our research follows Dolado, Goria, and Ichino (1994) and Orefice (2011) as we investigate the effect of a certain kind of immigration rather than that of immigration as a whole, and focus on the role of human capital in determining the effect of immigration on growth. However, we investigate the role of a different type of human capital (i.e., knowledge on better technology and institutions embodied in immigrants) in promoting economic growth, rather than the level of education used in the abovementioned studies. For this purpose, we assess the heterogenous effects of immigration on growth in the host country depending on the characteristics of both the origin and host countries. The effects of human capital on growth, particularly knowledge on better technology and institutions brought by immigrants, if any, might be more clearly pronounced in immigratin from developed to developing countries than from developing to developed ones. We analyze the distinctive impacts of immigration on growth in the host country by using different independent variables to capture the origin of immigration and by altering the sample of the host countries in a way that either includes both developed and developing countries or excludes the developed ones.

This paper investigates the effects of immigration from major industrialized countries

(MICs) on the economic growth of the host nations, and compares these effects with those of immigration from all available countries, including the MICs.[2] In addition, we evaluate the different magnitudes of the growth-enhancing effects of immigration from the MICs depending on whether we use the sample of the host countries that either includes or excludes the MICs. We claim that immigration from more advanced to less advanced countries provides a good opportunity to test the effect of immigration on growth through human capital. Migrants from these countries carry embodied intangible assets, such as knowledge on technology and institutions, to less developed countries. As such, they can be viewed as carrier of better knowledge and institutions that can contribute to economic growth in the host countries. As our theory predicts, we expect that the magnitude of the effects of immigration is the largest when the flow of immigration is from the MICs to developing countries, followed by that from MICs to countries including both the MICs and developing ones.

This study is related to the strand of literature that deals with the role of intangible assets in economic growth. For example, culture in immigrants from frontier countries can be involved in the process of adopting the frontier countries' technology and market-supporting institutions, which is a very important issue for less-developed countries. Therefore, the immigrant inflows from MICs provide less-developed ones the opportunity to obtain knowledge of a better way to organize work and the society through face to face interactions. Spolaore and Wacziag (2010) hypothesize that the cultural differences between individual and frontier countries may act as a barrier to technology adoption, and show that genetic differences have statistically significant effects on income differences. In a similar vein, Andersen and Dalgaard (2011) find that the temporary in- and outflows of travelers is one of the channels that gives exposure to the country abroad. This leads to our hypothesis that immigrants are the crucial channels by which improvements in knowledge and institutions are achieved.

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[2] The paper defines the major industrialized countries as joining OECD before 1970 and being ranked above 18th place with respect to per capita real GDP, 1960. Appendix A shows the list of the major industrialized countries.

This paper aims to contribute to the literature in three ways. First, we investigate the role of knowledge on better technology and institutions carried by immigrants from richer countries in facilitating growth in the host country. To the best of our knowledge, this study is the first attempt to look into the relationship between immigration and economic growth within this strand in literature. Second, we make our contribution by showing that the effects of immigration on growth depend on the choice of the origin and destination countries. In other words, the relationship between immigration and growth can be negative, neutral, and positive depending on the country of origin of immigrants and where they settle eventually. Third, we improve the literature by estimating the dynamic equation of immigration, which is more appealing because of the past dependency of immigration.

We use Global Bilateral Migration Database from the World Bank. This data set spans the period from 1960 to 2000 and is disaggregated by gender, origin country, and destination country. We develop a simple growth equation modified by considering the flow of immigration. Panel estimations are utilized instead of cross-sectional regressions that might suffer from unobserved heterogeneity. Furthermore, we estimate the growth equation using external (gravity) instrument and internal instrument (GMM-estimator).

The rest of the paper is organized as follows. Section 2 shows the conceptual framework in order to understand channels through which immigration flows affect the long-run economic growth per capita. Section 3 presents a description of the dataset and the estimation strategy. Section 4 discusses estimation results, and Section 5 summarizes the main findings.

2. A Conceptual Framework

We modify the Dolado, Goria, and Ichino (1994) standard augmented neoclassical Solow-Swan growth model with migration by specifying a technology term in production function in accordance with Andersen and Dalgaard (2011). We obtain the steady-state real GDP per effective worker ($\hat{y}^*$) as follows:[3]

$$\hat{y}^* = \left(\frac{s_K^{\alpha(1+\beta)} s_H^{\alpha}}{(\delta + g + n)^{\beta(1+\alpha)} [\delta + g + n + m(1-\kappa^I)]^{\alpha}} \right)^{\frac{1}{1-\alpha-\beta}}, \qquad (1)$$

where s_K is the savings rate, s_H is the fraction of resources used for human capital accumulation, δ is the rate of (human) capital depreciation, g is the growth rate of technological progress, n is the rate of labor force growth, m is the ratio of immigrant stock to the population of the host country, and κ^I is the ratio of the average human capital of immigrants to that of workers in the host economy.

We introduce a new role of immigrants who carry better knowledge about technology and market-supporting institutions, which can be considered as an additional channel to promote economic growth. To explain this channel, we specify technology term (A) in production function in accordance with Andersen and Dalgaard (2011). The evolution of technology (A) is characterized by:

$$\dot{A} = \phi \cdot (A^w - A), \quad \phi > 0\,. \qquad (2)$$

The parameter ϕ reflects the intensity of knowledge spillover from a world technology frontier (A^w). The more connected to the frontier an economy is through trade, FDI, flows of people and so on, the higher the value of ϕ. Therefore, ϕ can be the function of immigrant stock from frontier countries because immigrants from these countries help a less developed country get closer to the world technology frontier; that is, $\phi = \phi(m,\cdot)$, where $\cdot$ represents variables that affect the connection with the frontier countries given by $\phi' = \frac{\partial \phi(m,\cdot)}{\partial m} > 0$ and $\phi'' = \frac{\partial^2 \phi(m,\cdot)}{\partial m^2} < 0$. For simplicity, we assume that A^w expands over time at a constant rate of technological progress ($\dot{A}^w = g^w A^w$). At a steady state, the rate of (local) technological progress is equal to the frontier rate.

3 Refer to Appendix B for more details on how to obtain it.

Therefore, along a steady state, A is calculated using the following equation:

$$A = \frac{\phi(m,\cdot)}{\phi(m,\cdot)+g^{w}} A^{w}. \tag{3}$$

To examine the impact of immigrants on economic growth, we need to check the trajectory of $\hat{y}^{*}$ around the steady state. To approximate around the steady state, the pace of convergence is obtained using the following equation:

$$\frac{d\ln\hat{y}}{dt} = \lambda[\ln(\hat{y}^{*}) - \ln\hat{y}(t)], \tag{4}$$

where $\lambda = (n+g+\delta)(1-\alpha-\beta)$ (see Appendix C). Thus, Equation (4) implies that:

$$\ln\hat{y}(t_2) = (1-e^{-\lambda\tau})\ln\hat{y}^{*} + e^{-\lambda\tau}\ln\hat{y}(t_1) \quad . \tag{5}$$

By substituting for $\hat{y}^{*}$ and using $\ln\hat{y}(t) = \ln y(t) - \ln A$ (y: real GDP per worker), we obtain the equation for growth regression as follows:

$$\begin{aligned}\ln y(t_2) = {} & (1-e^{-\lambda\tau})\left\{\left(\frac{\alpha(1+\beta)}{1-\alpha-\beta}\right)\ln s_K + \left(\frac{\alpha}{1-\alpha-\beta}\right)\ln s_H\right\} \\ & -(1-e^{-\lambda\tau})\left\{\left(\frac{\beta(1+\alpha)}{1-\alpha-\beta}\right)\ln(\delta+g+n) + \left(\frac{\alpha}{1-\alpha-\beta}\right)\ln[(\delta+g+n)+m(1-\kappa^{I})]\right\}. \\ & + e^{-\lambda\tau}\ln\hat{y}(t_1) + (1-e^{-\lambda\tau})\ln\left(\frac{\phi(m,\cdot)}{\phi(m,\cdot)+g^{w}} A^{w}\right).\end{aligned} \tag{6}$$

To identify how immigrants affect economic growth in the host country, we differentiate Equation (6) with respect to m as follows:

$$\frac{\partial\ln y(t_2)}{\partial m} = \underbrace{(1-e^{-\lambda\tau})}_{(+)}\left[\underbrace{\phi'\frac{g^{w}}{\phi(\phi+g^{w})}}_{(+)} - \underbrace{\left(\frac{\alpha}{1-\alpha-\beta}\right)\frac{(1-\kappa^{I})}{(\delta+g+n)+m(1-\kappa^{I})}}_{(-/+)}\right]. \tag{7}$$

The first term in the bracket reflects the immigrants' role in diffusing knowledge on technology and market-supporting institutions from frontier countries, whereas the second term in the bracket shows the effect of human capital accumulation. Specifically, the sign of the second term is dependent on κ^{I}, i.e., the ratio of the average human capital of immigrants to that of workers in the host economy. If $\kappa^I > 1$ ($\kappa^I < 1$), immigration is more likely to affect economic growth positively (negatively).

This analysis suggests that the choice of the origin and destination countries has an impact on the magnitude of economic growth in the host country because it influences the values of ϕ, ϕ', and κ^I. With other things equal, less-developing countries have the lower value of ϕ and higher ϕ' than developed countries, because the number of people with knowledge on better technology and institutions is less than that in developed countries. Moreover, immigration from developed to developing countries is associated with an even higher κ^I.

The three kinds of immigration flow should be distinguished in terms of the magnitude of immigration on growth. First, the case of immigrant flows from developed countries to developing ones, which is the most restricted in terms of the choice of the sample countries, has the highest ϕ' and κ^I and the smallest ϕ, thereby resulting in the largest effect of immigration on growth in the host countries. If developed countries are excluded from the host nations, the first term in bracket in Equation (7) increases because of the lower ϕ and higher ϕ'. This term also causes the value of κ^I, which refers to the ratio of average human capital of immigrants to that of the host countries, to increase because countries with higher average human capital are excluded from the host countries.[4] These variables imply that the origin of immigrants plays a crucial role in facilitating economic growth in the host country. Second, immigration from developed countries only is considered, but both developed and developing countries are included in the host countries. In this case, ϕ is

[4] This can be more clearly explained by the following equation:

$$\left[\phi' \frac{g^w}{\phi(\phi + g^w)} - \frac{\alpha(1-\kappa^I)}{(\delta + g + n) + m(1-\kappa^I)}\right] < \left[\phi'_r \frac{g^w}{\phi_r(\phi_r + g^w)} - \frac{\alpha(1-\kappa_r^I)}{(\delta + g + n) + m_r(1-\kappa_r^I)}\right],$$

where the subscript r implies the restricted sample, $\kappa^I < \kappa_r^I$, $m > m_r$, $\phi > \phi_r$, and $\phi' < \phi'_r$.

expected to be larger but ϕ' and κ^I are smaller compared with the first case. Hence, the impact of immigration on the economic growth of the host country is smaller than that in the first case. Third, both developed and developing countries are included in the origin countries as well as in the host countries. This type of immigration results in the smallest κ^I among the three cases and larger ϕ compared with the first case, suggesting that the effect of immigration on growth is lower compared to the two other cases. Therefore, the third type of immigration has the smallest effect on the economic growth of a host country.

3. Estimation Strategy

3.1 Model Specification and Data

On the basis of the conceptual framework presented in Section 2, we construct the following equation in a panel data setting:

$$\ln(y_{i,t}) = \beta_1 \ln(y_{i,t-1}) + \beta_2 imm\_index_{i,t} + \varphi' Z_{i,t} + \alpha_i + \mu_t + e_{i,t}, \qquad (8)$$

where $\ln(y_{i,t})$ and $\ln(y_{i,t-1})$ are the current and lagged logarithms of real GDP per capita in the country i at time t, respectively; $imm\_index_{i,t}$ is the ratio of the number of immigrants (the immigrant stock) to the number of total population in the country i at time t; $Z_{i,t}$ contains other classic growth variables in growth regression, such as the average of investment/GDP ratio (proxy for saving rate), the lagged value of second enrollment rate and the average of population growth rate, $\alpha_{i,}$ is the country-specific effect; $\mu_{t,}$ represents the time-specific effects; and $e_{i,t}$ is the error term.

Although separately identifying ϕ and κ^I in Equation (7) is not possible due to data limitation, we are able to check which type of immigration affects economic growth by combining the different indices of immigration with the varying sample of the host nations. We use the two measures of immigration, namely, the ratio of immigrant stock from all countries to the number of population in the country i at time t ($imm\_ratio_{i,t}$) and the ratio of immigrant stock only from

MICs to the number of population in the country i at time t ($immMIC\_ratio_{i,t}$).[5] The magnitude of the coefficient on $immMIC\_ratio_{i,t}$ should be greater than that of $imm\_ratio_{i,t}$ because Equation (9) holds and M / M_{MIC} is greater than 1, that is:

$$\frac{\partial \ln \hat{y}(t_2)}{\partial m_{MIC}} = \frac{M}{M_{MIC}} \times \frac{\partial \ln \hat{y}(t_2)}{\partial m}, \tag{9}$$

where M is the immigrant stock, and M_{MIC} is the immigrant stock from the major industrialized countries.

Next, we estimate the three models. In Model 1, we use as an immigration index, $imm\_ratio_{i,t}$. In addition, we include both developed and developing countries in the list of host nations. In other words, Model 1 looks at the effect of the general immigration on economic growth of the destination country. Model 2 employs an alternative index, $immMIC\_ratio_{i,t}$. We also use the entire list of countries, including both developed and developing countries in the host nations. This specification allows us to analyze the growth-enhancing effect of immigration from MICs. Model 3 has the same specification as Model 2, but the sample of host countries excludes the MICs. In other words, we look at the effect of immigration only from the MICs on less advanced countries. The difference in the estimates between Model 2 and Model 3 is attributed to changes in ϕ, ϕ', and κ^I. Hence, Model 3 can highlight the carriage of better knowledge on technology and higher quality of institutions by immigrants from more advanced countries, which may affect economic growth in less advanced host countries.

To measure the ratio of the immigrant stock to the entire population, we use the Global Bilateral Migration Database from the World Bank. This dataset spans the period from 1960 to 2000,

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[5] The major industrial countries include a total of 18 nations, namely, Australia, Austria, Belgium, Canada, Germany, Denmark, Finland, France, United Kingdom, Ireland, Italy, Netherlands, Norway, New Zealand, Sweden, United States, Switzerland, Luxembourg.

and is disaggregated by gender, origin country and destination country, but not by education. The data refer to the period split in five sub-periods of ten years each. This larger time period than previous data used in literature enables us to examine the long-run impact of immigration on the economic growth of a host country. Additionally, these data are collected by destination countries; hence, they are more reliable. Meanwhile, keeping track of the people who leave the country of origin is difficult.

According to this data set, the share of the flow from the MICs to the other countries is small, about 5% of total immigrants. Panel (a) in Table 1 reports the rankings of the MICs from which people immigrate to other countries. Until 1970, the largest number of immigrants came from Italy, but the U.S. became the first country in terms of the number of immigrants moving to other countries since 1980. Panel (b) suggests that the top four source countries in terms of the number of immigrants according to Panel (a) tend to have a colonial history, the stock of existing same ethnic group, or closer economic ties with the host countries.

Aside from the immigration ratio, Equation (9) includes real GDP per capita, the growth rate of population, the savings rate, and the rate of investment in human capital. Output y is measured by per capita real GDP (constant prices 2000). The saving rate is approximated by the share of investment in real GDP. The ratio of the sum of exports and imports to GDP is used to measure openness. These data come from Penn World Table 7.1 version. We also use the secondary enrollment rate as a proxy for the rate of investment in human capital, which comes from the World Development Indicator.

Table 2 presents the summary statistics of main variables in the sample. The average of $immMIC\_ratio_{i,t}$ in the other countries is smaller than that of $immMIC\_ratio_{i,t}$ in the MICs. We find that $immMIC\_ratio_{i,t}$ is positively correlated to $imm\_ratio_{i,t}$, with a sample correlation coefficient of 0.274. Figure 2 shows a scatter plot of the logarithm of per capita real GDP and the ratio of immigrant stock from MICs to the number of population. The scatter plot suggests the positive relationship between the two. However, Figure 2 is merely suggestive because of the existence of econometric issues that we should address.

3.2. Econometric Issues

The endogeneity problem may arise in empirical estimations when migration is included as an independent variable. This arises because immigrants choose a country to live in mainly on the basis of differences in wages or income per capita between the origin and destination countries. Hence, the economic performance of the host country can affect the decision to immigrate, which leads to reverse causality. This problem, in turn, results in a biased estimation of the effects of immigration on economic performances. We use an instrument variable approach to deal with this endogeneity problem. We choose our instruments on the basis of two main findings in literature: (i) geographic variables are important in estimating bilateral migration flows (Mayda 2008; Berthelemy, Beuran, Maurel 2009; Peri and Ortega 2009); and (ii) migration is positively correlated with past settlements of immigrants (Beine, Docquier, and Ozden 2009; Colliner and Hoeffler 2011). The former is related to an external instrument variable approach, whereas the latter is related to its own lagged variable and, therefore, an internal instrument variable approach. We use the gravity equation and GMM estimator for the external and internal instrument approaches, respectively.[6]

3.2.1 External instrument variable: Gravity instrument

To avoid the endogeneity problem, Felbermayr, Hiller and Salo (2008), Mayda (2008), and Ortega and Peri (2009) use the instrument variable based on the gravity equation of immigration. This instrument uses the fact that geographic variables are exogenous to growth and are associated with the decision to immigrate. The distance between the origin and destination countries can be

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[6] We prefer the results from the system-GMM estimator for the following reasons. First, the previous stock of migrants is the most important determinant of migration, as documented by Colliner and Hoeffler (2011). Second, estimating a dynamic equation, such as Equation (8) leads to biases (Nickell 1981).

correlated with the cost of migration. Specifically, a common land border is likely to encourage migration. Moreover, past or present colonial relationship should increase the bilateral flows of migration due to strong political and economic relations between the two countries.

We follow the same approach adopted by Ortega and Peri (2009) to estimate Equation (9). Here, we use such geographic variables as distance, the existence of a common language, the existence of a present or past colonial link, and geographic contiguity to determine the probability of immigration. The aggregated value for each destination country predicted from this first stage is employed as an instrumental variable for the equation for economic growth. Therefore, this instrument variable is likely to be correlated with immigration flows but independent from economic growth, as expressed by:

$$\ln(imm_{i,j,t}) = \beta_1 \ln(pop_{i,t}) + \beta_2 \ln(pop_{j,t}) + \beta_3 \ln(dist_{i,j}) + \beta_4 com_{i,j} + \beta_5 col_{i,j} + \beta_6 cont_{i,j} + \varepsilon_{i,j,t}, \quad (10)$$

$$\ln(immMIC_{i,j,t}) = \beta_1 \ln(pop_{i,t}) + \beta_2 \ln(pop_{j,t}) + \beta_3 \ln(dist_{i,j}) + \beta_4 com_{i,j} + \beta_5 col_{i,j} + \beta_6 cont_{i,j} + \varepsilon_{i,j,t}, \quad (11)$$

where $\ln(imm_{i,j,t})$ is the logarithm of immigrant stock from all sample countries i to country j at time t, $\ln(immMIC_{i,j,t})$ is the logarithm of immigrant stock from countries i (the MICs) to j at time t, $\ln(pop_{i,t})$ is the logarithm of (origin) country i population, $\ln(pop_{i,t})$ is the logarithm of (destination) country j population at time t, $\log(dist_{i,t})$ is the logarithm of distance from countries i to j, $com_{i,j}$ is the dummy variable for common language between countries i and j, $col_{i,j}$ is the colonial history between countries i and j, $cont_i$ is the geographical contiguity between countries i and j, and $\varepsilon_{i,j,t}$ represents the country-specific ($\alpha_{i,}$) and time-specific ($\mu_{t,}$) effect as well as the error term ($e_{i,t}$), respectively.[7]

To estimate Equations (10) and (11), we employ a Pseudo-Poisson Maximum Likelihood

[7] The data used in the regression are obtained from Mayer and Zignago (2011).

(PPML) estimator. In the log linear specification, such as in Equations (10) and (11), the OLS estimates tend to be biased because of the zero values of the dependent variable (16.3 % in the sample). Hence, rather than discarding the observations with $immMIC_{i,j,t} = 0$, some authors attempt to use OLS using $immMIC_{i,j,t} + 1$ as the dependent variable and a Tobit estimator. However, Santos, Silva, and Tenreyro (2006) argue that in the presence of heteroskedasticity, the PPML is a better estimator than the OLS or Tobit estimator in dealing with the problem of censored distribution.[8]

3.2.2 Internal instrument: GMM estimator

Migration is positively correlated with past settlements of immigrants (Beine, Docquier, and Ozden 2009). Immigrants already living in the destination country help new immigrants reduce the cost of settlement and look for appropriate jobs. This indicates that information on the past stock of immigrants is an instrument relevant to newer flows of immigration. Furthermore, it satisfies an exogeneity condition to become a valid instrument, because new immigration cannot affect the past immigrant stock (Cortes 2008; Altonji and Card 2001).

The system GMM estimator uses the lagged immigrant stock as the instrument variable. As documented by Blundell and Bond (1997), the system GMM is derived from the estimation of a system of two simultaneous equations, one in levels (with lagged first differences as instruments) and the other in first differences (with lagged levels as instruments). In other words, this estimator employs the over-identified set of lagged immigrant stock as instrument variables. Additionally, it has an advantage of addressing the problem of dynamic structure in Equation (9) in a way that reduces the Nickell (1981) bias. The system GMM mitigates biases arising from omitted variables, including both time-invariant and time-variant ones, endogeneity, and measurement errors (Arellano and Bover, 1995; Blundell and Bond, 1997). Lee and Kim (2009) apply the system GMM estimator

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[8] Poisson Pseudo Maximum Likelihood (PPML) assigns the same weight to all observations. Santos, Silva, and Tenreyro (2006) point out that this is the most natural procedure without any further information on the pattern of heteroskedasticity.

to an economic growth model augmented by innovation.

To use the system GMM estimator, two criteria must be satisfied: the test for serial correlation in the first-differenced errors and the Sargan test for overidentifying restrictions. Given that a system has the first-differenced components, the first test aims to check whether or not serial correlation exists among the error terms. The Sargan test evaluates the validity of instruments. We are also concerned with overfitting and finite sample biases for the system GMM estimator. Bowsher (2002) shows that employing too many instruments in a GMM estimation causes the p-value of the Sargan test to be close to 1, implying that the accuracy of this test is poor. To correct this problem, this current study restricts the instrument sets by not using lags further than $t-4$. This correction could improve the ability of the test in overidentifying restrictions despite some loss in the efficiency of the estimates brought about by fewer instrument variables. We also apply Windmeijer's (2005) correction for small sample bias in standard errors.

4. Estimation Results

Table 3 presents the estimation results of Models 1 to 3 of Equation (9) using fixed-effects regressions. Our key variable – immigration – is insignificant in Model 1, suggesting that general immigration without considering the origin country neither promotes nor deters growth. In contrast, immigration from MICs presented in the results from Models 2 and 3 positively affects growth. Moreover, the impact of immigration on the economic growth of the host countries is larger than that observed in Model 1; it also turns out to be significant when $imm\_ratio_{i,t}$ used in Model 1 is replaced $immMIC\_ratio_{i,t}$ in Models 2 and 3. These results concur with our prediction that the immigrant stock from the MICs is smaller than those from all countries. In Model 3 where the MICs are excluded from the sample of host countries, the coefficient of $immMIC\_ratio_{i,t}$ is significantly larger than $immMIC\_ratio_{i,t}$ in Model 2 that uses all samples. This result can be attributed to the differences in the intensity of knowledge spillover (ϕ) and in the relative average human capital of immigrants (κ^I) in Equation (7). In more detail, the exclusion of MICs from the sample of host countries results in a higher average value of κ^I. At the same time, it leads to higher marginal value of immigrants on the spillover effect (ϕ'), because the average immigrant stock from MICs is smaller. In sum, these results suggest that the origin of immigrants plays a crucial role in promoting economic growth in the host countries due to the widening gap – in terms of technology and market-supporting institutions – between the origin and destination countries.

The results on other variables concur with the findings from related literature. The average logarithm of investment share is positively and significantly associated with the growth of per capita real GDP at the 1% level. Enrollment in secondary schools positively and significantly affects the growth of per capita real GDP at the 5% level, except in Model 3. Openness is positively but insignificantly related to economic growth, which is often found in other studies (Harrison, 1996; Rodriguez and Rodrik, 2000; Rodrik et al., 2004; Wacziarg and Welch, 2008).[9] Finally, the average growth rate of population is negatively and insignificantly related at the 10% level of significance.

The signs and magnitudes of the coefficients of our key variables coincide with our expectation. However, as discussed previously, these variables may suffer from the endogeneity problem, which leads to biased estimates. Thus, to obtain more reliable results, this study uses the two instrumental variable approaches, namely, the gravity equation and the system GMM estimator, and the results are reported in Tables 4 and 5, respectively.

Table 4 shows the estimates of $immMIC\_ratio_{i,t}$ using the gravity equation as an instrumental variable. To construct the instrumental variables, we estimate the gravity equation for immigration as shown in Equations (10) and (11), respectively. Panel (b) in Table 4 presents the estimates of Equations (10) and (11) using PPML. The existing colonial relationship, common land

[9] Freund and Bolaky (2008) and Chang et al. (2009) show that the growth effect of trade openness is significantly positive only if certain complementary domestic reforms are undertaken, including deregulations of business, financial developments, better education or rule of law, labor market flexibility, and so on.

border, the population of the origin country, the population of the destination country, and common language are positively and significantly associated with the log of immigrant stocks from the MICs at the 1% level, whereas the physical distance between the origin and destination countries is negatively and significantly related. The high F-test statistics suggest that these are relevant instruments in all models. Using these results, we construct the instrumental variable by aggregating the fitted values for each destination country. According to Panel (a) in Table 4, the estimate from the two-stage least squares (2 SLS) estimator is smaller than those within the estimator. This implies that the positive correlation between the variable of our interest and the error term is controlled.

In Table 5, we present results from the system GMM estimations. The stock of immigration from the MICs is, again, significant at the 10% significance level. The result implies that a 1% point increase in the ratio of immigrant stock to the number of total population raises the growth rate of per capita real GDP by 8%. It also indicates that the growth of $immMIC\_ratio_{i,t}$ by 1% results in increasing per capita real GDP by 0.04%.[10] All three diagnostic statistics in Table 5 are satisfactory. The Hansen test does not reject the over-identification restrictions, and the null of no second-order serial correlation is not rejected. Furthermore, the magnitude of the coefficient of $immMIC\_ratio_{i,t}$ in Table 5 lies between the estimator and the 2 SLS estimator, indicating that a finite sample bias associated with weak instruments is not present.

We sharpen our estimates by excluding transition economies in Eastern Europe from our sample. Free migration into these economies from the world began after the collapse of socialist states in the late 1980s and the early 1990s. Hence, the presence of these economies in our sample of host countries does not allow the use of lagged variables before 1990s in GMM, which is likely to result in reduced precision in estimates. Table 6 shows the estimation results of Model 3 using the sample of host countries excluding former socialist countries in Eastern Europe. These results are

[10] Given that the average of $immMIC\_ratio_{i,t}$ is 0.5% in Table 1 and the value of $immMIC\_ratio_{i,t}$ increases by 1%, the growth rate is about 200% because [(1.5-0.5)/(0.5)]*100=200%.

similar to those presented in Tables 3 to 5. Furthermore, $immMIC\_ratio_{i,t}$ becomes more significant in system GMM estimations compared with the results in Table 5.

5. Summary

This paper finds that the origin and the destination countries in immigration matter especially where economic growth is concerned. Immigrants from the MICs positively affect the economic growth in the host country, whereas general immigration without considering the origin country neither promotes nor deters growth. In addition, the effect of immigration from the NMCs on growth in the host countries is significantly larger in estimations that involve only less developed countries as host countries than in those that include both MICs and less developed countries. These findings can be interpreted as follows: the effect of immigration on economic growth in the host countries depends on the gap in the quality of technology and institutions between the origin and the host countries. In other words, the results indicate that immigrants from the MICs to less developed countries are more likely to be carriers of better knowledge and institutions.

These findings suggest that the effect of immigration on growth in the host country is sensitive to the choice of the sample countries. The results on the growth-enhancing effects of immigration differ significantly depending on which countries are included in the samples of origin and destination countries. Hence, researchers dealing with the relationship between immigration and growth should be aware that their results can be sample-specific.

Our findings shed some light on the strategy for economic growth in less-developing countries. The attraction of foreigners from advanced countries can be effective in improving technology and institutions, in addition to the positive contributions made in the areas of trade (Coe and Helpman, 1999) and business travel (Hovhannisyan and Keller, 2012). An investigation on why people migrate from rich to poor countries and what policies encourage such movements shall serve as important research topics for our future research.

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Figure 1. The logarithm of per capita GDP vs. the ratio of immigrant stock from major industrialized countries

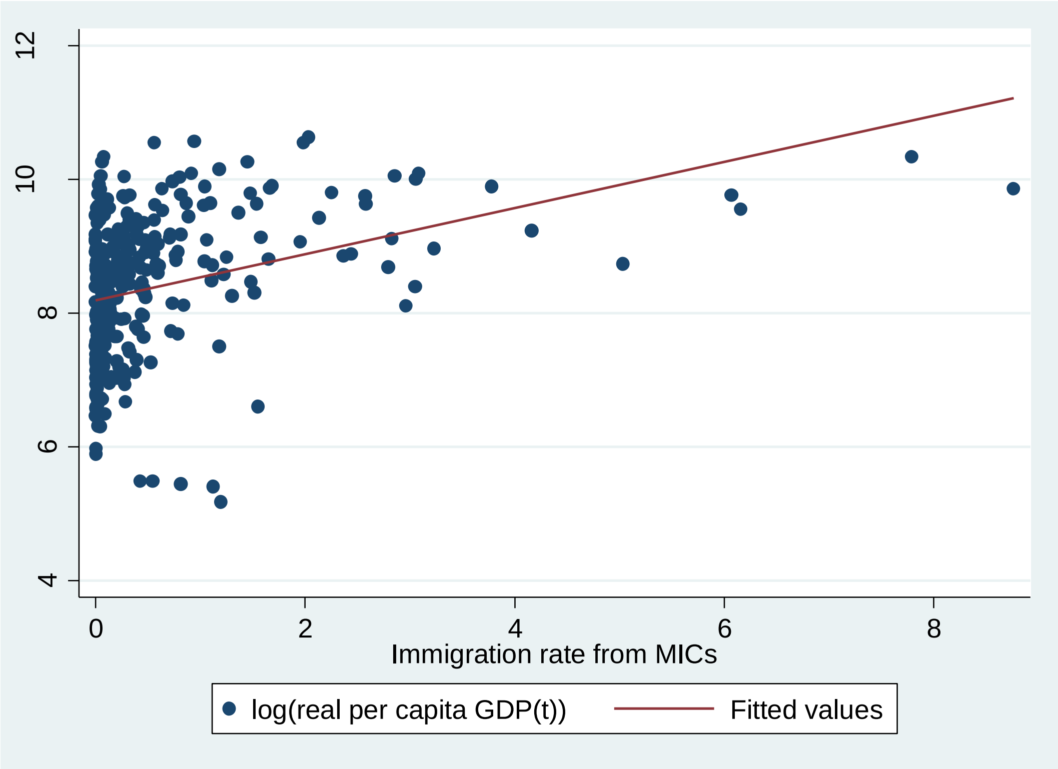

Table 1. Descriptive statistics of immigrant stocks

Panel (a): The rankings of origin countries among the major industrialized countries

	1960		1970		1980		1990		2000	
Australia	35,454	10	53,606	9	50,310	11	76,659	11	135,465	7
Austria	70,934	8	64,650	8	121,939	6	97,689	7	137,137	6
Belgium	789,151	3	179,535	6	106,877	7	98,294	6	103,892	11
Canada	32,925	11	42,728	11	66,977	10	82,777	10	117,155	10
Switzerland	36,025	9	49,779	10	72,783	9	92,627	9	123,933	8
Germany	377,844	6	438,179	5	505,873	5	662,142	4	931,747	4
Denmark	9,483	14	14,881	13	18,083	13	24,617	14	30,418	14
Finland	4,060	18	4,479	17	5,539	17	8,666	16	16,305	16
France	810,733	2	687,927	3	757,014	4	782,714	3	960,024	3
U.K.	588,581	4	717,317	2	825,709	2	828,726	2	970,175	2
Ireland	6,080	16	3,757	18	1,388	18	1,342	18	1,519	18
Italy	**1,511,918**	**1**	**1,087,926**	**1**	805,031	3	625,177	5	473,183	5
Luxembourg	16,548	12	9,560	15	5,737	16	6,171	17	5,978	17
Netherlands	89,648	7	82,107	7	93,395	8	95,710	8	119,617	9
Norway	5,748	17	5,741	16	6,891	15	10,169	15	17,709	15
New Zealand	7,446	15	11,005	14	15,685	14	26,935	13	34,431	13
Sweden	15,808	13	17,462	12	24,991	12	26,986	12	46,133	12
U.S.	434,472	5	595,370	4	**846,205**	**1**	**994,371**	**1**	**1,356,576**	**1**

Panel (b): The rankings of top four origin countries with their associated host countries

1960		1970		1980		1990		2000	
Italy	ARG	Italy	ARG	USA	MEX	USA	MEX	USA	MEX
	BRA		BRA		NGA		JPN		ISR
	VEN		VEN		GRC		GRC		JPN
	TUN		URY		JPN		ISR		PHL
France	MAR	U.K.	ZAF	U.K.	ZAF	U.K.	IRL	U.K.	IRL
	DZA		IRL		IRL		ZAF		ZAF
	TUN		ZWE		ZWE		ESP		ESP
	ESP		ZMB		NGA		ZWE		ARE
Belgium	ESP	France	ESP	Italy	ARG	France	ESP	France	ESP
	ZAF		DZA		BRA		PRT		PRT
	BRA		MAR		VEN		DZA		ISR
	HUN		ARG		URY		MAR		DZA
U.K.	ZAF	U.S.	MEX	France	ESP	Germany	TUR	Germany	TUR
	HUN		JPN		DZA		ESP		ESP
	IRL		GRC		NGA		BRA		ISR
	ZWE		PHL		MAR		ZAF		PRT

Notes: ARE=United Arab Emirates, ARG=Argentina, BRA=Brazil, DZA=Algeria, ESP=Spain, HUN=Hungary, GRC=Greece, IRL=Ireland, ISR=Israel, JPN=Japan, MAR=Morocco, MEX=Mexico, NGA=Nigeria, PHL=Philippines, PRT=Portugal, TUN=Tunisia, TUR=Turkey, URY=Uruguay, VEN=Venezuela, ZAF=South Africa, ZMB=Zambia, ZWE=Zimbabwe.

Table 2. Summary statistics of the main variables

Variable	Total		MIC		Others	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
$\ln(RGDP_{i,t})$	8.85	1.12	10.12	0.31	8.49	0.99
$A\ln(gpop_{i,t})$	1.62	1.13	0.68	0.49	1.89	1.12
$A\ln(k_{i,t})$	3.082	0.37	3.080	0.20	3.082	0.40
$Aopen_{i,t}$	65.42	53.47	53.37	41.16	68.82	56.07
$\sec ondenrol_{i,t-1}$	41.42	32.56	62.35	34.87	35.51	29.36
$imm\_ratio_{i,t}$	6.17	9.84	10.04	6.88	5.08	10.28
$immMIC\_ratio_{i,t}$	1.42	2.77	4.67	4.26	0.51	0.98

Notes: MIC refers to the major industrialized countries in Appendix A.

Table 3. The effect of immigrants on per capita real GDP (fixed-effects estimator)

	Model 1	Model 2	Model 3
Sample	All	All	Restricted to non- MICs
$\ln(RGDP_{i,t-1})$	0.684***	0.679***	0.676***
	(0.065)	(0.066)	(0.069)
$A\ln(gpop_{i,t})$	-0.019	-0.018	-0.022
	(0.025)	(0.023)	(0.027)
$ALog(k_{i,t})$	0.264***	0.267***	0.258***
	(0.065)	(0.062)	(0.070)
$Aopen_{i,t}$	0.0004	0.0004	0.0003
	(0.0006)	(0.0006)	(0.0006)
$\sec ondenrol_{i,t-1}$	0.002**	0.002**	0.002
	(0.0008)	(0.0008)	(0.0013)
$imm\_ratio_{i,t}$	0.006		
	(0.007)		
$immMIC\_ratio_{i,t}$		0.026*	0.087**
		(0.014)	(0.037)
Time dummy	Yes	Yes	Yes
R-square	0.783	0.784	0.753
Observations	300	300	234
Number of id	90	90	72

Notes: [a]: Clustered-adjusted standard errors are reported in brackets. Significant variables at the 10%, 5%, and 1% significance levels are marked with *, ** and ***, respectively.

Table 4. Results from the 2 SLS: gravity IV

Panel (a):

	Model 1	Model 2	Model 3
	2SLS	2SLS	2SLS
$\ln(RGDP_{i,t-1})$	0.688***	0.688***	0.705***
	(0.065)	(0.065)	(0.068)
$A\ln(gpop_{i,t})$	-0.015	-0.018	-0.025
	(0.024)	(0.023)	(0.027)
$A\ln(k_{i,t})$	0.270***	0.267***	0.270***
	(0.062)	(0.063)	(0.067)
$Aopen_{i,t}$	0.0005	0.0004	0.0003
	(0.0006)	(0.0006)	(0.0006)
$\sec ondenrol_{i,t-1}$	0.002**	0.002**	0.0016
	(0.0008)	(0.0008)	(0.0013)
$\widehat{imm\_ratio}_{i,t}$	-0.0000001		
	(0.0000001)		
$\widehat{immMIC\_ratio}_{i,t}$		0.0004	0.053***
		(0.0006)	(0.013)
Time dummy	Yes	Yes	Yes
R-square	0.783	0.783	0.753
Observations	300	300	234
Number of id	90	90	72

Panel (b): First-stage regressions

	Model 1	Model 2	Model 3
	PLM	PLM	PLM
$\ln(pop_{i,t})$	0.277***	0.377***	0.299***
	(0.023)	(0.109)	(0.120)
$\ln(pop_{j,t})$	0.125***	0.090***	0.078***
	(0.002)	(0.004)	(0.004)
$contig_{i,j}$	0.202***	0.308***	0.149***
	(0.018)	(0.030)	(0.048)
$comlang_{i,j}$	0.501***	0.189***	0.118***
	(0.010)	(0.019)	(0.023)
$colony_{i,j}$	0.305***	0.271***	0.226***
	(0.017)	(0.026)	(0.030)
$\ln(dis\tan ce_{i,j})$	-0.180***	-0.105***	-0.101***
	(0.005)	(0.009)	(0.010)
Time dummy	Yes	Yes	Yes
Origin country dummy	Yes	Yes	Yes
R2	0.354	0.406	0.483
F-test exclu. Ins.	22451.9	5423.1	4545.5
Log likelihood	-90572.9	-18139.6	-12,653.7
Observations	37,800	7,560	5,940

Notes: [a]: Clustered-adjusted standard errors are reported in brackets. Significant variables at the 10%, 5%, and 1% significance levels are marked with *, ** and ***, respectively.

Table 5. Results from the GMM estimator

	Model 1	Model 2	Model 3
	SYS GMM	SYS GMM	SYS GMM
$\ln(RGDP_{i,t-1})$	0.889***	0.844***	0.870***
	(0.080)	(0.063)	(0.073)
$A\ln(gpop_{i,t})$	-0.087*	-0.102***	-0.039
	(0.052)	(0.035)	(0.054)
$A\ln(k_{i,t})$	0.401***	0.516***	0.460***
	(0.130)	(0.113)	(0.151)
$Aopen_{i,t}$	-0.0002	0.0005	-0.0002
	(0.001)	(0.0007)	(0.0009)
$\sec ondenrol_{i,t-1}$	0.004*	0.0047***	0.0041*
	(0.002)	(0.0015)	(0.0023)
$imm\_ratio_{i,t}$	0.001		
	(0.004)		
$immMIC\_ratio_{i,t}$		0.003	0.079*
		(0.013)	(0.047)
Time dummy	Yes	Yes	Yes
AR(1)/AR(2)	0.000/0.199	0.001/0.312	0.002/0.362
Hansen test	0.281	0.791	0.710
Observations	300	300	234
Number of id	90	90	72

Notes: [a]: Robust standard errors are reported in brackets. Significant variables at the 10%, 5%, and 1% significance levels are marked with *, ** and ***, respectively. [b]: This system-GMM uses lags up to *t*-4 as instrument to avoid overfitting biases.

Table 6. Results in the sample excluding transition countries

	Model 3 Within	Model 3 2 SLS	Model 3 SYS GMM
$\ln(RGDP_{i,t-1})$	0.676***	0.703***	0.874***
	(0.070)	(0.069)	(0.076)
$A\ln(gpop_{i,t})$	-0.020	-0.023	-0.025
	(0.027)	(0.027)	(0.062)
$A\ln(k_{i,t})$	0.256***	0.269***	0.473***
	(0.071)	(0.068)	(0.129)
$Aopen_{i,t}$	0.0004	0.00045	-0.0005
	(0.0007)	(0.0068)	(0.00096)
$\sec ondenrol_{i,t-1}$	0.0019	0.0018	0.004
	(0.0013)	(0.0013)	(0.0026)
$imm\_ratio_{i,t}$	0.082**		
	(0.037)		
$immMIC\_ratio_{i,t}$		0.051***	0.130**
		(0.013)	(0.059)
Time dummy	Yes	Yes	Yes
R2	0.759	0.759	
AR(1)/AR(2)			0.001/0.344
Hansen test			0.766
Observations	218	218	218
Number of id	62	62	62

Notes: [a]: Robust standard errors are reported in brackets. Significant variables at the 10%, 5%, and 1% significance levels are marked with *, ** and ***, respectively. [b]: This system-GMM uses lags up to *t*-4 as instrument to avoid overfitting biases.

Appendix: A. List of 90 countries included in the sample

The MICs (18)	The other countries (72)
Australia, Austria, Belgium, Canada, Germany, Denmark, Finland, France, United Kingdom, Ireland, Italy, Netherlands, Norway, New Zealand, Sweden, United States, Switzerland, Luxembourg	United Arab Emirates, Argentina, Bahamas, Bolivia, Brazil, Chile, China, Congo, Colombia, Costa Rica, Cyprus, Dominican Republic, Algeria, Ecuador, Egypt, Guatemala, Honduras, Haiti, Indonesia, India, Iran, Israel, Jamaica, Jordan, Kenya, Korea, Kuwait, Lebanon, Sri Lanka, Morocco, Mexico, Malta, Malaysia, Nigeria, Nicaragua, Pakistan, Panama, Peru, Philippines, Paraguay, Saudi Arabia, Senegal, Singapore, El Salvador, Syrian, Thailand, Trinidad and Tobago, Tunisia, Turkey, Taiwan, Uganda, Uruguay, Venezuela, South Africa, Zambia, Zimbabwe, Spain, Greece, Ireland, Portugal, Japan, Hong Kong, Czech Republic, Estonia, Croatia, Russia, Slovakia, Slovenia, Poland, Hungary, Bulgaria, Romania

Appendix: B. Real GDP per capita at the steady state

Aggregate output Y is assumed to be produced from technology (A), physical capital (K), human capital (H) and labor (L), using a Cobb-Douglas function with constant returns to scale. Labor is augmented by technology and institutions (A) which grows at the rate g, and is given by:

$$Y = H^{\alpha} K^{\beta} (AL)^{1-\alpha-\beta}, \quad \alpha + \beta < 1. \tag{B.1}$$

Labor force growth is given by:

$$\frac{\dot{L}}{L} = n + \frac{M}{L} = n + m, \tag{B.2}$$

$$\dot{H} = s_h Y - \delta H + M\kappa^I \frac{H}{L} = s_h Y - \delta H + m\kappa^I H, \tag{B.3}$$

where M is the immigrant stock, n is the growth rate of the labor force due to the demographic factor, m is the ratio of immigrant stock to the entire population of the host country, s_H is the fraction of resources devoted to human capital accumulation, δ is the depreciation rate of human capital, κ^I is the relative average human capital of immigrants compared with the average human capital per worker in the host economy. The dynamics of physical capital are the same as those in the

Solow model. The depreciation rate of capital is assumed to be the same as that of human capital expressed as:

$$\dot{K} = s_K Y - \delta K, \tag{B.4}$$

where s_K is the savings rate. Using units of labor ($\hat{y} \equiv Y/(AL)$, $k \equiv K/(AL)$ and $h \equiv H/(AL)$), the production function is given by:

$$\hat{y} = h^{\alpha} k^{\beta}. \tag{B.5}$$

The evolution of the economy is determined by:

$$\dot{k} = s_K \hat{y} - (\delta + g + n)k, \tag{B.6}$$

$$\dot{h} = s_H \hat{y} - [\delta + g + n + m(1-\kappa^I)]h. \tag{B.7}$$

The economy converges to a steady state defined by:

$$k^* = \left(\frac{s_K}{\delta + g + n}\right)^{\frac{1}{1-\alpha-\beta}} \left(\frac{s_H}{[\delta + g + n + m(1-\kappa^I)]}\right)^{\frac{\alpha}{1-\alpha-\beta}}, \tag{B.8}$$

$$h^* = \left(\frac{s_H}{[\delta + g + n + m(1-\kappa^I)]}\right)^{\frac{1}{1-\alpha-\beta}} \left(\frac{s_K}{s_H} \frac{[\delta + g + n + m(1-\kappa^I)]}{(\delta + g + n)}\right)^{\frac{\beta}{1-\alpha-\beta}}. \tag{B.9}$$

Finally, we obtain the steady-state real GDP per effective worker in Equation (B.10).

$$\hat{y}^* = \left(\frac{s_K^{\alpha(1+\beta)} \cdot s_H^{\alpha}}{(\delta + g + n)^{\beta(1+\alpha)}[\delta + g + n + m(1-\kappa^I)]^{\alpha}}\right)^{\frac{1}{1-\alpha-\beta}}. \tag{B.10}$$

Appendix: C. Speed of convergence

Following Boubtane and Dumont (2010) and using Equations (B.4), (B.6) and (B.7), we obtain the following equation:

$$\frac{\dot{\hat{y}}}{\hat{y}} = \alpha\left[s_H \frac{\hat{y}}{h} - (\delta + g + n + m(1-\kappa^I))\right] + \beta\left[s_K \frac{\hat{y}}{k} - (\delta + g + n)\right]. \tag{C.1}$$

Given that $\dot{k} = 0$ and $\dot{h} = 0$ are at the steady state, we can respectively rewrite (B.6) and (B.7) as:

$$s_K \frac{\hat{y}^*}{k^*} = (\delta + g + n), \quad \text{(C.2)}$$

$$s_H \frac{\hat{y}^*}{h^*} = (\delta + g + n) + m(1-\kappa^I). \quad \text{(C.3)}$$

Therefore, Equation (C.1) is as follows:

$$\frac{\dot{\hat{y}}}{\hat{y}} = \alpha\left[s_H \frac{\hat{y}}{h} - s_H \frac{\hat{y}^*}{h^*}\right] + \beta\left[s_K \frac{\hat{y}}{k} - s_K \frac{\hat{y}^*}{k^*}\right] = \alpha s_H \frac{\hat{y}^*}{h^*}\left[\left(\frac{h}{h^*}\right)^{\alpha-1}\left(\frac{k}{k^*}\right)^{\beta} - 1\right] + \beta s_K \frac{\hat{y}^*}{k^*}\left[\left(\frac{h}{h^*}\right)^{\alpha}\left(\frac{k}{k^*}\right)^{\beta-1} - 1\right].$$

(C.4)

Note that:

$$\left(\frac{h}{h^*}\right)^{\alpha-1}\left(\frac{k}{k^*}\right)^{\beta} - 1 = \exp\left[(\alpha-1)\ln\left(\frac{h}{h^*}\right) + \beta\ln\left(\frac{k}{k^*}\right)\right] - 1. \quad \text{(C.5)}$$

Around the steady state, $\left[(\alpha-1)\ln\left(\frac{h}{h^*}\right) + \beta\ln\left(\frac{k}{k^*}\right)\right]$ is small, so; thus, we can use exponential approximation such as $e^x = 1 + x$. Hence,

$$\begin{aligned}\frac{\dot{\hat{y}}}{\hat{y}} &= \alpha(\delta+g+n)\left[(\alpha-1)\ln\left(\frac{h}{h^*}\right) + \beta\ln\left(\frac{k}{k^*}\right)\right] + \beta((\delta+g+n) + m(1-\kappa^I))\left[\alpha\ln\left(\frac{h}{h^*}\right) + (\beta-1)\ln\left(\frac{k}{k^*}\right)\right] \\ &= -(\delta+g+n)\left[(1-\alpha-\beta)\ln\left(\frac{\hat{y}}{\hat{y}^*}\right) + \beta\frac{m(1-\kappa^I)}{(\delta+g+n)}\left(\ln\left(\frac{\hat{y}}{\hat{y}^*}\right) - \ln\left(\frac{h}{h^*}\right)\right)\right]\end{aligned}.$$

(C.6)

For $\frac{m(1-\kappa^I)}{(\delta+g+n)}$ small, $\beta\frac{m(1-\kappa^I)}{(\delta+g+n)}\left(\ln\left(\frac{\hat{y}}{\hat{y}^*}\right) - \ln\left(\frac{h}{h^*}\right)\right)$ may be neglected. Thus, as the economy converges to the steady state, the rate of growth can be expressed as:

$$\frac{\dot{\hat{y}}}{\hat{y}} = -(\delta+g+n)(1-\alpha-\beta)\ln\left[\frac{\hat{y}}{\hat{y}^*}\right]. \quad \text{(C.7)}$$

The rate of convergence is given by:

$$\lambda = (1-\alpha-\beta)(\delta+g+n). \quad \text{(C.8)}$$