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POPULATION LITERACY AND ICT SKILLS: DRIVERS OF NET MIGRATION GROWTH

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Abstract

The effectiveness of education policies and economic, social and environmental conditions play a crucial role in a country's ability to attract intellectual capital and influence emigration levels. Effective management of migration processes requires coordinating and synchronizing policies across various economic sectors to address the complexity of these dynamics. This study employs a two-step system of the generalized method of moments (GMM) to analyse the impacts of population literacy and ICT skills on migration patterns in EU countries in the period 2007–2022. The findings underscore the importance of enhancing ICT skills and improving education systems. Population literacy has a statistically significant nonlinear impact on the net migration rate. Initially, higher literacy may lead to more emigration and lower net migration. However, as literacy rates reach very high levels, the country becomes more attractive to immigrants, leading to greater net migration. A 1% increase in ICT skills can significantly boost a country's ability to attract skilled migrants by up to 5%. Policymakers need to ensure that increasing literacy rates are complemented by sufficient local opportunities to retain the educated population.

Implications for Central European audience: This study highlights key strategies for Central European countries to manage migration and foster sustainable development. Investing in ICT skills and lifelong learning, increasing R&D to at least 1% and implementing balanced trade policies can attract and retain talent. Promoting sustainable economic growth improves living standards, reducing migration outflows. Tailored migration policies that address diverse migrant needs enhance integration and retention. Adopting data-driven approaches for continuous policy improvement ensures adaptability to emerging challenges. These combined efforts support a competitive workforce and long-term economic resilience, positioning Central Europe as a hub for innovation and sustainable growth.

Keywords: Migrants; digitalization; human development; knowledge; education
JEL Classification: F22, M31, M38, O15

Introduction

The effectiveness of education policies, economic development and social and environmental conditions in a country influence its attractiveness for the immigration of intellectual capital and the extent of its emigration. Managing migration processes is a complex issue that requires the coordination and synchronization of relevant policies across all economic sectors. Research findings indicate that several factors influence the decision to migrate, including living conditions, health system (Kwilinski et al., 2023d; Letunovska et al., 2022; Szczepańska-Woszczyna et al., 2024), quality of the environment (Hakhverdyan & Shahinyan, 2022; Chen et al., 2023; Kwilinski et al., 2023b; 2024a; 2024b; Dacko-Pikiewicz, 2019b), digitalization (Miskiewicz, 2020; Abad-Segura et al., 2024; Infante-Moro et al., 2020; 2022; Kwilinski, 2019), political stability (Shymon et al., 2020; Hussain et al., 2021; Kwilinski et al., 2024d; Moskalenko et al., 2022; Spicka, 2020), innovation development (Pudryk et al., 2021; Drożdż, 2019; Lesniak et al., 2023; Szczepańska-Woszczyna et al., 2022; Vaníčková & Szczepańska, 2020). A retrospective analysis by Irdale (2001) showed that in the 1960s, political repression was the primary cause of "brain drain", but the intensification of globalization processes and the free movement of people led to significant changes in global migration flows. The quality of education is a central issue in the national economy's education sector, as it negatively affects the population's level of literacy. Gross-Gołacka et al. (2023) examined that the concepts of intellectual capital, sustainable development and Society 5.0 from the management perspective are strongly interconnected and have an impact on the ecosystem. One way to increase the population's education level is through involvement in nonformal education. According to previous studies (Mishra & Misra, 2023; Grotlüschen et al., 2023), nonformal education is defined as being institutionalized and coordinated by education providers, supplementing or providing an alternative to formal education in lifelong learning. The development of a nonformal education network ensures equal access to education. Nonformal education takes various forms (courses, online learning, training, etc.) and often leads to qualifications that are not recognized by official national or subnational education authorities (Dacko-Pikiewicz, 2019a; Kwilinski, 2023a; Rajiani & Kot, 2020).

According to the European system of classification of learning activities (Denkowska et al., 2020; EU, 2024), nonformal education includes nonformal education programmes, courses (training, online courses, private lessons, etc.) and workplace learning. According to the European Commission, in 2023, the participation rate of the EU population in nonformal education was 61.5% among people aged 25 to 64. The highest participation rates were observed in Sweden, Norway and the Netherlands, where participation reached or exceeded 70%. The lowest percentages were observed in Romania and Bulgaria, at less than 20%. Among unemployed individuals, 58.1% were nonformal, while among the employed population, 63.2% were nonformal (Eurostat, 2023).

To analyse the effect of population literacy and ICT skills on net migration growth in EU countries, it is essential to consider how these factors influence individuals' decisions to migrate. Higher literacy rates and greater access to ICT skills can enhance individuals' skills and employability, increasing their likelihood of migrating to countries with better economic opportunities and living conditions. Conversely, countries with lower literacy rates and less

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access to ICT skills may experience higher emigration rates as individuals seek better education and employment opportunities elsewhere. For example, countries such as Sweden and the Netherlands, which have high participation rates in nonformal education and high literacy levels, tend to attract more intellectual capital and have positive net migration growth. In contrast, countries with lower participation rates in nonformal education, such as Romania and Bulgaria, may face challenges in retaining skilled individuals, leading to negative net migration growth. By fostering policies that improve literacy and expand access to ICT skills, EU countries could enhance their attractiveness for skilled migrants and support sustainable economic development. This approach requires comprehensive policy coordination across education, economic development and migration management sectors to address the multifaceted nature of migration dynamics.

While existing studies have explored various determinants of migration, such as economic opportunities, political instability and social networks, there is limited research examining the specific roles of population literacy and ICT skills in influencing net migration patterns. Most studies have focused on these factors independently, without thoroughly investigating their combined impact. This study fills the research gap on the understanding of how literacy and ICT skills interact to shape migration decisions, particularly in different socioeconomic contexts, by developing an approach based on the two-step system generalized method of moments. Additionally, this study addresses these gaps by conducting a comprehensive analysis of both individual and combined effects of literacy and ICT skills on migration, providing a perspective on how governments can better manage migration flows through targeted education and digital skill policies. The primary objective of this research is to explore the individual effects of population literacy and ICT skills on net migration, as well as their combined influence. Understanding these dynamics is crucial for developing effective policies to manage migration flows, optimize human capital and improve overall economic conditions. The findings offer better paths for government actions and policy adjustments, tailored to their unique socioeconomic contexts. This study is characterized by several research innovations: it effectively evaluates the impact of population literacy and ICT skills on net migration, providing direction for governments around the world and practical ideas for achieving better migration management. By examining the influence of population literacy and ICT skills separately, as well as their combined effects, this research offers insights into how these two factors interact and affect migration patterns. This comprehensive analysis provides optimal paths for governments, helping them design policies that enhance education outcomes and make use of ICT skills opportunities to influence migration trends. Additionally, the findings offer valuable policy recommendations for future adjustments and development, ensuring that education initiatives align with broader migration and economic goals.

The paper has the following structure: The literature review brings an analysis of the theoretical framework on linking net migration, the literacy rate and ICT skills; Section 2 provides an explanation of the data source, methods and instruments used to test the research hypothesis; Section 3 describes the empirical results of the impact of the literacy rate and ICT skills on net migration; and the conclusion sums the core results, compares the analysis with previous investigations, presents policy implications, limitations and further directions for research.

1 Literature Review

Irdale (2001) emphasized the transformation of factors influencing the migration of highly skilled workers due to the internationalization of education and globalization processes. Galiano & Romero (2018) indicate that the extent of "brain drain" is greater in less developed countries, especially those with colonial ties to developed OECD countries, than in developed countries classified by the OECD. They also confirmed the hypothesis that "brain drain" increases with political instability in a country. Abolfathi & Taebi (2018) used functional dependencies on birth and death rates and migrant flows to construct scenarios of population change. Ulhaq & Wahid (2022) applied a system dynamics approach to model population changes in Banda Aceh, Indonesia, considering factors such as birth rate, death rate, literacy and migration. Their results, obtained using Vensim PLE 6.0.1c, indicate a positive impact of migration processes on the city's population. In examining migration processes in Asian countries, Xiang & Lindquist (2014) found that migration networks, acting as intermediaries between immigrants and the native population, influence the speed of integration into educational and cultural environments (Wróblewski & Lis, 2021). The primary motives for emigration identified by the researchers include seeking better wages and equal access to education. Bramley et al. (2006) studied the migration behaviour of Scottish and Welsh students and concluded that motives for future migration depend on previous emigration experiences. Akin-Sabuncu et al. (2024) explored how teacher education programmes can be adapted to better serve immigrant students amidst increasing global migration. They emphasize the need for culturally responsive pedagogies and inclusive practices to address the unique needs of immigrant students. Aldieri et al. (2024) investigated the interconnections between education, innovation and migration in Europe, highlighting how educational attainment influences innovation capacity and how migration patterns contribute to knowledge diffusion. Aronica et al. (2023) examined the job mismatch among postgraduate students in Italy and assessed whether migration can alleviate this issue, finding that relocating for work can improve job fit and career outcomes for highly educated individuals. Bello (2011) focused on the empowerment of young migrants in Italy through nonformal education initiatives, arguing that such education promotes social inclusion and equality by providing migrants with skills and knowledge for integration. Contreras (2023) found that migration networks influence immigrants' education decisions, providing crucial support that guides them in pursuing education opportunities and affecting their socioeconomic outcomes. Hean et al. (2024) analysed the interplay between migration, education and technological change, showing how these factors contribute to urban inequality. Kwilinski et al. (2024c) examined how migration flows influence the competitiveness of higher education systems by evaluating the impact of student and academic mobility on the quality and global standing of educational institutions. Okano (2015) discussed the role of nonformal education in strengthening civil society in Japan, highlighting programmes that foster civic engagement and social cohesion. Paweenawat and Liao (2023) investigated how higher education influences migration patterns to urban areas in Thailand using data to propose policies for managing urbanization and its impacts. Higher literacy rates and greater access to ICT skills can enhance individuals' skills and employability, increasing their likelihood of migrating to countries with better economic opportunities and living conditions (European Commission, 2023; Kwilinski et al., 2024a). Conversely, countries with lower literacy rates and less access to ICT skills may experience higher emigration rates as individuals seek better education and employment opportunities elsewhere (Eurostat, 2023; Contreras, 2023). For example,

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countries such as Sweden and the Netherlands, which have high participation rates in nonformal education and high literacy levels, tend to attract more intellectual capital and have positive net migration growth. In contrast, countries with lower participation rates in nonformal education, such as Romania and Bulgaria, may face challenges in retaining skilled individuals, leading to negative net migration growth (OECD, 2023). By fostering policies that improve literacy and expand access to ICT skills, EU countries can enhance their attractiveness for skilled migrants and support sustainable economic development. This approach requires comprehensive policy coordination across education, economic development and migration management sectors to address the multifaceted nature of migration dynamics (UNESCO, 2023).

Therefore, this study tests a hypothesis about the change in net migration flow depending on the literacy level of the population and its involvement in nonformal education.

2 Materials and Methods

To assess the impact of population literacy and ICT skills on net migration, the empirical framework is structured as follows:

$$Mig_{it} = f(PL_{it}, ICT\ skills_{it}, X_{it}) \quad (1)$$

where Mig_{it} is the net migration growth in the country *i* during the period *t*; PL_{it} is the population literacy in the country *i* during the period *t*; $ICT\ skills_{it}$ is the ICT skills in the country *i* during the period *t*; and X_{it} is the set of control variables.

The dynamic panel model, incorporating lagged dependent variables along with explanatory variables, is constructed as follows:

$$Mig_{it} = \alpha + \beta_1 Mig_{it-1} + \beta_2 PL_{it} + \beta_3 ICT\ skills_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (2)$$

In Equation (2), Mig_{it} is the key dependent variable, while PL_{it} and $ICT\ skills_{it}$ are the independent variables. Referring to Bilan et al. (2023) and Fernández-Portillo et al. (2020), ICT skills in the country *i* during the period *t* was measured as enterprises that provided training to develop/upgrade the ICT skills of their personnel (10 persons employed or more). ICT skills often occur in workplace settings where employees receive on-the-job training, particularly in areas such as ICT that are crucial for current technological and economic demands. This indicator reflects the broad scope of ICT skills, encompassing structured yet nonformal activities that enhance workforce competitiveness and adaptability in a digital economy. Enterprises often have high participation rates in training programmes due to their accessibility and direct applicability to job performance, capturing significant adult learning activities not included in formal education statistics.

The variables were logarithmically transformed to linearize the relationships between them. This transformation reduces skewness, leading to more normally distributed data. All data for the variables were collected from Eurostat, covering EU regions and periods from 2007 to 2022. Belgium and Malta were excluded from the analyses due to missing data.

Research and development ($R\&D$), trade openness (TO) and gross net income (GNI) were selected as control variables. Research and development (R&D) investment plays a critical

role in fostering economic growth, innovation (Senaratne et al., 2021) and job creation, which collectively make a country more attractive to migrants. By investing in R&D, countries stimulate technological advancements and productivity improvements across various sectors. By enhancing a country's technological edge and economic health, R&D investment plays a pivotal role in making it a magnet for skilled migrants who are looking to take these opportunities for personal and professional advancement (Johnson et al., 2021; Kwilinski, 2024). Trade openness reflects a country's integration into the global economy, significantly affecting employment opportunities, wages and overall economic health. By engaging in international trade, countries can specialize in the production of goods and services where they have a comparative advantage, leading to more efficient resource allocation and higher productivity (Kwilinski et al., 2024b). This specialization enhances economic growth and generates a broader range of employment opportunities as industries expand and new markets are accessed (Fatima et al., 2020; Ali et al., 2022). The GNI represents the overall economic strength and living standards of a country. Higher GNI levels are typically associated with better job prospects and quality of life, which can affect migration decisions (Varkey et al., 2021; Niva et al., 2021). The descriptive statistics of the chosen variables are presented in Table 1.

Table 1 | Summary statistics

Variables	N	Mean	SD	Min	Max
Mig	275	47,652.833	229,221.935	-254,292.000	3,366,387.000
PL	275	40.828	9.399	22.500	63.000
$ICT\ skills$	275	21.179	9.611	3.100	42.500
$R\&D$	275	1.636	0.864	0.380	3.490
TO	275	125.053	63.182	54.868	393.141
GNI	275	32,697.24	19,539.83	7,400	89,200

Source: Developed by the authors

The methodology framework for analysing the impact of population literacy and enterprises providing ICT training on net migration involves a multistep process to ensure the robustness and reliability of the results. The first step is to conduct unit root tests using the cross-sectional augmented Dickey-Fuller (CADF) test and the cross-sectionally augmented Im, Pesaran and Shin (CIPS) test. These tests assess the stationarity of the panel data while accounting for cross-sectional dependence, which is crucial for ensuring that the variables used in the analysis are suitable for regression modelling. Next, the analysis includes the cross-sectional dependence test (Pesaran test) and the slope heterogeneity test. The cross-sectional dependence test evaluates whether the cross-sectional units (countries) are interdependent, which helps us understand the extent of shared shocks or spillover effects among countries. The slope heterogeneity test examines whether the relationships between the dependent and independent variables vary across countries, indicating whether country-specific effects should be considered in the model. Following these tests, cointegration tests (Kao test, Pedroni test and Westerlund test) are performed to determine whether there is a long-term equilibrium relationship among the variables, accommodating heterogeneity and cross-sectional dependence. For the benchmark regression, the two-step system generalized method of moments (GMM) is employed. This method addresses potential endogeneity and the dynamic nature of panel data by including lagged dependent variables and using lagged

values of the independent variables as instruments. The two-step GMM estimation provides consistent parameter estimates and corrects for heteroskedasticity and autocorrelation, enhancing efficiency. Finally, robustness checks are conducted by replacing GNI with GDP per capita to test the sensitivity of the results to different economic measures and by excluding two countries with extreme net migration levels to assess the impact of outliers. This comprehensive methodology framework ensures a thorough and reliable analysis of the factors influencing net migration in EU countries.

3 Results and Discussion

The second-generation unit root tests (CADF and CIPS) are presented in Table 2. All the variables, except *TO* in the CADF test, are nonstationary at their levels (I(0)). However, after first differencing (I(1)), all the variables achieve stationarity, with significance levels ranging from 1% to 5%. Specifically, *PL*, *ICT skills*, *R&D* and *GNI* are nonstationary but become stationary after differencing, ensuring reliable regression analysis results by mitigating the risk of spurious correlations. Trade openness is stationary at level in the CADF test and remains so after differencing.

Table 2 | Results of unit root tests

Variables	CADF		CIPS	
	I(0)	I(1)	I(0)	I(1)
PL	-0.463	-2.230**	-1.955	-2.842***
$ICT\ skills$	-1.732	-2.828***	-1.766	-2.555**
$R\&D$	-1.804	-2.310**	-1.771	-2.532**
TO	-2.215**	-2.944***	-1.365	-2.955***
GNI	-0.230	-2.185**	-0.851	-2.521**

Note: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1
Source: Developed by the authors

The Pesaran test evaluates whether cross-sectional units (countries) in the panel data are interdependent. The results of the test are presented in Table 3 (CD statistics and p-values for each variable).

Table 3 | Results of cross-sectional dependence test and slope heterogeneity test

Variable	Pesaran test for weak cross-sectional dependence			
	CD	p-value	N	t
Mig	2.394	0.017	25	11
PL	37.744	0.000	25	11
$ICT\ skills$	2.923	0.003	25	11
$R\&D$	9.819	0.000	25	11
TO	36.303	0.000	25	11
GNI	43.152	0.000	25	11
Slope heterogeneity test	**Delta**	**p-value**		
	-2.773	0.006		
Adj.	-4.598	0.000		

Source: Developed by the authors

For migration (*Mig*), the CD statistic is 2.394, with a p-value of 0.017, indicating significant cross-sectional dependence. Population literacy (*PL*) shows very strong cross-sectional dependence, with a CD statistic of 37.744 and a p-value of 0.000. Similarly, *ICT skills*, *R&D*, trade openness (*TO*) and gross national income (*GNI*) also exhibit significant cross-sectional dependence, with CD statistics of 2.923 (p-value 0.003), 9.819 (p-value *0.000*), 36.303 (p-value 0.000) and 43.152 (p-value 0.000), respectively. These results suggest that these variables are highly interrelated across different countries in the dataset.

The slope heterogeneity test further indicated significant variability in the relationships between these variables across countries. The delta statistic is -2.773 with a p-value of 0.006, while the adjusted delta statistic is -4.598 with a p-value of 0.000. These results confirm significant slope heterogeneity, suggesting that the impact of these variables on migration differs substantially between countries.

Table 4 presents the results of various cointegration tests, including the Kao test, Pedroni test and Westerlund test.

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Table 4 | Results of cointegration tests

Tests	Statistic	p-value
Kao test		
Modified Dickey-Fuller *t*	1.028	0.152
Dickey-Fuller *t*	-18.284	0.000
Augmented Dickey-Fuller *t*	7.408	0.000
Unadjusted modified Dickey-Fuller *t*	-8.176	0.000
Unadjusted Dickey-Fuller *t*	-27.741	0.000
Pedroni test		
Modified Phillips-Perron *t*	5.371	0.000
Phillips-Perron *t*	-12.570	0.000
Augmented Dickey-Fuller *t*	-19.082	0.000
Westerlund test		
Variance ratio	0.193	0.423
Variance ratio (all panels)	-1.481	0.069

Source: Developed by the authors

The Kao test shows strong evidence of cointegration based on the Dickey-Fuller *t*, augmented Dickey-Fuller *t*, unadjusted modified Dickey–Fuller *t* and unadjusted Dickey-Fuller *t* statistics, all with highly significant p-values (0.000). However, the modified Dickey-Fuller *t* statistic was not significant (p-value 0.152). All three statistics of the Pedroni test (modified Phillips-Perron *t*, Phillips-Perron *t* and augmented Dickey-Fuller *t*) are highly significant, indicating strong evidence of cointegration. In contrast, the variance ratio statistics of the Westerlund test are not significant at conventional levels, with one being marginally significant at the 10% level, indicating weak or no evidence of cointegration. Overall, the results from the Kao and Pedroni tests strongly suggest the presence of a long-term equilibrium relationship among the variables, while the Westerlund test results indicate that the variables likely move together in the long run, maintaining a stable relationship despite short-term fluctuations.

The two-step system GMM was used for the benchmark regression; the results are displayed in Table 5.

Table 5 | Results of benchmark regression

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
$L.Mig$	0.078*** (0.001)	0.071*** (0.001)	0.065*** (0.000)	0.052*** (0.012)	0.068*** (0.010)	0.081*** (0.000)	0.061*** (0.013)
PL	-0.003*** (0.000)		-0.008*** (0.000)		-0.008*** (0.001)	-0.016*** (0.002)	-0.053*** (0.008)
PL^2						0.0001*** (0.000)	0.001*** (0.000)
$ICT\ skills$		0.013*** (0.000)		0.015*** (0.001)	0.016*** (0.000)		0.016*** (0.001)
$R\&D$			0.109*** (0.008)	0.069*** (0.011)	0.040*** (0.015)		0.091*** (0.019)
TO			0.191*** (0.012)	0.025 (0.027)	0.124*** (0.012)		0.075** (0.031)
GNI			0.036*** (0.008)	0.125*** (0.022)	0.080*** (0.016)		0.152*** (0.017)
$Constant$	11.653*** (0.006)	11.337*** (0.012)	10.563*** (0.067)	12.580*** (0.163)	11.798*** (0.201)		13.611*** (0.307)
Arellano–Bond test for AR(1)	0.336	0.318	0.305	0.565	0.313	0.323	0.393
Arellano–Bond test for AR(2)	0.325	0.340	0.330	0.336	0.351	0.327	0.351
Sargan test	0.442	0.423	0.227	0.279	0.272	0.353	0.178
Hansen test	0.992	0.694	0.998	0.994	0.918	0.995	0.825
Observations	250	250	250	250	250	250	250
Number of id	25	25	25	25	25	25	25

Note: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1
Source: Developed by the authors

Previous migration rates have a positive and significant impact on current migration, indicating a persistent effect where past trends influence future movements. *Population literacy*, included in Models 2, 4 and 5, shows a negative and significant effect, suggesting that higher literacy rates reduce migration outflows. Conversely, *ICT skills* positively and significantly affect migration in Models 3, 4 and 5, implying that individuals with better *ICT skills* are more likely to migrate and are likely to seek better opportunities abroad. *R&D* investment also has a strong positive impact on migration, attracting skilled workers and researchers. Trade openness exhibits mixed effects: it significantly increases migration in Models 3 and 5 but is not significant in Model 4. The impact of gross national income (*GNI*) on migration varies, showing a significant effect in Models 4 and 5, highlighting the complex relationship between economic conditions and migration patterns. The positive coefficient for the squared term of *PL* (Models 6 and 7) indicates that the relationship between population literacy and net migration is nonlinear; specifically, it is U-shaped. This means that at higher

levels of literacy, further increases in literacy lead to an increase in net migration. This suggests that very high literacy levels make the country more attractive to immigrants and/or reduce emigration, thus increasing net migration. Statistical tests, including the Arellano-Bond tests for autocorrelation and the Sargan and Hansen tests for instrument validity, indicate no significant issues, supporting the robustness of the results.

The robustness checks presented in Table 6 validate the benchmark regression findings through two additional models. Models 8 and 9 restrict observations to Italy and Greece, confirming the main findings within these specific contexts.

Table 6 | Results of robustness checks

Variables	Model 8	Model 9	Model 10	Model 11
$L.Mig$	0.061*** (0.010)	0.070*** (0.004)	0.066*** (0.012)	0.068*** (0.002)
PL	-0.004** (0.001)	-0.039*** (0.009)	-0.007*** (0.001)	-0.051*** (0.009)
PL^2		0.000*** (0.000)		0.001*** (0.000)
$ICT\ skills$	0.018*** (0.001)	0.015*** (0.002)	0.017*** (0.000)	0.016*** (0.001)
$R\&D$	0.071*** (0.013)	0.103*** (0.022)	0.039*** (0.015)	0.082*** (0.015)
TO	0.160*** (0.019)	0.063 (0.055)	0.134*** (0.011)	0.104*** (0.011)
GDP			0.093*** (0.013)	-0.156*** (0.016)
GNI	0.178*** (0.018)	-0.178*** (0.037)		
$Constant$	12.439*** (0.223)	13.450*** (0.316)	11.879*** (0.204)	13.394*** (0.313)
Arellano-Bond test for AR(1)	0.431	0.309	0.385	0.291
Arellano-Bond test for AR(2)	0.337	0.347	0.347	0.353
Sargan test	0.241	0.180	0.271	0.175
Hansen test	0.835	0.917	0.996	0.847
Observations	230	230	250	250
Number of id	23	23	25	25

Note: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1
Source: Developed by the authors

Models 10 and 11 replace gross national income (*GNI*) with *GDP* per capita to assess whether a change in economic indicators affects the results. The findings indicate that lagged migration remains significant, demonstrating persistence in migration trends. Population literacy continues to have a significant nonlinear impact on migration, suggesting that higher literacy reduces outflows. *ICT skills* and *R&D* maintain their positive and significant effects, reinforcing their roles in attracting skilled migrants. Trade openness positively affects migration, while *GDP* per capita has a significant negative effect, implying that better domestic economic conditions reduce migration. Statistical tests validate these models, confirming the robustness of the results.

Conclusion

This study investigated factors influencing migration using a two-step system GMM and showed that past migration significantly influences current migration trends, which is consistent with earlier research into migration persistence (Massey et al., 1993; de Haas, 2010). When literacy levels are relatively low to moderate, increasing literacy initially decreases net migration. This may be because as literacy improves, individuals find better opportunities within their own country, reducing the relative appeal of immigrating to other countries or the need for others to immigrate. As literacy levels become very high, the trend reverses. Highly literate societies may become more attractive to skilled immigrants seeking advanced opportunities, increasing net migration; this aligns with Beine et al. (2008). Additionally, highly educated residents may have better resources and networks to bring in skilled migrants, thus increasing immigration. Creating favourable conditions for immigrants, such as through visa policies, employment opportunities and integration programmes, can help utilize the positive impact of high literacy levels. ICT skills and R&D investments positively affect migration, highlighting their role in attracting skilled migrants, which supports the findings of Docquier and Rapoport (2012). Specifically, a 1% increase in ICT skills can significantly boost a country's ability to attract skilled migrants by up to 0.016%. Additionally, a 1% increase in R&D investment is associated with a 0.04% increase in the retention of intellectual capital. Improving education systems and achieving high literacy rates, with a target literacy rate of 95% or higher, are crucial for creating an environment conducive to sustainable development. Trade openness has mixed effects on migration, consistent with Ortega and Peri (2013), while the GNI has a complex relationship with migration, as reflected by Clemens (2014). Robustness checks, including replacing GNI with GDP per capita and restricting observations to Italy and Greece, confirm these findings. Statistical tests validate the results, emphasizing the importance of enhancing ICT skills and investing in R&D while maintaining high literacy rates to manage migration effectively. These insights are crucial for policymakers to improve economic conditions and manage migration patterns through targeted educational and technological advancements:

1. Given the nonlinear impact of population literacy on migration outflows, EU countries should invest in improving education systems and increasing literacy rates. For instance, Finland’s high literacy rate has been associated with low emigration rates. Policymakers should expand access to quality education, particularly in underprivileged areas, to retain talent and reduce emigration (Beine et al., 2008).

2. The positive effect of ICT skills on migration suggests that individuals with better technological skills are more likely to migrate. Ireland has successfully implemented policies that focus on ICT education and training, which have helped attract and retain

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skilled professionals (European Commission, 2023; Kwilinski et al., 2023a; Szczepańska-Woszczyna & Muras, 2023; Zhanibek et al., 2022). EU policymakers should enhance ICT education and training programmes to build a competitive workforce locally and internationally (Docquier & Rapoport, 2012). Recent studies further emphasize the importance of digital skills in modern economies (Kwilinski et al., 2024c).

3. R&D investment significantly attracts skilled migrants. Germany's robust R&D sector has made it a prime destination for skilled migrants. EU countries should boost funding for research and development initiatives, foster innovation and create high-quality job opportunities that draw and maintain talented individuals within the region. Recent research has also highlighted the role of R&D in regional development and migration patterns (Hean et al., 2024). The mixed effects of trade openness on migration indicate the need for nuanced trade policies. Sweden's balanced approach to trade liberalization has helped integrate skilled workers into the economy without driving them away (Ortega & Peri, 2013). Policymakers should balance trade liberalization with measures that support domestic labour markets, ensuring that trade policies do not inadvertently drive skilled workers away.

4. The effect of GDP per capita on migration suggests that better economic conditions reduce the need for migration. Denmark's high GDP per capita and strong social welfare system have contributed to lower emigration rates (Clemens, 2014). EU countries should implement policies that promote sustainable economic growth, ensuring that economic benefits are widely shared to improve living standards and reduce migration pressure (Clemens, 2014; Kwilinski, 2023b; Kwilinski et al., 2023c). Considering the persistent effect of past migration trends, EU countries should develop targeted migration policies that address the specific needs and circumstances of different migrant groups. Germany's policies to attract and integrate high-skilled migrants, particularly those with strong ICT and R&D backgrounds, provide a useful model (European Commission, 2023; Szczepańska-Woszczyna & Gatnar, 2022). Recent studies suggest that targeted policies can significantly enhance migrant integration and economic contributions (Akin-Sabuncu et al., 2024).

The findings of this study provide several strategic insights for Central European businesses and managers. Companies should invest in education and training, collaborating with educational institutions to enhance literacy and ICT skills among their workforces. For instance, Poland has seen success in its efforts to boost digital skills through nationwide initiatives. Emphasizing digital literacy through targeted training programmes will improve productivity and make companies more attractive to skilled migrants. Increasing investments in research and development (R&D) to foster innovation is crucial. Businesses should engage in partnerships with universities and research institutions, like Hungary's collaboration with its academic sector, to create high-quality job opportunities. Best practices from Germany, such as their robust R&D investment and innovation hubs, can serve as a model for fostering an attractive environment for skilled migrants. Strategic HR policies should be implemented to attract and integrate skilled migrants, offering competitive salaries, career development opportunities and cultural integration programmes. The Czech

Republic's approach to balancing trade liberalization with strong domestic labour policies is a good example. Understanding the mixed effects of trade openness, businesses should advocate for balanced trade policies that support both international trade and the domestic labour market. Supporting policies that promote sustainable economic growth and high living standards, as seen in Slovakia's economic reforms, will help retain local talent. Businesses should work closely with government agencies to influence policies that enhance the business environment, making use of EU-funded programmes and initiatives aimed at improving education, R&D and digital skills. Examples from Austria, which has successfully integrated skilled migrants through targeted policies and strong collaboration between the public and private sectors, highlight the importance of comprehensive integration strategies. Staying informed about migration trends and policy changes, and being prepared to adapt business strategies in response to sudden shifts, is essential for mitigating risks associated with migration fluctuations. By creating a supportive and innovative environment, Central European businesses can attract and retain skilled migrants, driving growth and competitiveness in the region.

The dynamic nature of migration decisions influenced by sudden policy changes or economic shocks is not fully captured, necessitating further research incorporating additional variables such as political stability and quality of life. Future research should also include longitudinal studies and comparative analyses between EU and non-EU countries to identify effective policies across different contexts. Evaluating the specific impacts of recent policy changes and exploring the role of emerging technologies in migration patterns are crucial for future policy development. Finally, investigating the long-term impacts of the COVID-19 pandemic on migration trends could provide valuable insights for policymakers.

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