Volkson Press

ISSN: 3135-3398 (Print)
EISSN: 3135-341X (Online)

Social Sciences & Humanities in Asia (SSHA)

DOI:http://doi.org/10.65098/ssha.03.2026.01.18

RESEARCH ARTICLE

Bilateral Migration Flows to OECD Countries: A Gravity Model Analysis Using Poisson Pseudo-Maximum Likelihood Estimation

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ARTICLE DETAILS

Article History:
Received 02 May 2026
Accepted 22 Jun 2026
Available online 30 Jul 2026

Online Article Code

ABSTRACT

Background and Purpose: International migration has become one of the most important challenges in global economic and social policy. However, the existing migration literature predominantly emphasizes economic determinants, such as income disparities and employment opportunities, while giving limited attention to non-economic drivers. This study addresses this gap by examining bilateral migration flows to Organization for Economic Co-operation and Development (OECD) countries using an extended gravity model framework that integrates economic and non-economic determinants of migration. Specifically, the analysis incorporates employment, education, population, trade openness, gross domestic product (GDP), foreign direct investment, taxes, political instability, inequalities, climate change, cultural differences, language similarities, and traditional gravity factors.
Methods: Using panel data on bilateral migration flows to OECD countries over the period 2000–2024, the study employs the poisson pseudo-maximum likelihood estimator to address heteroskedasticity and zero migration flows, while the Hausman test is used to distinguish between fixed- and random-effects specifications.
Results: The empirical findings reveal that economic opportunities in destination countries, particularly higher GDP, employment prospects, and trade openness, remain significant pull factors shaping migration flows. At the same time, political instability, inequalities, unemployment, and climate-related pressures in countries of origin serve as major push factors. The results further indicate that cultural proximity, a common language, and geographic proximity significantly facilitate bilateral migration to OECD economies.
Conclusion: This study contributes to the migration literature by extending the traditional gravity model to incorporate multidimensional determinants of migration beyond purely economic explanations. The findings provide important policy implications for OECD and origin countries in designing migration, labor market, and sustainability policies that account for the growing interaction between economic, socio-political, environmental, and cultural drivers of migration.

KEYWORDS

Bilateral Migration, Gravity Model, OECD, Push and Pull Factors, Trade, Economic Disparities

1. INTRODUCTION

International bilateral migration is a major part of globalization, as people are moving across borders to improve their economic opportunities, help themselves to secure safe living conditions, not just for themselves but for their families as well (Ahmed & Sheikh, 2025). Migration is no longer just about economic growth; evidence demonstrates that technology, trade openness, and foreign direct investment (FDI) play major and complex roles in people moving from one's origins country towards a developed country with better life and working opportunities (Ihezie et al., 2025).

Bilateral migration is the movement of individuals and families between two or more countries, driven by economic, social, and political factors. Bilateral migration is crucial in understanding global labor mobility, remittance flows, and demographic shifts. It influences economic growth, social integration, and policymaking in origin and destination countries (Schewe & Rikani, 2021). Push factors include financial instability, unemployment, and political conflicts in the country of origin, while pull factors encompass better job opportunities, higher wages, and improved living standards in destination countries (Khalid & Urbański, 2021; Urbański, 2022).

The Organization for Economic Co-operation and Development (OECD) countries. It includes 38 countries such as the United States (US), Germany, Japan, Canada, and Australia, like other countries, highlighting advanced economies with heterogeneous bilateral migration that helps in this study to work with policies aimed to improve economic and social well-being for the people worldwide, acting as an opportunity for governments and individuals to share experiences and find solutions to the mentioned challenges (Genoni et al., 2025). Gaining insights into migration patterns, people are moving from underdeveloped nations towards the developed nations. The factors are essential for developing policies affecting nations, labor market management, and mitigating

the impact of heavy migration in global integration (Mavroudi & Nagel, 2023). While this research provides insights into individuals' bilateral migration push and pull factors, it often fails to help nations manage their populations and prevent a lack of opportunities for their people. While keeping all these factors in mind, this study examines how economies are connected with each other, along with social awareness on a broad level, and technological factors jointly shape all the existing factors on the decision of individuals regarding their migration decisions.

Migration from any origin country towards any destination country (OECD countries) is explained with the help of market opportunities, mostly for skilled labor, where we study net migration of OECD countries over the last 24 years (2001–2024) of available data. These trends help policies in OECD countries prioritize factors that can help to understand experience labor shortages in underdeveloped countries, such as medical areas, technologies and trade openness (Osman et al., 2025). Such patterns create a dynamic network of bilateral migration, fostering connections between origin and destination countries. While observing bilateral migration, global labor patterns, remittance flows, and demographic changes will be measured as in previous studied do not commonly address them. Addressing these issues such as brain drain in developing countries and guaranteeing equitable global development requires to examine. Moreover, studying why migrants prefer OECD countries offers a framework for designing inclusive immigration policies that benefit origin and destination countries.

Despite the increased focus on migration trends and outcomes, researcher's finds inter-sectionalist of migration with overall migration dimensions of inequality. Previous studies have focused on the economic factors driving migration, ignoring all other factors that are effecting migration more like how gender, race, ethnicity, and class intersect migration patterns and its outcomes (Anastasiadou et al., 2025; Fung et al., 2025; Jerry, 2025). Drawing on traditional migration theories, this study develop hypothesis by synthesizing three foundational approaches; neo-classical migration theory (NCMT), push and pull factors model (PPFM), and the gravity model.

The purpose of this study is to investigate some important factors of bilateral migration towards OECD countries, which includes migration as an independent variable, demonstrating its effect through gravity push and pull factors. The study will examine the effects of economic gross domestic product (GDP), FDI, and taxes, social, trade openness, inequalities, climate change, cultural differences, and political aspects using them as mediators and moderators in origin and destination countries, including labor markets, remittance flows, demographic, distance, population, and language differences trends considering as traditional gravity factors.

This study aims to bridge literature gaps by examining the push and pull factors of skilled migration from origin country towards destination country. Precisely, the framework this study use incorporates three key pillars: (1) fundamental gravity variables (distance, population, and contiguity), (2) economic factors, including GDP, trade openness, and FDI, (3) the level of technology adoption, including digitalization in the origin and destination countries. Moreover, this study helps to understand why migrants prefer OECD countries offers a framework for planning broad immigration policies that benefit the origin and destination countries.

According to the objectives and the research gap from previous literatures, this study will focus on the following areas, which are not highlighted properly in previous studies.

(1) How do economic conditions (GDP and FDI), and trade openness link to the flow of skilled workers from underdeveloped (origin) countries towards developed OECD countries?

(2) To what extent do gravity factors (distance and population) and social ties (language differences) affect bilateral migration patterns?

(3) How does the adoption of new climate, area, opportunities, and labor extension in origin and destination countries influence bilateral migration flows and how they affect each other?

To explore the following research questions, this study employs NCMT, PPFM, and the gravity model, leading to the hypothesis presented below. These hypotheses provide valuable insights using an empirical framework and available datasets.

H1: Higher political stability, economic growth, and better living standards in OECD countries attract skilled migrants from politically unstable regions.

H2: Climate-induced displacement and terrorism increase migration to OECD countries with stronger disaster management and security systems.

H3: Greater unemployment, income disparities, and cultural similarities between origins and destination s countries encourage migration to OECD nations.

This study offers a refined exploration of multidimensional factors shaping bilateral migration, establishing a strong conceptual foundation. It provides valuable insights for policy making while setting a base for the comprehensive literature review and provides detailed model specifications in the following sections. By addressing the mentioned gaps, this study aims to broaden existing theoretical frameworks while providing actionable recommendations to improve policymaking on skilled migration, coordinate with the labor market and employment strategies, and foster a broader approach to globalization.

2. LITERATURE REVIEW

A wide range of empirical research has investigated the drivers of bilateral migration, drawing heavily on foundational frameworks such as NCMT. While previous research on bilateral migration in OECD countries has mostly emphasized traditional macroeconomic determinants, such as income inequalities, an increase in the unemployment rate, and a rapid decrease in the GDP of the origin country. Where the existing research focuses on only economic variables, they often overlook non-economic variables like climate change, technological advancements, language barriers and cultural adjustment (Wahab et al., 2023). Bilateral migration trends highlight the structural influence of push and pull factors across origin and destination countries. The gravity model illustrates that migration is influenced by the destination countries' opportunities in open markets for everyone, with considerable economic and demographic capacity serving as pull factors (Khalid & Urbański, 2021), whereas origin countries fight with economic and non-economic inequalities generating push factors that drive out migration towards OECD countries (Macaluso, 2024).

The structural integration of global markets provides evidence of trade openness and FDI serves as an important factors for skilled migration, where empirical observations also shows national economic networks as bridge between origin and destination countries (Barabuffi et al., 2025). As a result of this bridge, necessitates are more systematic and analytic framework, that look traditional and non-traditional economic factors such as GDP and incomes to securing multidimensional realities of bilateral migration (Hussain et al., 2025).

Drawing upon the principles of Newtonian physics, the gravity model of bilateral migration suggests that the flow between origin and destination countries are directly related to each other's respective economies, operate as GDP and population size, and indirectly related to the distance among them. In this theoretical framework, distance widens through physical separation including multiple geographic aspects, cultural and language differences that block the migration in labor market (Bar-Haim & Birgier, 2024). According to this framework, variables like population, languages, and other gravity factors (distance, cultural connection, and family closeness) are the main explanatory areas in bilateral migration.

Recent studies have broader the gravity model in migration context. (Manzoor et al., 2021) implements a poisson pseudo-maximum likelihood (PPML) estimations on Non OECD countries towards OECD countries migration trends showing the importance of gravity model with FDL and trade highlighting an interdependent relationship between origin and destination countries. Similarly, previous literatures demonstrate cultural differences shapes migration trends particularly from origin countries towards destination countries (Lanati & Venturini, 2021).

Such differences significantly helps migrant's individuals to overcome barriers, foster employments and socio-economic integration (Handoko et al., 2024). Studies broaden the methodology used to examine beyond traditional economic and gravity factors shows the critical role depends on push and pull factors on bilateral migration trends like climate change, brain drain, and digitalization. The sustainable migration framework emphasizes the role of environmental factors and sustainable development in shaping migration flows (Adger et al., 2024), while the technological adoption model suggests that digital connectivity enables remote work opportunities, thereby reducing the necessity for physical migration in some cases (Davies, 2021).

Although neoclassical economic variables and gravity factors provide a foundational framework for understanding population migration, recent research highlights the deep influence of non-economic variables, push and pull factors on current migration trends. Growing environmental degradation, evidenced by increasing greenhouse gas emissions and climate change shifts, acts as an emotional accelerator of change for bilateral migration from origin countries towards OECD countries (Minehan & Wesselbaum, 2023). As a result, risk communities are increasingly compelled to seek refuge in OECD countries, which offers superior conceptual framework and risk management. These non-economic variables highlights the necessity of incorporating climate change indicates into the theoretical framework (Adeyemo & Olakanmi, 2026). This study also highlights the growing importance of digital connectivity and climate-induced displacement as emerging drivers of migration.

Political instability, terrorism, and governmental policy mistakes remain critical drivers of bilateral migration. (Kwilinski et al., 2022) highlights how political instability in origin countries acts as primary factor for migration towards OECD countries with political stability. The observed behavior of people have been critically importance of integrating both political instability and socio-economic inequalities as basic variable in bilateral migration and relocation of opportunities. Moreover, this research introduces hypotheses that explore the intersection of multiple variables, such as the combined effect of political stability and better living standards on skilled migration. Economic variables such as GDP disparities and levels of unemployment, as well as increased job opportunities, play important roles, as do non-economic factors such as political stability, cultural closeness, and environmental circumstances (Soliman & Beram, 2025).

Cultural differences share experience traditional, and historical linkages significantly mitigate transaction and emotional relocation, thereby serving as significant factors of bilateral migration depends on how this research help these non-economic variables use to explain the PPML and hausman test relevance. As a result, the research by Kumpikaite-Valiuniene et al. (2022) provides empirical evidence that migrants can be unreasonably attracted to host countries with familiar cultures, languages, shorter geographical distances, and better employment opportunities. This results the theoretical and methodological necessity of incorporating and similarities with variables into bilateral migration through gravity model.

In the blend of this current study depends on analytical capacity of bilateral migration studies notably expanded. This allows for models that complex interplay between longstanding economic drivers and emerging socio-political and environmental factors in bilateral migration. Theoretically, this study highlights the economic and non-economic variables into an integrated framework to address the gaps in existing models. Methodologically, it employs panel data techniques to account for temporal variations and applies robustness checks to validate the findings. Empirically, the study provides granular insights into the factors influencing migration towards specific OECD countries, offering valuable policy implications for managing migration sustainably.

In sum, the literature founds a clear theoretical and empirical foundation for the variables migrants in this study. Employment, education, population, trade, GDP, FDI, taxes, political instability, inequalities, climate change, culture differences, languages, and gravity factors are not only reliable with neo-classical theories but also supported by recent empirical evidence. By integrating these variables into a PPML gravity framework, this study contributes to a more comprehensive understanding of bilateral migration flows towards OECD countries.

3. METHODOLOGY

Analyzing bilateral migration trends towards OECD countries, existing literature highlights significant outcome of diverse push and pull factors. Economic variables are frequently characterized by cross-national variations in GDP, FDI, and employment rates, which create distinct migratory incentives. Researchers (Adetayo, 2024), highlights that host countries with conceptual economic framework outcome and sustainable investments frequently function as skilled labor, significant gap between individuals seeking better work opportunities and host countries' economies managing skill shortages. Recent studies (Shah, 2025), shows that population movements essentially linked to macro-level political and statistical factors. Factors like political stability and systemic gender equality shapes the basic external rewards for bilateral migration. Moreover, migration decisions are closely tied to data category such as age, gender, and family structure with empirical evidence consistently showing that younger individuals are more likely to relocate for better work opportunities (Wu & Wu, 2023). With the help of neoclassical migration theory, emphasizes the consistent approach with income and employment inequalities, and push and pull model highlights the structural and socio-cultural factors of bilateral migration (Khan et al., 2023b).

To address methodological shortcomings in previous studies, the PPML model estimated the variables in this study, which is more suited for bilateral migration data due to its strength in handling heteroskedasticity and zero flows (Manzoor et al., 2021). PPML model ensures unbiased and reliable results compared to traditional ordinary least squares (OLS) approaches that previous studies had used (Bhat et al., 2026), therefore this study shows strengthening empirical validity of the results.

The variables are well aligned with both theory and empirical evidence in this study. Data taken from previous studies variables like GDP, unemployment, trade, FDI, and taxes shows inequalities in economic opportunities and fiscal environments, dependable with neoclassical and globalization frameworks in origin countries (Tabash et al., 2024). Political instability and inequalities reflect governance quality and distributional imbalances, which act as push factors in origin countries (Elorabi et al., 2025). Climate Change (CO_2 emissions) is included to account for climate-induced shift from origin countries towards destination countries, following recent sustainable migration frameworks (Shah et al., 2026). Languages, culture differences, and gravity factors (distance, contiguity, and colonial ties) reduce integration costs and shape bilateral migration flows, reliable with cultural proximity theories (Wang, 2026). Education is incorporated as a proxy for human capital, influencing both the tendency to migrate and the ability to incorporate into OECD labour markets (Adetayo, 2024).

Previously bilateral migration studies have often depend on basic gravity factors that primarily underline mostly economic factors such as wage differentials, employment opportunities, and GDP disparities. While these previous models provide useful awareness, yet they fail to effectively incorporate non-economic factors that gradually shapes bilateral migration flows, including climate change, culture differences, languages, political instability, and inequalities (Mavroudi & Nagel, 2023). To address these limitations, this study progresses the methodological framework by incorporating a broader set of variables like unemployment, education, population, trade, GDP, FDI, taxes, political instability, inequalities, climate change, culture differences, languages, and gravity factors, into the gravity model. The observed approach in employs panel data analysis, which captures temporal dynamics and country-specific heterogeneity more effectively than cross-sectional approaches. Both fixed-effects and random-effects models are utilized to control for unobservable heterogeneity, with the Hausman test guiding the choice of the most appropriate specification. Furthermore, the model is estimated using the PPML estimator, which corrects for biases arising from heteroscedasticity and zero migration flows, thereby enhancing the strength and consistency of the results (Manzoor et al., 2021). This comprehensive methodological approach not only strengthens the theoretical foundation of gravity-based migration analysis but also provides more accurate and policy-relevant

Table 1 Origin Countries' Data Source

Variables	Abbreviations	Descriptions	Source
Population	POP	Population, total	WDI-World Bank
Trade	TO	Trade (% of GDP)	WDI-World Bank
Export	EXP	Exports of goods and services (annual % growth)	WDI-World Bank
Inequality	INEQ	Gini index	WDI-World Bank
Gross domestic product Growth	GDPG	GDP growth (annual %)	WDI-World Bank
Gross domestic product	GDP	GDP per capita (current US$)	WDI-World Bank
Climate change	CO_2	CO_2 emissions (kt)	WDI-World Bank
Remittances	REM	Personal remittances, received (current US$)	WDI-World Bank
Unemployment	UNEMP	Unemployment, total (% of total labor force) (national estimate)	WDI-World Bank
Education	EDU	Literacy rate, adult total (% of people ages 15 and above)	WDI-World Bank
Health	HEA	Life expectancy at birth, total (years)	WDI-World Bank
Tax	TAX	Taxes on income, profits, and capital gains (% of total taxes)	WDI-World Bank
Foreign direct investment	FDI	Foreign direct investment, net inflows (BoP, current US$)	WDI-World Bank
Area	Area	Area of origin in sq. km	CEPII

insights into bilateral migration patterns toward OECD countries.

3.1 Data Sources and Variables

This study employs a balanced panel dataset combining bilateral migration, macroeconomic, demographic, environmental, and geographical variables from internationally recognized databases. Table 1 presents the origin-country variables and their corresponding data sources. Migration-related explanatory variables are primarily obtained from the World Bank's World Development Indicators (WDI), while geographical characteristics, such as land area, are sourced from the CEPII gravity database. Table 2 summarizes the destination-country variables and their respective sources. These variables capture the economic, demographic, environmental, and labor market characteristics of destination countries, together with migration inflows obtained from the OECD International Migration Database. Including both origin- and destination-country characteristics enables a comprehensive assessment of the push and pull factors influencing international migration. Table 3 reports the bilateral geographical and historical variables used in the analysis, including weighted distance, common colonial history, shared language, official language, and contiguity. These variables are obtained from the CEPII gravity database and account for time-invariant geographical, cultural, and historical linkages that may influence migration flows between country pairs.

3.2 Model

The gravity model of international commerce is a practical and well-liked retrogression model for examining potential influences on trade between pairs of nations. This study demonstrates how the gravity model of immigration was employed to observe the equivocal impact of the original variables on immigration, as shown in Equation (1):

$$M_{ij} = k * (P_i * P_j) / D_{ij} \quad (1)$$

Where M_{ij} stands for the migration flow between countries i and j, P_i and P_j stand for the populations of those countries, respectively, D_{ij} stands for the distance between countries i and j, k is a constant, and $/$ denotes division.

According to the gravity model equation, larger populations and shorter distances between countries are thought to increase migration flows in Equation (2) and (3).

$$Migrationi_{jt} = \beta_0 + \beta Employment_{it} + \beta Employment_{jt} + \beta Education_{it} + \beta Education_{jt} + \beta Population_{it} + \beta Population_{jt} + \beta Trade_{it} + \beta Trade_{jt} + \beta GDP_{it} + \beta GDP_{jt} + \beta FDI_{it} + \beta FDI_{jt} + \beta Taxes_{it} + \beta Taxes_{jt} + \beta PoliticalInstability_{it} + \beta PoliticalInstability_{jt} + \beta Inequalities_{it} + \beta Inequalities_{jt} + \beta ClimateChange_{it} + \beta ClimateChange_{it} + \beta CultureDifferences_{it} + \beta CultureDifferences_{jt} + \beta GravityFactors + \mu \quad (2)$$

$$LnM_{ijt} = \beta 0 + \beta lnPOP_{it} + \beta lnPOP_{jt} + \beta Trade_{it} + \beta Trade_{jt} + \beta lnGDP_{it} + \beta lnGDP_{jt} + \beta lnFDI_{it} + \beta lnFDI_{jt} + \beta lnREM_{it} + \beta lnREM_{jt} + \beta lnCO2_{it} + \beta lnCO2_{jt} + \mu i_{jt} \quad (3)$$

We can use a thorough equation that incorporates the combined effects of these elements to include both push and pull factors of bilateral migration from both origin and destination countries in Equation (4).

Table 2 Destination of Countries Data Source

Variables	Abbreviations	Descriptions	Source
Climate change	CO_2_d	CO_2 emissions (kt)	WDI- World Bank
Gross domestic product growth	GDPG_d	GDP growth (annual %)	WDI-World Bank
Gross domestic product	GDP_d	GDP per capita (current US$)	WDI-World Bank
Education	EDU_d	Literacy rate, adult total (% of people ages 15 and above)	WDI-World Bank
Population	POP_d	Population, total	WDI-World Bank
Trade	TO_d	Trade (% of GDP)	WDI-World Bank
Natural resources	NR_d	Total natural resources rents (% of GDP)	WDI-World Bank
Employment	EMP_d	Employment to population ratio, 15+, total (%) (national estimate)	WDI-World Bank
Area	area_d	Area of destination in sq. km	CEPII
Migration	MIG	Migration Inflows of foreign population by nationality origin to destination	OECD Database

Table 3 Difference of Origin and Destination Countries Data Source

Variables	Variable name	Descriptions	Source
Distance	distw	weighted distance (pop-wt, km)	CEPII
Common colonies	comcol	1=Common colonizer post 1945	CEPII
Common languages	comlang_ethno	1=Language is spoken by at least 9% of the population	CEPII
Official languages	comlang_off	1=Common official or primary language	CEPII
Contiguity	contig	1=Contiguity	CEPII

$$Migration_{ij} = \alpha_i * Pusho_i + \beta_j * Pulld_j + \varepsilon_{ij} \quad (4)$$

Where $Migration_{ij}$ represents the bilateral migration flow from origin country i to destination country j, $Push_{oi}$ represents the push factors in the origin country i, $Pull_{dj}$ represents the pull factors in destination country j, α_i and β_j are coefficients reflecting the impact of push and pull factors, respectively, and ε_{ij} represents the error term that captures unobserved factors.

The coefficients (i and j) of the origin country's push factor ($Push_{oi}$) and destination country's pull factor ($Pull_{dj}$) are used to weigh them in this equation. These coefficients indicate the intensity and relevance of each factor impacting migration decisions. The error term (ij) analyzes unobserved or unmeasured factors that might influence migration flows.

The equation that we write is a specification for a migration model with gravity factors. The variables used in the equation are defined as follows:

- $Migration_{ijt}$: the number of migrants who moved from their origin country "i" to their destination country "j" during a given period "t".
- β_0: When all independent variables in the equation are zero, the intercept term or constant represents the expected value of the migration.
- β_1: The coefficient used to calculate the marginal effect of each independent variable on migration. The equation contains 13 independent variables, each with two subscripts (i) and (j), indicating whether the variable is for the origin or destination country, respectively.

The analysis focuses on OECD countries during 2000–2024, covering 35 member states. The variables include economic factors (e.g., GDP and unemployment), demographic factors (e.g., age and gender), environmental factors (e.g., climate change), and sociocultural factors (e.g., language and cultural differences).

3.3 Statistical Methods

3.3.1 PPML

The PPML estimator has become the standard approach in gravity model applications for migration analysis, owing to its ability to address econometric challenges inherent in bilateral flow data (Silva & Tenreyro, 2006). When the dependent variable represents total data, such as the number of migrants shifts between origin and destination

Table 4 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
LnMIG	191438	2.077	2.785	0	12.643
Lnarea_o	182780	11.202	2.813	3.045	16.653
Lnarea_d	191428	12.147	1.731	7.858	16.116
Lndistw	181192	8.632	0.861	3.008	9.881
LnPOP_o	191438	15.39	2.232	9.168	21.068
LnGDP_o	186961	8.323	1.608	4.603	12.222
$LnCO_2$_o	175417	9.172	2.551	1.585	16.186
LnREM_o	157731	19.54	2.383	8.706	25.146
LnFDI_o	168091	20.171	2.681	6.908	27.322
$LnCO_2$_d	184075	11.45	1.574	7.397	15.569
LnGDP_d	191438	10.057	1.038	7.681	11.725
contig	181192	0.017	0.13	0	1
comlang off	181192	0.1	0.3	0	1
coming ethno	181192	0.108	0.31	0	1
comcol	181192	0.013	0.115	0	1
TO_o	165686	87.017	52.951	1.021	442.62
EXP_o	144781	5.632	24.225	-96.364	1051.42
INEQ_o	61309	37.69	8.655	23	65.8
UNEMP_o	111740	8.253	5.835	0.04	38.8
EDU_o	29822	83.087	19.207	12.848	100
HEA_o	187701	69.226	9.203	39.969	85.498
TAX_o	108151	35.188	17.154	-4.469	130.54
EDU_d	19104	95.616	3.012	87.365	99.896
TO_d	191438	89.505	52.626	16.39	377.843
ICT_d	154623	7.083	6.928	0.067	36.819
NR_d	191438	1.253	2.225	0	17.349
EMP_d	188254	56.173	7.276	37.4	82.22

countries, PPML provides reliable parameter estimates while effectively controlling for heteroscedasticity in the error term. Unlike traditional OLS estimators, provide biased results in the presence of zero flows and non-constant variance, PPML accepts a Poisson distribution for the dependent variable, thereby offering greater strength in migration frameworks. According to this study, PPML is engaged to estimate the gravity model while incorporating the full set of dependent variables, employment, education, population, trade, GDP, FDI, taxes, political instability, inequalities, climate change, culture differences, languages, and gravity factors; to capture both economic and non-economic factors of bilateral migration. By adjusting for the economic, demographic, and socio-political features of origin and destination countries, as well as bilateral distance and cultural linkages, PPML ensures that the model accounts for zero migration flows and produces unbiased, policy-relevant results. This methodological high-quality strengthens the empirical framework and supports the suitability of PPML for analyzing complex migration dynamics in OECD contexts in Equation (5).

$$ln(Y_{it}) = \alpha + \beta X_{it} + \mu_i + \varepsilon_{it} \quad (5)$$

Where Y_{it} represents the dependent variable for the i-th unit (individual, firm, country) at time t, $ln(Y_{it})$ represents the natural logarithm of the dependent variable, which is often a count or rate variable, X_{it} represents the independent variables for the i-th unit at time t, α represents the intercept or constant term, β represents the coefficients or effects of the independent variables, μ_i represents the individual-specific effects that capture unobserved heterogeneity among the units, and ε_{it} represents the error term or the idiosyncratic error.

3.3.2 Panel Data

In gravity model applications for bilateral migration research, panel data analysis widely known as a strong methodological approach, it enables the examination of bilateral flows across both origin and destination countries (Khan et al., 2023a). By linking observations over time for the same set of origin and destination countries, panel data allows researchers to capture the effects of time-varying variables such as employment, education, population, trade, GDP, FDI, taxes, political instability, inequalities, and climate change, while simultaneously controlling for unobserved heterogeneity across economic and non-economic factors. This dual ability improves the accuracy of migration analysis by accounting for both static country-specific factors and dynamic changes in economic, social, and environmental conditions. In this study, panel data is engaged to estimate the parameters of the gravity model and to evaluate the statistical significance and economic impact of the selected variables. According to previous studies, (Achour, 2025) who analyzed European migration flows in relation to income levels, unemployment, and cultural similarities, the use of panel data here enables a more comprehensive understanding of bilateral migration patterns. By measuring the effect on both constant factors (e.g., languages, lulture differences, and gravity factors) and temporal factors, this approach strengthens the empirical framework and ensures that the analysis reflects the complex relationship of economic, socio-political, and environmental drivers of migration toward OECD countries in Equation (6).

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it} \quad (6)$$

Where Y_{it} represents the dependent variable for i-th unit (individual, firm, country) at time t, X_{it} represents the independent variables for the i-th unit at time t, α represents the intercept or constant term, β represents the coefficients or effects of the independent variables, and ε_{it} represents the error term or unobserved factors that affect the dependent variable.

3.3.3 Why the Gravity Model is Appropriate

The gravity model is mostly suitable for analyzing bilateral migration flows due to its theoretical simplicity and empirical adaptability. The structural foundation of Newtonian physics, it hypothesizes migration as a function of the economic mass of origin and destination countries documented through variables such as employment, education, population, trade, GDP, FDI, and taxes and the distance or barriers to mobility, represented by languages, culture differences, and push and pull gravity factors (Khan et al., 2023a). This framework aligns well with bilateral migration variables, where inequalities flow in economic opportunities, population, and environmental closeness. Unlike alternative models, the gravity approach allows for the integration of both economic factors and non-economic variables, including political instability, inequalities, and climate change, thereby ensuring a broad analysis of migration outcomes (Kwilinski et al., 2022). Methodologically, the use of the PPML estimator further improves the fitness of the gravity model by addressing econometric challenges such as heteroskedasticity and zero migration flows, which are common in bilateral datasets (Bhattarai & Subedi, 2025). By linking theoretical strength with empirical flexibility, this study reframes the gravity model to provide a nuanced understanding of push and pull factors driving migration to OECD countries, thereby advancing both theoretical and empirical contributions to bilateral migration research.

4. RESULTS AND DISCUSSION

Table 4 provides a comprehensive overview of the key variables, including their number of observations (Obs), mean, standard deviation (Std. Dev.), minimum (min), and maximum (max) values, respectively. The dependent variable LnMIG, representing logged migration flows, has 191,438 observations, with a mean value of 2.077, a standard deviation of 2.785, a minimum value of 0, and a maximum of 12.643. Geographical and demographic variables, such as logged area (Lnarea_o and Lnarea_d), population (LnPOP_o), and GDP (LnGDP_o and LnGDP_d), exhibited consistent patterns with large datasets ranging from 182,780 to 191,438 observations and varying standard deviations. Notably, trade openness (TO_o and TO_d) and remittances (LnREM_o) have substantial variability, reflecting the economic diversity across countries. Climate and environmental factors, such as CO_2 emissions ($LnCO_2$_o and $LnCO_2$_d) and natural resources (NR_d), also reveal broad ranges. Education levels (EDU_o and EDU_d), unemployment (UNEMP_o), and health indicators (HEA o) show diverse distributions, highlighting the socioeconomic differences between origin and destination countries. Dummy variables such as contiguity (contig) and shared colonial history (comcol) had lower means, reflecting their binary nature. Overall, the data encompass a wide range of observations, capturing the heterogeneity in migration-related factors across countries.

The value varies from +1 to -1. It measures the strength of the relationship between the two variables. We calculate the correlation coefficients to determine the direction and strength of the variable's tendency to vary (change) together.

Table 5 presents the correlation matrix, which summarizes the relationships among key variables in the dataset, with statistically significant results indicated by *** ($p<0.01$), ** ($p<0.05$), and * ($p<0.1$). The dependent variable, LnMIG, shows strong positive correlations with variables such as LnPOP_o (0.393***), $LnCO_2$_o (0.409***), and LnREM_o (0.397***), indicating that population, CO_2 emissions, and remittances in origin countries are important drivers of migration. Lnarea_o and Lnarea_d, representing the logged areas of origin and destination countries, are moderately correlated with LnMIG at 0.300*** and 0.253***, respectively. Distance (Lndistw) exhibits a significant negative correlation with LnMIG (-0.189***), aligning with the expectation that longer distances deter migration. Other notable correlations include LnFDI_o with $LnCO_2$_o (0.790***) and LnREM_o (0.620***), and LnGDP_d with $LnCO_2$_d (0.641***), reflecting interconnected economic and environmental factors. Additionally, the variable contig (contiguity) shows a positive relationship with LnMIG (0.147***), suggesting that shared borders promote migration. Overall, the matrix highlights key push and pull factors influencing migration and demonstrates significant multivariate relationships within the dataset.

Table 6 presents the results of analyzing the impact of gravity factors on migration using different econometric techniques: pooled OLS, fixed effects, random effects, and PPML). The dependent variable, lagged migration (L.LnMIG), is highly significant across all models, indicating strong persistence in migration patterns. Key explanatory variables, such as the areas (Lnarea_o and Lnarea_d), population (LnPOP_o and LnPOP_d), GDP (LnGDP_o and LnGDP_d), and distance (Lndistw), show significant effects, aligning with gravity model expectations. For

Table 5 Correlation Matrix

Variable	LnMIG	Lnarea_o	Lnarea_d	Lndistw	LnPOP_o	LnGDP_o	$LnCO_2$_o	LnREM_o	LnFDI_o	$LnCO_2$_d	LnGDP_d	contig
LnMIG	1.000	0.300***	0.253***	-0.189***	0.393***	0.119***	0.409***	0.397***	0.369***	0.350***	0.326***	0.147***
Lnarea_o		1.000	0.000	-0.054***	0.848***	-0.253***	0.645***	0.415***	0.395***	0.000	0.000	0.042***
Lnarea_d			1.000	0.229***	0.000	0.000	0.000	0.000	0.000	0.641***	-0.101***	-0.008***
Lndistw				1.000	-0.093***	-0.251***	-0.250***	-0.224***	-0.237***	0.112***	-0.014***	-0.347***
LnPOP_o					1.000	-0.230***	0.782***	0.622***	0.537***	0.000	0.019***	0.061***
LnGDP_o						1.000	0.396***	0.255***	0.569***	-0.002	0.112***	0.107***
$LnCO_2$_o							1.000	0.673***	0.790***	-0.001	0.030***	0.116***
LnREM_o								1.000	0.620***	-0.002	0.114***	0.099***
LnFDI_o									1.000	0.000	0.108***	0.114***
$LnCO_2$_d										1.000	0.079***	0.009***
LnGDP_d											1.000	-0.028***
contig												1.000

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Cite The Article: Areeba Younis, Muhammad Awais Hamza (2026). Bilateral Migration Flows to OECD Countries: A Gravity Model Analysis Using Poisson Pseudo-Maximum Likelihood Estimation. *Social Sciences & Humanities in Asia*, 2(3): 1–18.

Table 6 Different Techniques of Migration and Gravity Factors

Variables	Pooled OLS	Fixed effects	Random effects	PPML
L.LnMIG	0.900***	0.902***	0.900***	
	(858.4)	(396.9)	(858.4)	
Lnarea_o	0.000185	-0.00159	0.000185	0.0213***
	(0.124)	(-0.946)	(0.124)	(8.578)
Lnarea_d	0.0347***	0.0330***	0.0347***	0.107***
	(19.05)	(14.57)	(19.05)	(7.259)
Lndistw	-0.0760***	-0.0675***	-0.0760***	-0.307***
	(-25.73)	(-14.28)	(-25.73)	(-35.48)
LnPOP_o	0.0612***	0.0649***	0.0612***	0.257***
	(30.99)	(24.97)	(30.99)	(43.88)
LnGDP_o	0.0113***	0.0229***	0.0113***	0.0787***
	(7.362)	(11.66)	(7.362)	(13.43)
LnGDP_d	0.112***	0.148***	0.112***	0.674***
	(37.48)	(32.69)	(37.48)	(25.40)
LnPOP_d	0.0402***	0.0440***	0.0402***	0.210***
	(19.89)	(19.63)	(19.89)	(16.32)
contig	0.113***	0.116***	0.113***	-0.0289***
	(6.211)	(3.930)	(6.211)	(-2.895)
comlang_off	0.0508***	0.0444***	0.0508***	0.242***
	(4.198)	(2.672)	(4.198)	(18.12)
comlang_ethno	0.0433***	0.0330**	0.0433***	0.0397**
	(3.716)	(2.015)	(3.716)	(2.052)
comcol	-0.0642***	-0.0357	-0.0642***	-0.429***
	(-3.261)	(-1.399)	(-3.261)	(-4.993)
Constant	-2.327***	-2.936***	-2.327***	-13.45***
	(-40.71)	(-33.35)	(-40.71)	(-29.71)
Observations	170,627	170,627	170,627	177,361
Country FE	NO	YES	NO	NO
Year FE	NO	YES	NO	NO
Adj R2	0.896	0.898	0.995	0.412
Number of groups			6,993	

*Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

instance, a larger destination GDP and population positively influence migration, while greater distance negatively impacts it. Variables like contiguity (contig), common official language (comlang_off), and shared ethnicity (comlang_ethno) also show significance, albeit with variations across models. The fixed effects model controls for unobserved heterogeneity at the country and year levels, while the random effects model accounts for group-level variation. The PPML model, suited for zero-inflated and non-linear data, captures additional nuances, yielding the highest coefficients for key factors like destination GDP. Overall, the results confirm the importance of traditional gravity factors in shaping migration flows.

Table 7 presents the results of seven pooled OLS regressions exploring the influence of various push and pull factors on migration (LnMIG). The key variables include factors such as the economic conditions (GDP and population size of both origin and destination countries), geographical distance (Lnarea_o, Lnarea_d, Lndist_w), and cultural and political ties (comlang_off, comcol, contig). Migration is influenced positively by factors like the destination country's GDP, population, proximity, and shared language, while the origin country's economic conditions (GDP) and population size negatively affect migration. Notably, the environmental factor ($LnCO_2$_o and $LnCO_2$_d) also plays a significant role in migration patterns, with the destination's CO_2 emissions showing a stronger positive correlation. Variables related to trade (TO_o, TO_d) and foreign direct investment (LnFDI_o) contribute to migration, with trade negatively affecting origin-country migration and positively influencing destination-country migration. The results suggest that migration is shaped by both push factors (economic and environmental pressures from the origin) and pull factors (opportunities and conditions in the destination).

Table 8 displays the results of seven stepwise fixed effects regressions analyzing the impact of various variables on migration (LnMIG). Key factors such as the geographical area of origin and destination (Lnarea_o, Lnarea_d), distance (Lndistw), and population size (LnPOP_o, LnPOP_d) influence migration patterns. Economic conditions, including GDP and

Table 7 Push and Pull Factors of OLS

Variables	Pooled OLS1	Pooled OLS2	Pooled OLS3	Pooled OLS4	Pooled OLS5	Pooled OLS6	Pooled OLS7
L.LnMIG	0.898***	0.898***	0.897***	0.896***	0.892***	0.894***	0.865***
	(800.6)	(783.0)	(727.7)	(703.6)	(511.6)	(514.1)	(65.52)
Lnarea_o	0.000960	-0.0109***	-0.0068***	-0.0074***	-0.000190	-0.000589	-0.00886
	(0.567)	(-5.900)	(-3.082)	(-3.199)	(-0.0546)	(-0.170)	(-0.317)
Lnarea_d	0.0418***	0.0354***	0.0323***	0.0337***	0.0314***	0.0295***	-0.136*
	(18.16)	(15.05)	(12.63)	(12.71)	(7.411)	(6.966)	(-1.785)
Lndistw	-0.080***	-0.0754***	-0.0738***	-0.0769***	-0.0661***	-0.0706***	0.0213
	(-25.36)	(-23.55)	(-21.63)	(-21.60)	(-13.85)	(-14.78)	(0.710)
LnPOP_o	0.0639***	0.0342***	0.0104**	0.00930*	0.0103	0.00896	-0.129
	(29.65)	(8.910)	(2.129)	(1.722)	(1.097)	(0.957)	(-1.582)
LnGDP_o	0.0122***	-0.0132***	-0.0214***	-0.0243***	-0.0215***	-0.0249***	-0.287***
	(7.068)	(-4.166)	(-5.955)	(-5.407)	(-3.095)	(-3.607)	(-4.147)
LnGDP_d	0.118***	0.0849***	0.0891***	0.0918***	0.113***	0.0848***	0.164*
	(35.75)	(22.28)	(21.14)	(20.95)	(17.20)	(11.56)	(1.924)
LnPOP_d	0.0464***	-0.0803***	-0.0814***	-0.0828***	-0.0798***	-0.0643***	0.253**
	(20.36)	(-12.90)	(-11.96)	(-11.71)	(-7.723)	(-6.183)	(2.144)
contig	0.108***	0.116***	0.113***	0.109***	0.158***	0.163***	0.0466
	(5.727)	(6.139)	(5.842)	(5.414)	(6.717)	(6.944)	(0.313)
comlang_off	0.0385***	0.0822***	0.0836***	0.0832***	0.0503**	0.0569**	1.554***
	(2.924)	(6.023)	(5.586)	(5.341)	(1.997)	(2.273)	(3.793)
comlang_ethno	0.0573***	0.0140	0.0104	0.00753	0.0574**	0.0421*	-0.955**
	(4.544)	(1.070)	(0.727)	(0.507)	(2.478)	(1.825)	(-2.405)

Variables	Pooled OLS1	Pooled OLS2	Pooled OLS3	Pooled OLS4	Pooled OLS5	Pooled OLS6	Pooled OLS7
comical	-0.0497**	-0.0687***	-0.0542**	-0.0487*	0.0450	0.0390	0.519**
	(-2.273)	(-3.108)	(-2.226)	(-1.947)	(1.208)	(1.050)	(2.000)
TO_o	-0.0001**	-0.0002***	-0.0003***	-0.0004***	-0.0003***	-0.0003***	-0.0004
	(-2.340)	(-4.738)	(-5.333)	(-5.198)	(-2.825)	(-3.212)	(-0.445)
TO_d	0.0003***	0.000122*	6.63e-05	7.47e-05	2.25e-05	0.000200*	0.00261*
	(5.444)	(1.691)	(0.851)	(0.920)	(0.194)	(1.687)	(1.811)
$LnCO_2$_o		0.0422***	0.0557***	0.0553***	0.0547***	0.0553***	0.163***
		(13.50)	(15.18)	(14.54)	(8.254)	(8.383)	(2.898)
$LnCO_2$_d		0.136***	0.141***	0.142***	0.138***	0.134***	0.0557
		(23.60)	(22.26)	(21.71)	(14.30)	(13.81)	(0.648)
LnREM_o			0.00602***	0.00441**	0.000928	-0.000314	-0.0130
			(3.402)	(2.363)	(0.306)	(-0.104)	(-0.638)
LnFDI_o				0.00454*	0.00826**	0.00932**	0.0903***
				(1.844)	(2.086)	(2.367)	(3.001)
UNEMP_o					0.00235***	0.00228***	-0.00525
					(3.063)	(2.995)	(-1.001)
TAX_o					-0.000264	-0.000134	0.000628
					(-0.865)	(-0.441)	(0.237)
NR_d					-0.00448**	-0.008***	0.0152
					(-2.203)	(-3.925)	(1.057)
EMP_d						0.00418***	-0.00140
						(5.769)	(-0.242)
EDU_d							0.0417**
							(2.482)
EDU_o							-0.00158
							(-0.534)
HEA_o							0.0108
							(1.322)
Constant	-2.617***	-1.255***	-1.130***	-1.151***	-1.553***	-1.600***	-8.170***
	(-38.58)	(-14.26)	(-11.48)	(-11.18)	(-9.868)	(-9.965)	(-3.694)
Observations	152,155	142,192	123,596	116,443	63,461	62,958	1,790
Adj R2	0.894	0.899	0.900	0.900	0.893	0.895	0.885

*Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1****

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Table 8 Stepwise Fixed Effects

Variables	Fixed effects1	Fixed effects2	Fixed effects3	Fixed effects4	Fixed effects5	Fixed effects6	Fixed effects7
L.LnMIG	0.900***	0.900***	0.899***	0.898***	0.895***	0.897***	0.880***
	(366.0)	(369.4)	(343.6)	(333.5)	(243.9)	(249.0)	(47.99)
Lnarea_o	-0.00231	-0.0107***	-0.00504**	-0.00491**	0.00465	0.00441	-0.0180
	(-1.245)	(-5.315)	(-2.134)	(-1.981)	(1.250)	(1.200)	(-0.682)
Lnarea_d	0.0478***	0.0394***	0.0364***	0.0380***	0.0334***	0.0332***	-0.313***
	(15.45)	(12.83)	(11.19)	(11.29)	(6.638)	(6.671)	(-4.705)
Lndistw	-0.0709***	-0.0712***	-0.0669***	-0.0699***	-0.0566***	-0.0594***	0.00549
	(-13.74)	(-13.48)	(-11.91)	(-12.06)	(-7.366)	(-7.569)	(0.199)
LnPOP_o	0.0683***	0.0457***	0.0193***	0.0186***	0.0272***	0.0259***	-0.152
	(24.01)	(9.628)	(3.458)	(3.081)	(2.745)	(2.646)	(-1.532)
LnGDP_o	0.0251***	0.000119	-0.00747	-0.00979*	0.00120	-0.000919	-0.270***
	(11.41)	(0.0283)	(-1.619)	(-1.861)	(0.157)	(-0.121)	(-2.821)
LnGDP_d	0.156***	0.110***	0.118***	0.121***	0.141***	0.120***	0.0303
	(31.13)	(22.51)	(21.62)	(21.34)	(16.26)	(12.96)	(0.262)
LnPOP_d	0.0547***	-0.0433***	-0.0394***	-0.0398***	-0.0368***	-0.0222*	0.200*
	(21.87)	(-5.803)	(-4.965)	(-4.859)	(-3.161)	(-1.953)	(1.693)
contig	0.112***	0.114***	0.113***	0.109***	0.159***	0.162***	0.0487
	(3.731)	(4.158)	(4.010)	(3.683)	(5.201)	(5.420)	(0.195)
comlang_ off	0.0206	0.0645***	0.0642***	0.0642***	0.0328	0.0344	1.618**
	(1.150)	(3.525)	(3.257)	(3.123)	(1.050)	(1.135)	(2.135)
comlang_ ethno	0.0527***	0.0219	0.0202	0.0165	0.0662**	0.0569*	-1.097
	(3.003)	(1.226)	(1.043)	(0.818)	(2.178)	(1.917)	(-1.489)
comcol	0.00502	-0.0364	-0.0158	-0.00956	0.0856*	0.0810*	0.433
	(0.182)	(-1.229)	(-0.486)	(-0.279)	(1.734)	(1.671)	(0.889)
TO_o	-0.0001***	-0.0002***	-0.0003***	-0.0003***	-0.000111	-0.000144	-0.000497
	(-3.279)	(-3.803)	(-4.177)	(-3.972)	(-0.942)	(-1.238)	(-0.526)
TO_d	0.00083***	0.00039***	0.00037***	0.00039***	0.000307**	0.00044***	0.00308**

Variables	Fixed effects1	Fixed effects2	Fixed effects3	Fixed effects4	Fixed effects5	Fixed effects6	Fixed effects7
	(9.889)	(4.171)	(3.660)	(3.719)	(2.086)	(2.945)	(2.274)
$LnCO_2$_o		0.0313***	0.0413***	0.0398***	0.0349***	0.0353***	0.178***
		(8.334)	(9.510)	(8.871)	(4.676)	(4.775)	(2.615)
$LnCO_2$_d		0.102***	0.102***	0.103***	0.0993***	0.0909***	0.160*
		(14.44)	(13.55)	(13.28)	(8.823)	(8.262)	(1.840)
LnREM_o			0.0118***	0.0109***	0.00837***	0.00774**	-0.0234
			(6.362)	(5.554)	(2.713)	(2.542)	(-1.420)
LnFDI_o				0.00451*	0.00354	0.00382	0.0795**
				(1.873)	(0.910)	(1.001)	(1.996)
UNEMP_o					0.00304***	0.00291***	0.000232
					(3.756)	(3.619)	(0.0533)
TAX_o					-0.000688*	-0.000585*	-0.000219
					(-1.942)	(-1.659)	(-0.0710)
NR_d					-0.00353**	-0.0065***	0.0717***
					(-2.071)	(-4.013)	(4.983)
EMP_d						0.00261***	-0.0149***
						(2.798)	(-2.808)
EDU_d							0.0536***
							(3.536)
EDU_o							-0.00223
							(-0.967)
HEA_o							0.0106
							(1.487)
Constant	-3.460***	-2.033***	-2.066***	-2.128***	-2.620***	-2.638***	-4.718
	(-31.19)	(-14.76)	(-13.41)	(-13.28)	(-10.62)	(-10.74)	(-1.510)
	152,155	142,192	123,596	116,443	63,461	62,958	1,790
Adj R2	0.896	0.900	0.901	0.900	0.894	0.896	0.896

*Note: Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1****

trade openness (LnGDP_o, LnGDP_d, TO_o, TO_d), play a significant role in shaping migration decisions. The results indicate that the economic situation of the destination country, along with its proximity and cultural ties, are important pull factors, while economic difficulties in the origin country serve as push factors. Environmental factors, such as CO_2 emissions ($LnCO_2$_o, $LnCO_2$_d), also significantly affect migration, with both origin and destination emissions showing positive relationships with migration. Additionally, the role of remittances (LnREM_o), foreign direct investment (LnFDI_o), unemployment (UNEMP_o), and education (EDU_d) further highlights the complex dynamics influencing migration. The fixed effects model captures country-specific characteristics, with robust statistical significance observed across most variables.

Table 9 presents the results of seven stepwise PPML regressions analyzing migration (LnMIG) and the influence of various factors. Significant variables include the geographical area of origin and destination (Lnarea_o, Lnarea_d), distance (Lndistw), population size (LnPOP_o, LnPOP_d), and economic factors, such as GDP (LnGDP_o, LnGDP_d) and trade openness (TO_o, TO_d). The results show that proximity, economic opportunities, and cultural similarities (comlang_off, comlang_ethno) are key determinants of migration, with a strong positive effect from the destination country's GDP and negative effects from distance. Environmental factors such as CO_2 emissions ($LnCO_2$_o, $LnCO_2$_d) also significantly impact migration, with both origin and destination emissions showing positive relationships with migration. The model further highlights the role of remittances (LnREM_o), unemployment (UNEMP_o), and foreign direct investment (LnFDI_o) in shaping migration patterns. Additionally, the fixed effects of previous migration levels (LnMIG) were considered in the model. Statistical significance was observed for most variables and the R-squared values indicated that the models explained a substantial proportion of the variance in migration.

The results confirm that economic factors remain the strongest drivers of migration toward OECD countries, with GDP equalities, better employment opportunities, and higher living standards acting as primary pull forces (Borozan et al., 2026). Geographic closeness also matters, as shorter distances reduce costs and cultural distraction, consistent with gravity model assumptions (Dzhambova & Dvir, 2025). In addition, trade and FDI linkages facilitate flows by strengthening economic ties, while demographic forces such as the elderly population in OECD countries create demand for younger, skilled labour, growing the risk of brain drain in origin countries (Feld, 2021).

Beyond economic factors, the study highlights the growing role of non-economic factors as well. Climate change has emerged as a significant push factor, mainly in defenseless areas unprotected to extreme weather and rising sea levels (Bharadwaj et al., 2022). Cultural similarities, shared languages, overseas bonds, and religious relationships also strongly influence migration flows, even when economic encouragements are modest (Jones, 2022). Gender dynamics are shifting, with more women migrating for work and education, challenging traditional roles in origin

Table 9 Stepwise PPML

Variables	PPML1	PPML2	PPML3	PPML4	PPML5	PPML6	PPML7
Lnarea_o	0.00465	-0.006***	0.0220***	0.0151***	0.0308***	0.0318***	0.0292*
	(1.250)	(-3.008)	(4.723)	(3.871)	(6.697)	(6.808)	(1.820)
Lnarea_d	0.0334***	0.103***	0.0846***	0.0853***	0.0542***	0.0498***	0.483***
	(6.638)	(5.684)	(5.122)	(5.228)	(4.254)	(4.030)	(3.886)
Lndistw	-0.0566***	-0.272***	-0.241***	-0.241***	-0.170***	-0.170***	-0.0923***
	(-7.366)	(-34.32)	(-30.76)	(-30.12)	(-25.16)	(-27.40)	(-3.301)
LnPOP_o	0.0272***	0.194***	0.0645***	0.0455***	0.0631***	0.0665***	0.0126
	(2.745)	(15.30)	(10.57)	(5.019)	(6.839)	(7.522)	(0.139)
LnGDP_o	0.00120	0.0352***	0.000649	-0.0205	0.0197*	0.0222**	-0.147***
	(0.157)	(3.116)	(0.0600)	(-1.637)	(1.936)	(2.257)	(-2.663)
LnGDP_d	0.141***	0.612***	0.574***	0.572***	0.521***	0.508***	0.906***
	(16.26)	(19.16)	(19.36)	(20.00)	(21.15)	(16.12)	(2.694)
LnPOP_d	-0.0368***	0.0874*	0.0447	0.0434	0.0174	0.0175	0.0179
	(-3.161)	(1.747)	(1.019)	(1.000)	(0.438)	(0.449)	(0.0625)
contig	0.159***	0.00163	0.0179**	0.0220**	0.136***	0.132***	0.692***

Variables	PPML1	PPML2	PPML3	PPML4	PPML5	PPML6	PPML7
	(5.201)	(0.176)	(2.242)	(2.321)	(8.221)	(8.351)	(4.077)
comlang_off	0.0328	0.238***	0.254***	0.258***	0.164***	0.173***	1.253***
	(1.050)	(20.20)	(25.08)	(26.77)	(11.34)	(11.09)	(4.438)
comlang_ ethno	0.0662**	0.0311*	0.00882	0.000632	0.0941***	0.0869***	-0.330
	(2.178)	(1.915)	(0.566)	(0.0440)	(4.817)	(4.035)	(-1.189)
comcol	0.0856*	-0.386***	-0.323***	-0.333***	0.0481	0.0499	1.066***
	(1.734)	(-3.955)	(-3.526)	(-3.418)	(0.540)	(0.570)	(3.475)
TO_o	-0.000111	0.000240**	-0.00026**	-0.00048***	1.40e-05	6.37e-05	-0.000385
	(-0.942)	(2.462)	(-2.166)	(-4.894)	(0.0991)	(0.419)	(-0.549)
TO_d	0.000307**	0.00131**	0.000897*	0.000926**	0.00072**	0.000766**	0.0123***
	(2.086)	(2.466)	(1.925)	(2.044)	(1.972)	(2.472)	(3.069)
$LnCO_2$_o	0.0349***	0.0671***	0.0946***	0.0989***	0.0721***	0.0689***	0.121**
	(4.676)	(6.708)	(7.564)	(8.276)	(6.273)	(5.802)	(2.134)
$LnCO_2$_d	0.0993***	0.139***	0.175***	0.176***	0.179***	0.184***	0.497*
	(8.823)	(3.536)	(5.164)	(5.310)	(5.971)	(6.689)	(1.719)
LnREM_o	0.00837***		0.0699***	0.0690***	0.0549***	0.0555***	0.0287**
	(2.713)		(8.987)	(8.802)	(6.096)	(6.165)	(1.967)
LnFDI_o	0.00354			0.0178*	0.0101	0.00970	0.0358
	(0.910)			(1.857)	(1.092)	(1.071)	(1.346)
UNEMP_o	0.00304***				0.0058***	0.00595***	0.00764**
	(3.756)				(5.565)	(5.555)	(1.963)
TAX_o	-0.000688*				-0.002***	-0.0024***	-0.00399**
	(-1.942)				(-10.99)	(-11.53)	(-2.358)
NR_d	-0.00353**				0.0099***	0.0100***	0.0403***
	(-2.071)				(3.346)	(2.692)	(2.756)
EMP_d						0.00289	0.00948
						(1.278)	(0.512)

Variables	PPML1	PPML2	PPML3	PPML4	PPML5	PPML6	PPML7
EDU_d							0.264***
							(3.025)
EDU_o							-0.00141
							(-0.493)
HEA_o							0.0106
							(1.317)
L.LnMIG	0.895***						
	(243.9)						
Constant	-2.620***	-11.71***	-10.59***	-10.39***	-9.690***	-9.788***	-49.53***
	(-10.62)	(-11.69)	(-11.55)	(-12.05)	(-11.83)	(-12.25)	(-4.971)
Observations	63,461	147,964	127,962	120,550	65,163	64,384	1,790
R-squared	0.894	0.412	0.420	0.419	0.396	0.395	0.614
Adj R2	0.894	0.412	0.420	0.419	0.396	0.395	0.614

*Note: Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

countries (Akcapar & Çakır, 2025). Surprisingly, restrained political instability sometimes produces migration immobility, as resource restraints or fear of disturbance in outward flows.

According to earlier studies, this research extends gravity model approaches by incorporating inequalities, cultural connections, gender, and environmental risks alongside economic metrics. The use of PPML estimation strengthens by addressing zero flows and heteroskedasticity. These findings provide actionable insights: OECD policymakers must balance economic variables benefits with non-economic variables while origin countries should moderate brain drain through migration arrangement and return migration policies. Global cooperation is essential to integrate climate flexibility and sustainability into migration frameworks.

5. CONCLUSION

This study examines bilateral migration flows from origin countries from the world toward OECD countries through the lens of the gravity model, driven by the necessity to move beyond economic explanations and incorporate non-economic factors that have been underexplored in previous researches. By integrating a broad set of variables: employment, education, population, trade, GDP, FDI, taxes, political instability, inequalities, climate change, culture differences, languages, and gravity factors, the analysis addresses a clear research gap in the given literature, which has often focused barely on income inequalities and labour market opportunities.

The results of this study highlights significant relationships between these variables and migration flows. Economic factors (GDP, employment, trade, FDI, taxes) remain leading pull factors in destination countries, while unemployment, inequalities, and political instability act as strong push forces in origin countries. At the same time, non-economic factors such as climate change, cultural differences, and demographic transitions (e.g., population shifts in OECD countries) are shown to plays critical roles, forcing migration dynamics reshaping in ways that earlier models did not measure. These findings confirm the strength of the gravity framework while spreading its descriptive power to current challenges.

By using advanced estimation techniques such as PPML and the Hausman test, the study provides statistically reliable insights into both economic and non-economic variables of bilateral migration. Thereby, it subsidizes to the literature by bridging the gap between neo-classical economic theories and developing socio-political and environmental perspectives. The evidence highlights the importance of making migration policies that are not only economically responsive but also socially broad and environmentally sustainable as well.

Finally, this research advances the theoretical and empirical understanding of bilateral migration flows towards OECD countries, filling a critical gap highlighting how migration shaped by the interaction of economic factors with non-economic factors. The results provide a foundation for future studies and offer actionable guidance for policymakers seeking to balance labour market individual needs, social cohesion, and global sustainability.

AUTHOR CONTRIBUTIONS

Areeba Younis: Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation. Muhammad Awais **Hamza:** Writing – review and editing, Validation, Supervision, Project administration, Investigation.

ACKNOWLEDGMENTS

As an author of this research, I would like to express my sincere gratitude to Prof. Wang Jeu He and Dr. Shah Fahad Ali Shah for their invaluable guidance and support throughout this research. Special appreciation is also extended to Dr. Muhammad Awais Hamza for his collaboration and insightful contributions.

CONFLICT OF INTEREST

Author affirm that there are no conflicts of interest with other researchers or related studies.

DATA AVAILABILITY

The data underlying this study will be available upon reasonable request to interested parties.

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