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Revisiting a Gravity Model of Immigration: A Panel Data Analysis of Economic Determinants*

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This study investigates the effect of economic factors on immigration using the gravity model of immigration. Cross-sectional regression and panel data analyses are conducted from 2000 to 2019 using the OECD International Migration Database, which consists of 36 destination countries and 201 countries of origin. The Poisson pseudo-maximum-likelihood method, which can effectively correct potential biased estimates caused by zeros in the immigration data, is used for estimation. The results indicate that the economic factors strengthened after the global financial crisis. Additionally, this effect varies depending on the type of immigration (the income level of origin country). The gravity model applied to immigration performs reasonably well, but it is necessary to consider the country-specific and time-varying characteristics.

Keywords: Gravity Model, Immigration, Poisson Pseudo-maximum Likelihood

JEL Classification: F22, C51

I. Introduction

The movement of population between countries is subject to several additional constraints compared to those of capital or goods. Although the cross-border movement of capital has differed depending on the type of investment in the last few decades, when the degree of capital account openness has progressed significantly around the globe (Lane and Milesi-Ferretti, 2007), foreign investors' capital flows through integrated financial markets are very frequent. Sometimes, capital movements are sudden, which lead to financial crises (Mendoza, 2016). Due to the extensive global value chain, the import and export of intermediate goods as well as final goods are now a common economic phenomenon (Hummels et al., 2001).

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However, the scale and pattern of immigration differ among countries, as they tend to be determined by immigration policies or special relations between countries.[1] In addition, with the exception of immigration determined by specific events (war refugees and international political situations);[2] most immigration tends to be influenced by mid- to long-term trends rather than capital movements, which show high volatility in the short term.

In traditional economic theory, cross-border movement of the population has been studied, focusing on labor as a factor of production. Therefore, in this theoretical model, immigration occurs as workers move from a country with low wages to another country with high wages (Friedberg and Hunt, 1995; Card, 2001; Borjas, 2003).[3] While immigration is easy to understand through this clear channel, the limitations of the theoretical model tend to be simplistic.

Immigration is not only a means of supplying labor in foreign countries, but is also closely related to the movement of one's place of residence; therefore, immigration is affected by various factors. This study attempts to build an empirical model that explains immigration in terms of economic, geographic, historical, and cultural factors. To this end, the gravity model of trade (Tinbergen, 1962; Ball, 1967; Anderson, 1979; Deardorff, 2011) is applied to immigration; however, some explanatory variables in the traditional gravity model are replaced with explanatory variables that are relevant to immigration. After controlling for other factors, the study extends its focus on economic factors.

The OECD International Migration Database is used for this analysis. It is a bilateral country panel dataset consisting of 36 destination countries of immigration and 201 countries of origin. The analysis took place from 2000 to 2019 (annual data).[4] The

[1] Great diversity in immigration across countries is mainly sourced from different immigration policies (Borjas, 1999). de Haas et al. (2019) examine the effectiveness of migration policies using new global data. This paper investigates the relationship between migration policies and its trends.

[2] A study has analyzed the economic effect of immigrants from Cuba to Miami, USA for political reasons (Card, 1990), and a similar study analyzed the effect of the Israeli labor market due to the immigration of Russian Jews to Israel (Gandal et al., 2004).

[3] The empirical evidence is also presented in Taylor and Williamson (1997). Migrants from the Old World to the New World (Americas and Australia), which had been actively progressed from 1870 to 1913, left the Old World for new opportunities in the New World, especially for higher wages. At that time, the average real wage in the New World was almost three times higher than in Europe.

[4] In this paper, the analysis period is set after the period analyzed in the previous study, Lewer and Van den Berg (2008).

unbalanced panel has missing values in some country-pairs. The explanatory variables included in the gravity model are the number of population, Gross Domestic Product (GDP) per capita, distance, and dummy variables indicating neighboring countries (contiguity), common language, common colonizer, regional trade agreement (RTA), and common legal system. The gravity model of trade is a static model. Thus, the sample period is divided into two equal periods (8-year) before and after the 2008 global financial crisis (GFC). Cross-sectional regression is conducted using the average values for each period. In addition to the static model, panel data analysis to investigate the dynamics of economic factors, including time and country fixed effects is conducted.

The Poisson pseudo-maximum-likelihood (PPML) method is used to estimate the gravity model. Santos Silva and Tenreyro (2006) proposed this method. Since the standard empirical method may generate severely biased estimates resulting from zero immigrants (missing values), they propose a simple but effective method to address zeros in the immigration data.

The results of the cross-sectional regression reveal the fit (measured by R-squared) of the gravity model of trade (0.88) is higher than that of immigration. The gravity model applied to immigration reveals a model fit as high as the gravity model of trade, although it varies with the model specifications and sample periods (0.58~0.83). Population and distance are found to be closely related to immigration; this is similar to the general result in the gravity model of trade. In contrast, the control dummy variables—indicating contiguity, common language, and common colonizer—show considerable differences between the gravity models of trade and immigration.

Another cross-sectional regression was conducted for comparison with the results of a previous study, Lewer and Van den Berg (2008). In the current and previous studies, the number of population, distance, and common language are closely associated with immigration, whereas contiguity does not play an important role. The critical difference between the two studies is the result of GDP per capita, which reflects the economic factors (or motivation) of immigration. In Lewer and Van den Berg (2008), as the GDP per capita of the destination country increases relatively quickly compared with the GDP per capita of the country of origin (i.e., relative per capita GDP terms are included), immigration consistently increases. While this result is consistent with those of Lewer and Van den Berg (2008), the opposite can be seen in the current study. Thus, the current study examines the impact of the economic factors on immigration in detail through panel data analysis.

In the panel data analysis, the population and per capita GDP of destination and origin countries are separately considered instead of the multiplication of population and relative per capita GDP terms in the cross-sectional regression. Because of the panel data analysis, I find that the multiplication of population and the relative per capita GDP terms used in previous studies mask the different effects of destination and origin countries on immigration. Specifically, an increase in GDP per capita in the country of origin is associated with a decrease in immigration, whereas an increase in GDP per capita in the destination country is associated with an increase in immigration. The dominant effects vary with the type of immigration (income level of origin country and sample period). A similar result can be seen in the relationship between population and immigration.

Using panel data analysis, the study also examines whether the pattern of immigration differs before and after the GFC, and by country of origin. The analysis shows that economically motivated immigration has increased since the GFC. Economic factors are more closely associated with immigration when immigration occurs between high-income countries, whereas population changes play a relatively more important role in immigration from low- to high-income countries.

The same panel data analysis as above is also conducted by limiting the destination country to Korea in order to examine how different the effects of Korean-specific characteristics have on immigration compared with the panel data analysis results. Economic factors rather than population changes are closely associated with immigration in Korea. This trend also strengthened after the GFC. The countries of origin of immigrants to Korea are divided into low- and high-income, and the GDP per capita is estimated to be consistent with the overall panel data analysis results when the country of origin is low-income. However, when the country of origin is a high-income country, the sign is estimated to reverse or the statistical significance disappears. This can be interpreted as reflecting the Korean characteristic that most immigrants to Korea are from Asian low-income countries, leaving Korea to participate in the Korean labor market.

The study most relevant to the current study is that of Lewer and Van den Berg (2008). The authors applied the gravity model of trade to immigration. However, the sample period is different (in the current study, the data for the last 20 years are taken into consideration.). Therefore, this study uncovers new facts regarding immigration over the past 20 years. This study uses the PPML method instead of the standard empirical method, which can potentially cause biased estimators due to zero immigrants.

Additionally, new empirical results are derived by classifying the effects of origin and destination countries through panel data analysis.

The remainder of this paper is organized as follows: Section II discusses our data and empirical model, Section III presents empirical results, Section IV discusses the implications of the study for South Korea and Section V concludes.

II. Data and Empirical Model

1. Data

The number of immigrants required for empirical analysis is from the OECD International Migration Database. Immigrants are foreigners who hold a residence permit and have stayed a certain period of time (from 3 months to more than 9 months).[5] The data are on inflows and outflows of foreign population, thus these are a flow variable, not a stock variable. OECD statistics not only provides information on education, occupation, and class of immigrants, but also updates that information on immigrants, by country, annually. Therefore, these data are suitable for country panel data analysis with a relatively high frequency.[6] However, it should be noted that there is a limit to understanding the total number of migrants, as OECD statistics exclude those who immigrated to non-OECD countries as well as those under the age of 15 among OECD migrants (Lee, 2015).

The study comprised 36 sample countries and 201 countries of origin. Empirical analysis is carried out from 2000 to 2019;[7] it is an unbalanced country panel. Table 1 presents a list of sample countries and the starting and end years of the data. Appendix Table A1 presents a list of countries of origin.

[5] Definitions of immigrants differ from country to country. See metadata for each sample country (https://www.oecd.org/els/mig/Metadata.pdf)

[6] Another country panel data on immigration is the UN International Migration Stock. Although this database is useful for providing additional information on gender and age of immigrants, we did not use it in this study because its frequency is five-years beginning from 1990. Hence, it could not be used to analyze annual panel data.

[7] In the current study, the analysis period is set after the period analyzed in the related study by Lewer and Van den Berg (2008).

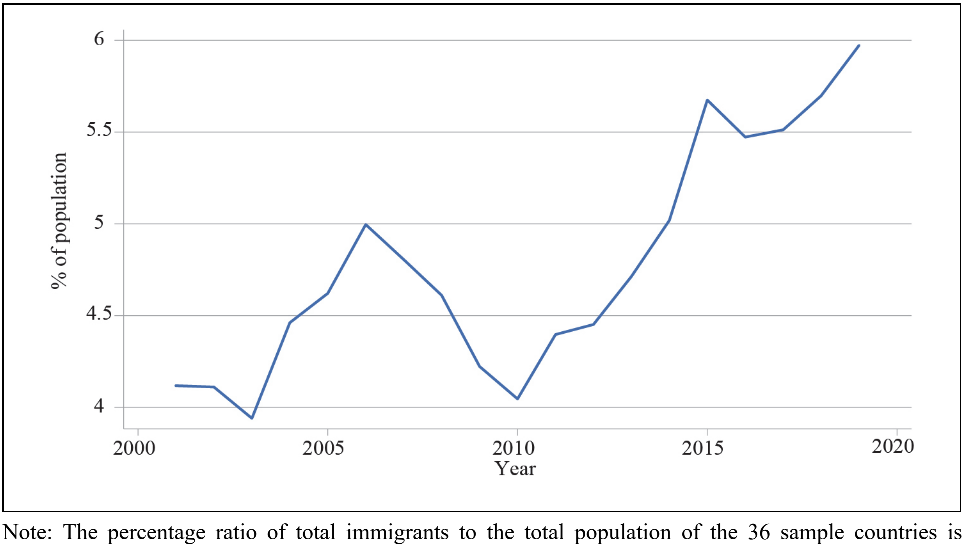
Table 1. Country List

Australia	France	Latvia	Slovak Republic
Austria	Germany	Lithuania	Slovenia
Belgium	Greece	Luxembourg	South Korea
Canada	Hungary	Mexico	Spain
Chile	Iceland	Netherlands	Sweden
Czech Republic	Ireland	New Zealand	Switzerland
Denmark	Israel	Norway	Turkey
Estonia	Italy	Poland	United Kingdom
Finland	Japan	Portugal	United States

Notes: All sample countries are classified as high-income countries based on the 2019 World Bank classification, except for Mexico and Turkey. There are 201 partner countries, including those listed above. Appendix Table A1 presents a list of partner countries.

Figure 1 shows the percentage of immigrants to the total population of the 36 countries analyzed in the current study. Immigration increased rapidly after 2003 and then decreased before and after the GFC, finally falling to the level of the early 2000s in 2010. This shows that immigration tends to be procyclical and changes according to economic incentives. There was a temporary stagnant growth in immigration in 2016 following the GFC, but it rapidly increased again until 2019.

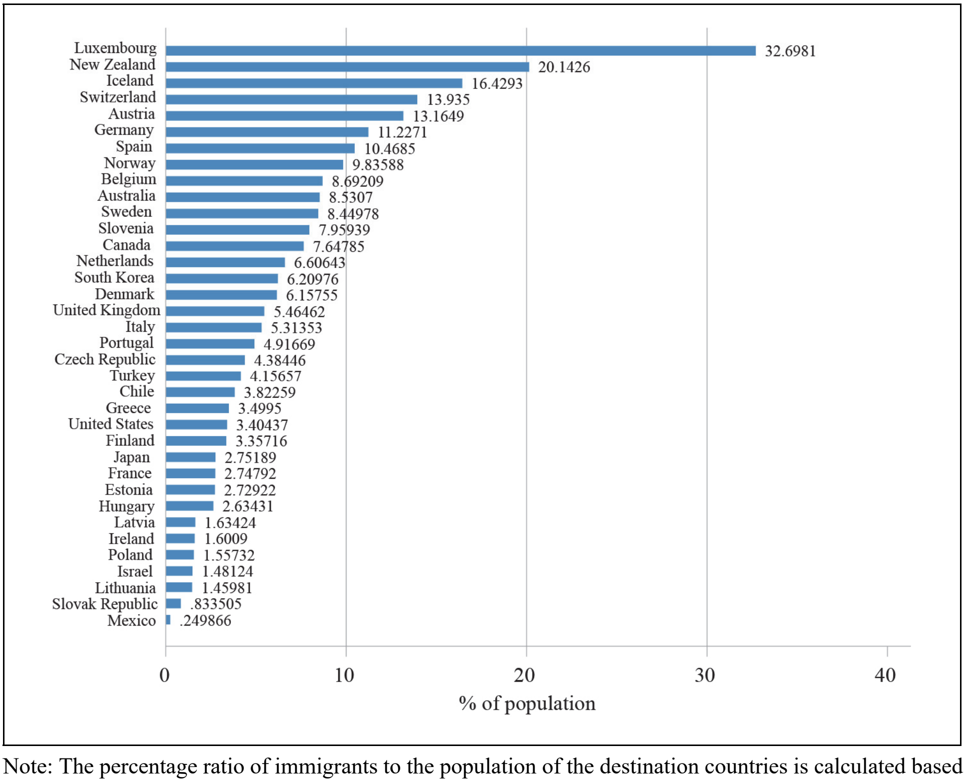
Figure 1. Immigrants to Population Ratio by Years from 2001 to 2019



Note: The percentage ratio of total immigrants to the total population of the 36 sample countries is calculated from 2001 to 2019.

Figure 2 illustrates the proportion of immigrants to their own population (annual average percentage ratio from 2001 to 2019) in the sample countries. Among these countries, Luxembourg had the highest proportion of immigrants. This was followed by New Zealand, Iceland, Switzerland, Austria, and Germany. Mexico had the lowest immigration ratio, followed by Slovak Republic, Lithuania, Israel, and Poland. These countries have an annual average ratio of immigrants that accounts for less than 1.5% of their population. In terms of the annual average ratio, Korea is at the upper-middle level, at the 15th position among 36 countries (about 6.2%).[8]

Figure 2. Immigrants to Population Ratio by Sample Countries

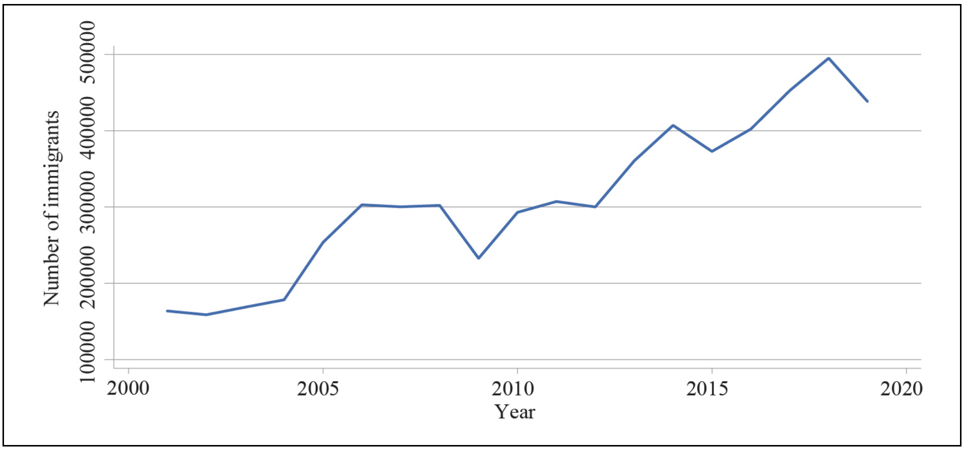


Note: The percentage ratio of immigrants to the population of the destination countries is calculated based on the annual average values from 2001 to 2019.

[8] When interpreting Figure 1, it is important to note that some immigrants reside for a long time, but some migrate back to their home country or a third country after some time. Therefore, it does not permanently increase the population.

Figures 3 and 4 demonstrate the change in the number of immigrants by year in Korea and the number of immigrants by country of origin, respectively. Similar to the global trend presented in Figure 1, immigrants to Korea have been steadily increasing since the 2000s; their number then decreased and stagnated before and after the GFC. Since 2012, the number of immigrants has steadily increased, reaching around 45,000 in 2019, based on OECD statistics.

Figure 3. Total Number of Immigrants to Korea by Year from 2001 to 2019

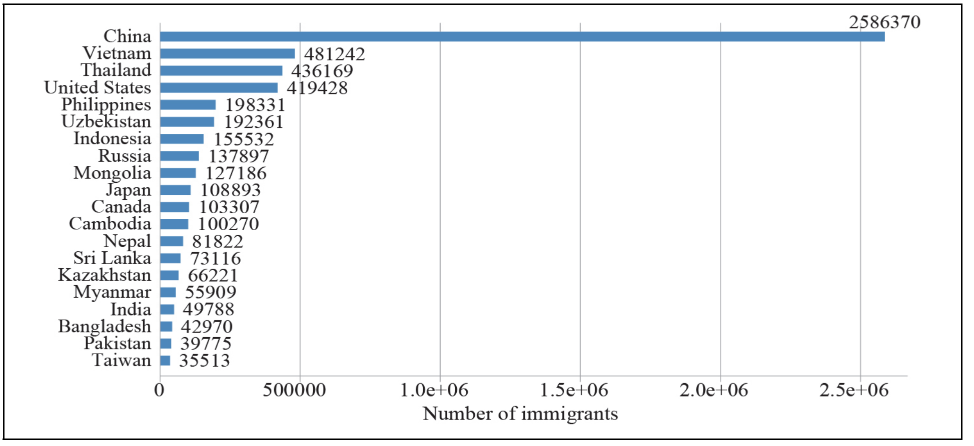


Note: The total number of immigrants to Korea is calculated by year from 2001 to 2019.

The number of countries of origin for immigrants to Korea is 196, which is diverse. China accounts for an overwhelming majority with 2,586,370 immigrants alone.[9] Vietnam, Korea's top-three trading partner country, accounted for the second-largest number (481,242), followed by Thailand, the United States, the Philippines, Uzbekistan, and Indonesia as the countries sending the most immigrants to Korea. Most of the top-20 countries are from Asia, and are relatively low-income compared to Korea. An analysis of the factors affecting immigration to Korea is presented in Section IV.

[9] At least 136 countries have sent more than 100 immigrants to Korea, 79 countries have sent more than 1,000 immigrants to Korea, and 50 countries have sent more than 3,000 immigrants to Korea. Figure 4 reports the top-20 countries in terms of the total number of immigrants to Korea from 2001 to 2019.

Figure 4. Total Number of Immigrants to Korea by Country of Origin



Note: The total number of immigrants to Korea is calculated from 2001 to 2019 by country of origin.

2. Empirical Model

The empirical analysis consists of two main parts. In the first empirical model, the sample period is divided into two equal periods (8-year) before and after the GFC, and cross-sectional regression is performed by calculating the average values for each period. In the second empirical model, a panel data analysis is conducted to capture the average annual dynamics of immigration.

The first empirical model is Equation (1):

$$mig_{ij} = \alpha + \beta_1(pop_i \cdot pop_j) + \beta_2 dist_{ij} + \beta_3 contig_{ij} + \beta_4 lang_{ij} + \beta_5 colony_{ij} + X_{ij}\Gamma + \varepsilon_i \tag{1}$$

The subscripts i and j denote the country of origin i and the destination country j, respectively. mig_{ij} represents the number of people flowing into country j from country i. The product of the total population for each country i and country j ($pop_i \cdot pop_j$), the distance between two countries ($dist_{ij}$), a dummy variable indicating neighboring countries ($contig_{ij}$), common language ($lang_{ij}$), and common colonizer ($colony_{ij}$) are included as explanatory variables.

Another dummy variable indicating regional trade agreement (RTA_{ij}) and the common legal system ($legal_{ij}$) are included as control variables (X_{ij}). In addition, as in Lewer and Van den Berg (2008), GDP per capita, which is a proxy variable representing economic reasons for immigration, is included after conversion into the ratio of GDP per capita of country j to country i ($GDP\ ratio_{ij}$). The population from country i living in country j ($stock_{ij}$), which is controlled because a large population from the same country indicates that it can be easier to adapt to a new society, is included. These control variables are taken from the Center d'Études Prospectives et d'Informations Internationales (CEPII) database. Explanatory variables, except for the dependent and dummy variables, are converted into natural logs. The one-period lags of $stock_{ij}$ and RTA_{ij} are used. Some control variables are excluded, and details have been provided in the relevant section (Section III).

We estimate the model using the PPML method, proposed by Santos Silva and Tenreyro (2006). The standard empirical method generates severely biased estimates; thus, Santos Silva and Tenreyro (2006) proposed a simple PPML method to estimate the gravity equations. This method effectively addresses the potential econometric problems resulting from heteroscedastic residuals and zero migration for some pairs of countries.

The second empirical model for the panel data analysis is presented in Equation (2):

$$mig_{ijt} = \alpha + \beta_1 pop_{it} + \beta_2 pop_{jt} + \beta_3 gdp_{it} + \beta_4 gdp_{jt} + X_{ijt}\Gamma + \mu_i + \mu_j + \tau_t + \varepsilon_{ijt} \quad (2)$$

The difference between the first and second empirical model is that the results including the product of the population of countries i and j as well as the results including the population of each country are presented (pop_i and pop_j) in the panel data analysis. To analyze immigration for economic reasons in detail, the GDP per capita of countries i and j are included (gdp_i and gdp_j) as separate explanatory variables instead of $GDP\ ratio_{ij}$. To verify whether the effects of economic factors on immigration change before and after the GFC, an interaction term between dummy variables indicating post-GFC (from 2012 to 2019) and GDP per capita of countries i and j is added in the extended model. Given that all variables are time varying (indicated by the subscript t), control variables that do not change with time are omitted. The fixed effects for the country of origin (μ_i), country of destination (μ_j), and year (τ_t) are included. In addition, $stock_{ij}$ and RTA_{ij} are included as control variables. Panel data analysis is estimated using PPML. Table 2 reports the summary statistics.

Table 2. Basic Statistics

	N	Mean	SD	Min	Max	p1	p5	p25	p50	p75	p95	p99
mig_{ij}	94.633	1,108.48	6,465.45	0	309,699	0	0	2	28	273	4,315	20,281
pop_i	91,911	15.62	2.17	9.16	21.06	9.92	11.37	14.54	15.93	17.07	18.66	20.90
pop_j	94,412	16.38	1.63	12.56	19.61	12.62	13.07	15.49	16.17	17.68	18.66	19.59
gdp_i	89,023	8.48	1.57	4.68	12.18	5.35	5.95	7.22	8.46	9.71	10.89	11.52
gdp_j	94,412	10.39	0.63	8.16	11.69	8.80	9.23	9.97	10.55	10.82	11.33	11.63
X_{ij}												
$dist_{ij}$	92,288	8.62	0.88	4.09	9.88	5.93	6.82	8.23	8.87	9.22	9.66	9.81
$contig_{ij}$	91,916	0.02	0.13	0	1	0	0	0	0	0	0	1
$lang_{ij}$	92,288	0.10	0.30	0	1	0	0	0	0	0	1	1
$colony_{ij}$	92,288	0.01	0.08	0	1	0	0	0	0	0	0	0
RTA_{ij}	93,366	0.30	0.46	0	1	0	0	0	0	1	1	1
$legal_{ij}$	94,657	0.25	0.43	0	1	0	0	0	0	0	1	1
$GDP\ ratio_i$	89,023	22.89	40.80	0.04	628.94	0.20	0.42	1.93	6.97	23.85	103.44	199.44
$stock_{ij}$	52,444	6.11	2.93	0	16.03	0	1.39	3.87	6.08	8.23	11.01	12.57

Notes: mig_{ij} is the population from country *i* to country *j*. pop_i and pop_j are the total population for country *i* and country *j*, respectively (natural log). gdp_i and gdp_j are the GDP per capita of countries *i* and *j*, respectively (natural log). $dist_{ij}$ is the distance between two countries (natural log). $contig_{ij}$, $lang_{ij}$, $colony_{ij}$, RTA_{ij}, and $legal_{ij}$ are dummy variables indicating neighboring countries, common languages, common colonizer regional trade agreements, and common legal systems, respectively. $GDP\ ratio_{ij}$ is the ratio of GDP per capita of country *j* to country *i*. $stock_{ij}$ is the population of country *i* living in country *j* (natural log).

III. Empirical Result

The first empirical analysis is compared with the traditional gravity model of trade to examine how well the gravity model explains the cross-border movement of population between countries. To this end, a gravity model using trade and immigration as dependent variables is estimated. The sample period does not take into account the GFC (2008–2011). It is divided into pre- and post-crisis periods. Therefore, the pre-crisis period is from 2000 to 2007 and the post-crisis period from 2012 to 2019. Trade is the total amount of imports and exports during the period, and immigration is the sum of the population inflows to the destination country, denoted as country j during the period. The product of the GDP of both countries is generally used in the gravity model of trade; the product of the population of both countries is used instead of the product of the GDP of both countries as a corresponding explanatory variable in the gravity model of immigration. All other explanatory variables are controlled for in the same way, and the average value of the relevant period is used for all of them.[10]

Table 3 presents the results for the first empirical model. The fit of the gravity model of trade evaluated by Pseudo R^2 is higher than that of the gravity model of immigration (0.88 vs. 0.58). This is observed both before and after the GFC. The product of the two countries' GDP per capita (the corresponding variable, the product of the population in the gravity model of immigration) and distance are statistically significant at the 1% level in both models. However, the control variables $contig_{ij}$, $lang_{ij}$, and $colony_{ij}$ show considerable differences between the two models. In the case of trade, $contig_{ij}$ and $colony_{ij}$ are closely related to trade, whereas in immigration, $lang_{ij}$ is more important than the other two variables. Historically, $colony_{ij}$ acts as an impediment to the movement of population between countries. $legal_{ij}$ and RTA_{ij} are similar in both the models, although there are some differences depending on the period.

[10] In order to control with the same number of explanatory variables as in the gravity model of trade, some control variables such as $GDP\ ratio_{ij}$ and $stock_{ij}$ are not included.

Table 3. Gravity Model: Trade vs. Immigration

Explanatory Variables	Gravity model of trade		Gravity model of immigration	
	(1) 2000~2007	(2) 2012~2019	(3) 2000~2007	(4) 2012~2019
$gdp_i \cdot gdp_j$	0.809***	0.844***	0.705***	0.711***
(or $pop_i \cdot pop_j$)	(0.0228)	(0.0283)	(0.0289)	(0.0235)
$dist_{ij}$	-0.536***	-0.490***	-0.628***	-0.713***
	(0.0844)	(0.0527)	(0.146)	(0.0755)
$contig_{ij}$	0.623***	0.846***	0.135	-0.0446
	(0.224)	(0.187)	(0.612)	(0.427)
$lang_{ij}$	-0.0284	-0.356***	0.709***	0.551***
	(0.128)	(0.122)	(0.244)	(0.201)
$colony_{ij}$	0.700***	1.110***	-2.547***	-1.404**
	(0.211)	(0.209)	(0.739)	(0.622)
RTA_{ij}	0.0695	0.244***	0.264	0.554***
	(0.150)	(0.0887)	(0.230)	(0.133)
$legal_{ij}$	0.350***	0.229***	0.431***	0.214
	(0.0870)	(0.0751)	(0.165)	(0.146)
Constant	-22.93***	-25.70***	-10.19***	-9.592***
	(1.647)	(1.730)	(1.945)	(1.170)
Observations	4,873	5,672	4,982	5,740
Pseudo R^2	0.877	0.889	0.580	0.578

Notes: Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10, 5, and 1-percent levels, respectively.

Using another cross-sectional model, the estimation results of the current study are compared with those of Lewer and Van den Berg (2008). Three factors were considered in the comparative analysis. First, the analysis periods in the two studies differ. Lewer and Van den Berg (2008) use data from 1991 to 2000, whereas the current study uses data from after 2000 for analysis. Second, while Lewer and Van den Berg (2008) estimate a simple regression, the current study estimates the PPML method (Santos Silva and Tenreyro, 2006). Third, the sources of some explanatory variables differ, and the origin of immigration is the same as that of the OECD. The counting methods and standards may have changed by country.

Therefore, caution is needed when interpreting the results of the two studies. Nevertheless, this study contributes to the existing literature by analyzing the determinants of recent immigration by updating the dataset of the gravity model of immigration for the last 20 years.

As shown in Table 3, the analysis period is divided into before and after the GFC, excluding the GFC period (2008–2011). The explanatory variables are included in the same way as in Lewer and Van den Berg (2008). The product of the population of both countries ($pop_i \cdot pop_j$), $dist_{ij}$, $contig_{ij}$, $lang_{ij}$, and $colony_{ij}$ are included, but RTA_{ij}, and $legal_{ij}$ are excluded.[11] Instead, both studies include $GDP\ ratio_{ij}$ and $stock_{ij}$. For all explanatory variables, the average value of the period is used, except for $stock_{ij}$. The initial value of the corresponding period is used for $stock_{ij}$.

Table 4 presents the estimation results of the comparison between Lewer and Van den Berg (2008) and the current study. The number of observations in both the studies is similar. As shown in Table 3, $pop_i \cdot pop_j$ and $dist_{ij}$ are still statistically significant at the 1% confidence level. Although both studies use different estimation methods, the estimation results for these two variables do not show a significant difference. The model fit is evaluated with Buse R^2 in Lewer and Van den Berg (2008), and Pseudo R^2 in the current study; therefore, the absolute comparison is cautious, but R^2 in the current study is higher than that in Lewer and Van den Berg (2008) (0.76~0.83 vs. 0.66). As new explanatory variables related to immigration are added, the overall fit of the model improved. It is, however, still slightly lower but close to the gravity model of trade.

As with the previous empirical results in Table 3, $contig_{ij}$ is less relevant to immigration, whereas $lang_{ij}$ is closely associated with immigration. However, the statistical significance of $lang_{ij}$ weakened after the GFC. The estimated coefficient of $colony_{ij}$ in Lewer and Van den Berg (2008) is similar to that of the gravity model of trade. However, as with the previous empirical results in Table 3, immigration to countries with common colonizers decreased, and was statistically significant in the current study. However, this tendency cannot be regarded as a robust result, because it differs depending on the sample period. $stock_{ij}$ is strongly related to immigration in both the studies. In the case of the $GDP\ ratio_{ij}$, which reflects the economic factors of immigration, results are consistent with Lewer and Van den Berg (2008) and

11 RTA_{ij}, and $legal_{ij}$ are excluded from the baseline empirical results of Lewer and Van den Berg (2008). For fair comparison, these two variables are also excluded in the current study.

opposite results simultaneously appear depending on the sample period. Therefore, additional analysis is required, which will be presented in the current study.

Table 4. Gravity Model of Immigration from 2000 to 2019

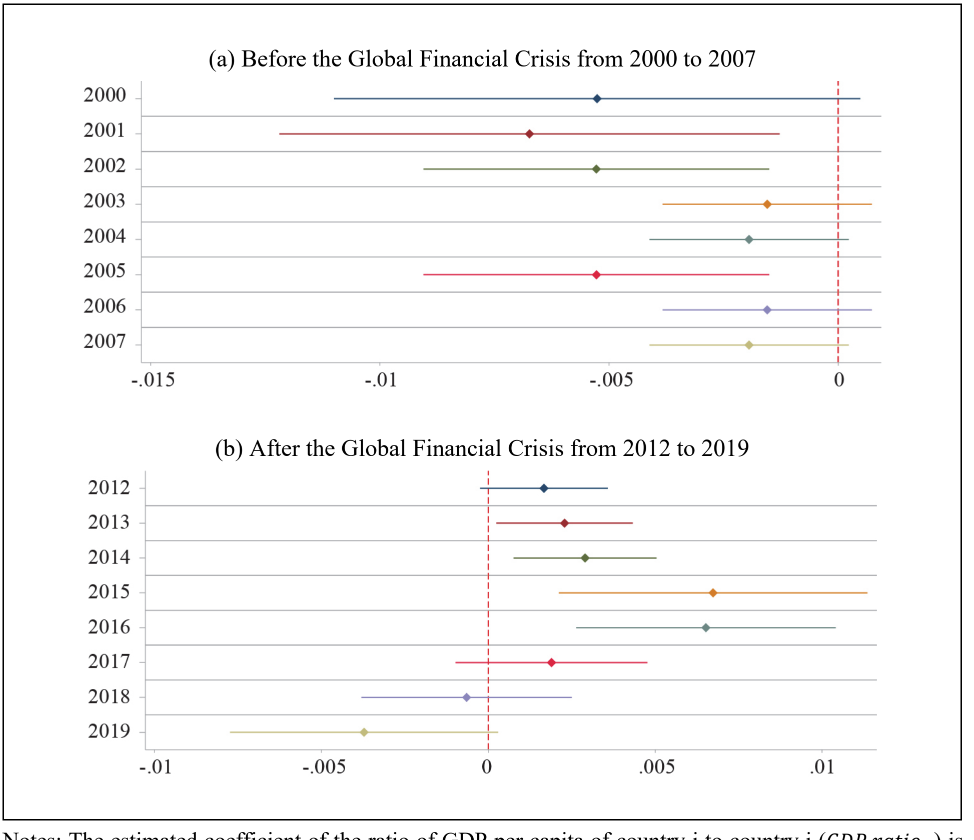
Explanatory Variables	Lewer and Van den Berg (2008) (1) 1991~2000	The Current Study (2) 2000~2007	(3) 2012~2019
$pop_i \cdot pop_j$	0.221**	0.256***	0.189***
	[14.48]	(0.0517)	(0.0308)
$dist_{ij}$	-0.261**	-0.253**	-0.274***
	[-8.79]	(0.0985)	(0.0643)
$contig_{ij}$	-0.091	-0.240	-0.192
	[-1.09]	(0.248)	(0.283)
$lang_{ij}$	0.275**	0.274*	-0.156
	[3.34]	(0.149)	(0.118)
$colony_{ij}$	0.288**	-0.926***	-0.0964
	[3.21]	(0.139)	(0.301)
$GDP\ ratio_{ij}$	0.00004**	-0.00279**	0.00364***
	[2.31]	(0.00129)	(0.00127)
$stock_{ij}$	0.401**	0.545***	0.656***
	[33.13]	(0.0312)	(0.0306)
Constant	4.218**	-1.985**	-0.725
	[13.90]	(0.996)	(0.717)
Observations	2,710	2,085	4,404
Pseudo R^2	0.662	0.760	0.834

Notes: Robust standard errors are in parentheses. *, **, and *** indicate significance at the 10, 5, and 1-percent levels, respectively. 1 and 5-percent significance levels are denoted by ** in Lewer and Van den Berg (2008). The figures in square brackets are heteroscedasicity-constraint t-statistics. Buse R^2 was reported by Lewer and Van den Berg (2008) instead of pseudo R^2.

To understand why the results on $GDP\ ratio_{ij}$ differ depending on the sample period between Lewer and Van den Berg (2008) and the current study, the gravity model of immigration is estimated for each year (i.e., cross-sectional regression for each year). The explanatory variables are the same as those in Table 4, but a one-year lag of $stock_{ij}$ is used instead of the original value of the corresponding period. Of the empirical analysis results, only the estimated coefficient of $GDP\ ratio_{ij}$ is presented in Figure 5 (the empirical analysis results are presented in Appendix Table A2).

The results of the analysis reveal that the statistical significance of the variable in the period before the GFC differs depending on the year, but statistically significant years are found to be less than zero (2001, 2002, and 2005). However, after the GFC, years with statistically significant estimation coefficients greater than zero are frequently estimated. This suggests that the economic factors affecting immigration may have strengthened after the GFC. For a more accurate estimation, a panel data analysis of the gravity model that can analyze immigration dynamics is performed.

Figure 5. Estimated Coefficient of GDP Ratio by Years



Notes: The estimated coefficient of the ratio of GDP per capita of country j to country i ($GDP\ ratio_{ij}$) is presented with 90% confidence intervals. The results of the empirical analysis are presented in Appendix Table A2.

The panel data analysis (Table 5) reveals that the sign of the estimated coefficients of $pop_i \cdot pop_j$ and $GDP\,ratio_{ij}$ previously confirmed in the cross-sectional regression, are changed to the opposite—or statistical significance disappears. This may be because the average values used in the cross-sectional regression could not capture the dynamic relationships that changed year by year. The results for $stock_{ij}$ and RTA_{ij} remain robust.

Table 5. Panel Data Analysis: Baseline and Extended Model

Explanatory	Baseline model		Extended model	
Variables	(1)	(2) Incl. interaction	(3)	(4) Incl. interaction
$pop_i \cdot pop_j$	-0.398	-0.744***		
	(0.242)	(0.260)		
pop_i			0.910***	0.888***
			(0.224)	(0.236)
pop_j			-8.646***	-9.407***
			(0.599)	(0.604)
$GDP\,ratio_{ij}$	-0.00214*	-0.00130		
	(0.00113)	(0.00114)		
$GDP\,ratio_{ij}$		0.00754***		
×Post GFC		(0.00107)		
gdp_i			-0.358***	-0.278***
			(0.0484)	(0.0513)
gdp_i ×Post GFC				0.00874
				(0.0182)
gdp_j			1.537***	1.174***
			(0.163)	(0.151)
gdp_j ×Post GFC				0.859***
				(0.0750)
$stock_{ij}$	0.737***	0.737***	0.758***	0.763***
	(0.00942)	(0.00943)	(0.00865)	(0.00852)
RTA_{ij}	0.239***	0.235***	0.222***	0.232***
	(0.0415)	(0.0413)	(0.0404)	(0.0393)
Constant	15.08*	27.36***	126.5***	137.7***
	(8.650)	(9.280)	(12.07)	(12.23)
Observations	37,911	37,911	37,911	37,911
Pseudo R^2	0.903	0.903	0.913	0.917

Notes: Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10, 5, and 1-percent levels, respectively.

Table 6. Panel Data Analysis: Immigration from Low- or High-Income Countries

Explanatory Variables	Baseline model (1) Low to High	Baseline model (2) High to High	Extended model (3) Low to High	Extended model (4) High to High
$pop_i \cdot pop_j$	-0.411*	-1.634***		
	(0.231)	(0.417)		
pop_i			0.668***	0.655
			(0.228)	(0.532)
pop_j			-9.247***	-7.457***
			(0.946)	(0.633)
$GDP\ ratio_{ij}$	-0.00274**	0.120***		
	(0.00133)	(0.0237)		
gdp_i			-0.192***	-0.783***
			(0.0674)	(0.134)
gdp_j			1.197***	1.834***
			(0.180)	(0.260)
$stock_{ij}$	0.718***	0.736***	0.735***	0.749***
	(0.0113)	(0.0154)	(0.0111)	(0.0142)
RTA_{ij}	0.192***	0.323***	0.179***	0.270***
	(0.0555)	(0.0508)	(0.0546)	(0.0517)
Constant	16.15*	57.21***	145.7***	108.8***
	(8.400)	(14.52)	(17.77)	(14.60)
Observations	24,001	12,933	24,001	12,933
Pseudo R^2	0.909	0.916	0.916	0.928

Notes: Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10-, 5-, and 1-% levels, respectively.

This study notes two interesting points from the analysis of the extended model in which the population and per capita GDP of countries, *i* and *j* are included as separate explanatory variables. First, the increase in the population of the country of origin (country *i*) is closely related to the increase in immigration, but on the contrary, the decrease in the population of the destination country (country *j*) increases the demand for immigration. Second, a decrease in GDP per capita in the country of origin and an increase in GDP per capita in the destination country are closely related to an increase in immigration. From this panel data analysis, it is observed that the multiplication of population and relative per capita GDP terms used in previous studies mask the different effects of destination and origin countries on immigration. Through the estimated coefficient of the interaction term, furthermore, the effect of immigration due to these economic factors appears to have increased after the GFC. This is consistent with the cross-sectional empirical results.

In Table 6, I examine whether the explanatory variables affecting immigration are different when the country of origin is low- or high-income countries that are classified according to the 2019 World Bank classification.[12] The destination countries are regarded as high-income countries based on the country classification in Table 1. The analysis shows that economic factors are highly related to immigration when the country of origin is a high-income country, which is also confirmed by the extended model. However, when the country of origin is low-income, as can be seen from the analysis results of the extended model, the increase in the population in the country of origin and the decrease in the population in the destination country are highly related to immigration than those in high-income countries.[13]

IV. Immigration to Korea

In Section IV, I conduct the same panel data analysis as in the previous section by limiting the destination country to Korea to derive implications for Korea.[14] Table 7 shows the results of the baseline and extended models for immigration to Korea. This is not significantly different from the results in Table 5. Statistical significance of the estimated coefficients of $pop_i \cdot pop_j$ and $GDP\,ratio_{ij}$ have disappeared. The results for $stock_{ij}$ and RTA_{ij} remain robust.

The analysis of the extended model in Table 7 when compared with the results of the extended model in Table 5 reveal that economic factors, rather than population size, are found to have a relatively higher correlation with immigration in Korea. This tendency is strengthened after the GFC. This is confirmed by the estimated coefficient of the interaction term.

[12] Upper- and lower-middle-income countries are classified as low-income countries in the current study. This is to obtain the number of observations enough for each country group for statistical inference.

[13] Estimated coefficients are larger between low- and high-income countries than high- and high-income countries.

[14] The results of the cross-sectional regression limiting the destination country to only Korea are not significantly different from Tables 3 and 4. However, some variables are estimated largely because the characteristics of Korea are reflected in some variables. Analysis results will be provided upon request.

Table 7. Panel Data Analysis: Baseline and Extended Model for Korea

Explanatory Variables	Baseline model (1)	Baseline model (2) Incl. interaction	Extended model (3)	Extended model (4) Incl. interaction
$pop_i \cdot pop_j$	0.766	0.484		
	(0.518)	(0.605)		
pop_i			1.143	-0.814
			(0.885)	(1.093)
pop_j			-2.643	5.244
			(3.926)	(4.900)
$GDP\ ratio_{ij}$	-0.00995	-0.00228		
	(0.00870)	(0.0103)		
$GDP\ ratio_{ij}$ ×Post GFC		0.0147*		
		(0.00822)		
gdp_i			-0.0126	-0.0829
			(0.162)	(0.160)
gdp_i ×Post GFC				-0.224***
				(0.0746)
gdp_j			0.464	0.591*
			(0.336)	(0.338)
gdp_j ×Post GFC				0.172**
				(0.0690)
$stock_{ij}$	0.302***	0.304***	0.297***	0.216*
	(0.0772)	(0.0794)	(0.114)	(0.114)
RTA_{ij}	0.291***	0.295***	0.263**	0.287**
	(0.107)	(0.107)	(0.109)	(0.120)
Constant	-21.49	-11.20	27.07	-74.56
	(18.73)	(21.92)	(60.09)	(78.01)
Observations	1,306	1,306	1,306	1,306
Pseudo R^2	0.977	0.977	0.977	0.978

Notes: Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10-, 5-, and 1-% levels, respectively.

Table 8 shows the empirical results analyzing the countries of origin of immigrants in Korea by dividing them into low- and high-income countries. In the case of low-income countries, GDP per capita is estimated to be consistent with the results in Table 6. However, when the country of origin is a high-income country, the sign is estimated to be reversed or the statistical significance is found to have disappeared. This can be interpreted as reflecting the Korean characteristic: most immigrants to Korea are from low-income Asian countries (Figure 4), who leave to go to Korea to participate in the Korean labor market.

According to Hur (2017), the total number of foreigners with long-term residence status of more than one year was 158,716 as of 2016, among which the proportion of foreigners staying on a work visa (non-professional employment, visiting employment, professional manpower), overseas Koreans, and foreigners with permanent resident status was approximately 66.1%. Approximately two-thirds of all foreigners actively participate in the Korean labor market compared to Koreans. Economically motivated immigration from Asian countries is reflected in the empirical results in Tables 7 and 8.

Table 8. Panel Data Analysis:
Immigration from Low- or High-Income Countries to Korea

Explanatory	Baseline model		Extended model	
Variables	(1) Low to High	(2) High to High	(3) Low to High	(4) High to High
$pop_i \cdot pop_j$	1.380**	0.748		
	(0.664)	(0.593)		
pop_i			-1.097	2.052**
			(1.189)	(1.033)
pop_j			7.192	-1.374
			(5.219)	(2.169)
$GDP\ ratio_{ij}$	-0.00399	-1.021***		
	(0.00826)	(0.209)		
gdp_i			-0.509**	0.248
			(0.206)	(0.177)
gdp_j			1.230***	-0.369*
			(0.415)	(0.217)
$stock_{ij}$	0.252***	0.190***	0.220*	0.200***
	(0.0955)	(0.0608)	(0.130)	(0.0765)
RTA_{ij}	0.429***	0.140	0.283*	0.150
	(0.160)	(0.107)	(0.147)	(0.114)
Constant	-43.86*	-19.56	-106.6	-5.787
	(23.99)	(21.74)	(77.89)	(45.32)
Observations	857	449	857	449
Pseudo R^2	0.975	0.992	0.977	0.992

Notes: Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10, 5, and 1-percent levels, respectively.

V. Conclusions

This study builds an empirical model of immigration by using a gravity model. After controlling for geographic, historical, and cultural factors, it focuses on the economic factors. For the analysis, the OECD International Migration Database is used, consisting of 36 destination countries of immigration and 201 countries of origin. The analysis period is 2000–2019. Cross-sectional regression and panel data analyses are conducted. The PPML method is used to estimate the gravity model.

From the cross-sectional regression results, it is found that the gravity model applied to immigration shows a model fit as high as that of trade. Compared to previous studies, Lewer and Van den Berg (2008), it is found that economically motivated immigration had increased since the GFC.

Furthermore, a panel data analysis is conducted, wherein the population and per capita GDP of destination and origin countries are considered separately. Consequently, I find that the multiplication of population and relative per capita GDP terms used in previous studies mask the different effects of destination and origin countries on immigration. This is important, because the dominant effects vary with the income level of the country of origin. Economic factors are more closely associated with immigration when immigration occurs between high-income countries, whereas population changes play a more important role in immigration from low- to high-income countries.

The same panel data analysis as above is also conducted by limiting the destination country to Korea. Economic factors, instead of population changes, are closely associated with immigration in Korea. This trend also strengthened after the GFC. The results can be interpreted as reflecting the fact that most immigrants to Korea are from Asian low-income countries, arriving in Korea to participate in the Korean labor market.

Based on the empirical results in this study, we now come to a conclusion that the gravity model applied to immigration performs reasonably well. I leave this interesting extension and advancement of gravity model of immigration to future research.

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APPENDIX

Table A1. List of the Partner Countries

Afghanistan; Albania; Algeria; Andorra*; Angola; Antigua and Barbuda*; Argentina; Armenia; Australia*; Austria*; Azerbaijan; Bahamas*; Bahrain*; Bangladesh; Barbados*; Belarus; Belgium*; Belize; Benin; Bermuda*; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Brunei*; Bulgaria; Burkina Faso; Burundi; Cambodia; Cameroon; Canada*; Cape Verde; Central African Republic; Chad; Chile*; China; Colombia; Comoros; Congo; Cook Islands; Costa Rica; Cote d'Ivoire; Croatia*; Cuba; Cyprus*; Czech Republic*; Democratic; Republic of Congo; Denmark*; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Eritrea; Estonia*; Ethiopia; Fiji; Finland*; France*; Gabon; Gambia; Georgia; Germany*; Ghana; Greece*; Grenada; Guam*; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Hong Kong*; Hungary*; Iceland*; India; Indonesia; Iran; Iraq; Ireland*; Israel*; Italy*; Jamaica; Japan*; Jordan; Kazakhstan; Kenya; Kiribati; Kuwait*; Kyrgyz Republic; Laos; Latvia*; Lebanon; Lesotho; Liberia; Libya; Liechtenstein*; Lithuania*; Luxembourg*; Macao*; Macedonia; Madagascar; Malawi; Malaysia; Maldives; Mali; Malta*; Marshall Islands; Mauritania*; Mauritius; Mexico; Micronesia; Moldova; Monaco*; Mongolia; Montenegro; Morocco; Mozambique; Myanmar; Namibia; Nauru*; Nepal; Netherlands*; New Zealand*; Nicaragua; Niger; Nigeria; Niue; North Korea; Norway*; Oman*; Pakistan; Palau*; Palestine; Panama*; Papua New Guinea; Paraguay; Peru; Philippines; Poland*; Portugal*; Puerto Rico*; Qatar*; Romania*; Russia; Rwanda; Saint Kitts and Nevis*; Saint Lucia; Saint Vincent and the Grenadines; Samoa; San Marino*; Sao Tome and Principe; Saudi Arabia*; Senegal; Seychelles*; Sierra Leone; Singapore*; Slovak Republic*; Slovenia*; Solomon Islands; Somalia; South Africa; South Korea*; Spain*; Sri Lanka; Sudan; Suriname; Swaziland; Sweden*; Switzerland*; Syria; Taiwan; Tajikistan; Tanzania; Thailand; Timor; Togo; Tonga; Trinidad and Tobago*; Tunisia; Turkey; Turkmenistan; Tuvalu; Uganda; Ukraine; United Arab Emirates*; United Kingdom*; United States*; Uruguay*; Uzbekistan; Vanuatu; Venezuela; Vietnam; Yemen; Yugoslavia; Zambia; Zimbabwe

Notes: * denotes high-income countries based on the 2019 World Bank classification. The rest of the countries are low- or middle-income.

Table A2. Gravity Model of Immigration by Years

(a) Before the Global Financial Crisis from 2000 to 2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2000	2001	2002	2003	2004	2005	2006	2007
$pop_i \cdot pop_j$	0.254***	0.281***	0.205***	0.186***	0.201***	0.211***	0.168***	0.138**
	(0.0439)	(0.0641)	(0.0583)	(0.0473)	(0.0452)	(0.0569)	(0.0631)	(0.0650)
$dist_{ij}$	0.012	-0.011	0.048	-0.024	-0.015	-0.040	-0.230**	-0.329***
	(0.1030)	(0.1342)	(0.1196)	(0.1007)	(0.1050)	(0.1318)	(0.1160)	(0.1152)
$contig_{ij}$	-0.168	-0.136	-0.083	-0.084	0.085	0.164	-0.378	-0.615*
	(0.5134)	(0.4562)	(0.4440)	(0.3948)	(0.4594)	(0.5483)	(0.3457)	(0.3630)
$lang_{ij}$	0.590	0.529*	0.507*	0.187	0.205	0.162	0.301*	0.143
	(0.3944)	(0.3109)	(0.2700)	(0.2203)	(0.2516)	(0.2884)	(0.1576)	(0.1576)
$colony_{ij}$	-	-0.779***	-0.465*	-0.793***	-0.827***	-0.922***	-1.230***	-0.969***
	-	(0.1035)	(0.2807)	(0.1062)	(0.1057)	(0.1181)	(0.1140)	(0.2797)
$GDP\ ratio_{ij}$	-0.005	-0.007**	-0.005**	-0.002	-0.002	-0.002*	-0.000	-0.001
	(0.0035)	(0.0033)	(0.0023)	(0.0014)	(0.0013)	(0.0014)	(0.0010)	(0.0011)
$stock_{ij}$	0.616***	0.580***	0.674***	0.712***	0.705***	0.726***	0.690***	0.730***
	(0.0505)	(0.0542)	(0.0613)	(0.0641)	(0.0645)	(0.0765)	(0.0465)	(0.0617)
Constant	-6.868***	-7.201***	-5.910***	-5.057***	-5.538***	-5.992***	-2.697**	-1.185
	(1.4415)	(1.3735)	(1.2105)	(1.0935)	(1.0498)	(1.1568)	(1.1710)	(1.3175)
Observations	896	1128	1137	1418	1497	1458	1617	1793
Pseudo R^2	0.716	0.736	0.816	0.808	0.809	0.829	0.834	0.805

(b) After the Global Financial Crisis from 2012 to 2019

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2012	2013	2014	2015	2016	2017	2018	2019
$pop_i \cdot pop_j$	0.198***	0.215***	0.230***	0.219***	0.190***	0.152***	0.146***	0.139***
	(0.0289)	(0.0377)	(0.0437)	(0.0587)	(0.0369)	(0.0357)	(0.0410)	(0.0378)
$dist_{ij}$	-0.308***	-0.354***	-0.338***	-0.326***	-0.252***	-0.188***	-0.204***	0.047
	(0.0625)	(0.0799)	(0.0867)	(0.1053)	(0.0707)	(0.0659)	(0.0701)	(0.0724)
$contig_{ij}$	-0.243	-0.198	-0.237	-0.230	-0.237	-0.200	-0.464*	-0.135
	(0.3434)	(0.3505)	(0.3395)	(0.3178)	(0.2671)	(0.2919)	(0.2670)	(0.2567)
$lang_{ij}$	-0.108	-0.187	-0.147	-0.311**	-0.247**	-0.184	-0.098	0.167
	(0.1297)	(0.1351)	(0.1322)	(0.1346)	(0.1157)	(0.1221)	(0.1324)	(0.1772)
$colony_{ij}$	-0.623***	-0.805***	-0.486**	-0.317	0.064	0.492	0.529	1.009**
	(0.1456)	(0.1470)	(0.2110)	(0.2219)	(0.2450)	(0.4571)	(0.3715)	(0.4373)
$GDP\ ratio_{ij}$	0.002	0.002*	0.003**	0.007**	0.007***	0.002	-0.001	-0.004
	(0.0012)	(0.0012)	(0.0013)	(0.0028)	(0.0024)	(0.0017)	(0.0019)	(0.0024)
$stock_{ij}$	0.664***	0.644***	0.645***	0.645***	0.681***	0.701***	0.728***	0.821***
	(0.0287)	(0.0313)	(0.0324)	(0.0388)	(0.0303)	(0.0380)	(0.0405)	(0.0533)
Constant	-3.070***	-3.075***	-3.791***	-3.426***	-3.441***	-2.687***	-2.633***	-5.225***
	(0.6883)	(0.7882)	(0.8601)	(1.0735)	(0.7532)	(0.7922)	(0.8577)	(0.8553)
Observations	3091	3172	3228	3113	3161	3814	3743	3361
Pseudo R^2	0.861	0.859	0.860	0.823	0.864	0.843	0.853	0.871

Notes: Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10, 5, and 1-percent levels, respectively.