THE EFFECTS OF HIGHLY-EDUCATED IMMIGRANTS ON INNOVATION IN THREE DEVELOPED EUROPEAN COUNTRIES

Elena-Alexandra SINOI*

Doctoral School of Economics and Business Administration, West University of Timisoara, Timisoara, Romania

Abstract

In the current globalized world, migration represents a topic of great interest, generating advantages and downsides as well, both for the people and the communities implicated. Highly-educated migrants represent a key factor in fostering innovation, productivity and economic growth, and promote knowledge diffusion/ distribution in both directions, from origin to destination country and vice versa. This research investigates the effects of highly-educated immigrants on the number of patents (a good proxy for measuring innovation activities), in the case of Austria, Finland and Sweden, between 2011 and 2017. For the empirical analysis of the study case, we used panel data and developed a multiple linear regression model estimated through the ordinary least squares method (OLS), at the country-level. In line with the vast existing literature, the main finding of this paper is that highly-educated immigrants, representing external factors of innovation, have a positive and significant impact on the number of patent applications in all three receiving countries. Moreover, financial support in R&D (in different sectors) and investments in human capital (from diverse fields) serve as internal factors of innovation and also contribute vastly to the enhancement of innovation.

Keywords: Highly-educated immigration, Innovation, R&D, European countries.

JEL Classification: F22, O31, O52.

* Corresponding author, **Elena-Alexandra Sinoi** – elena_sinoi@yahoo.com

1. Introduction

In the contemporary era of globalization, migration turned into a global phenomenon of flows and counter-flows of human beings with widespread impact on economic, social, cultural, political and demographic aspects.

Although migration has existed since ancient times, the world mass migration began in the early 19th century due to the transportation technology progress and industrial revolutions, which facilitated the movement of people in search of a more satisfying subsistence (Hatton and Williamson, 2006).

Migration, whether internal or international, represents a crucial issue at regional, national and global levels, generating both opportunities and challenges for individuals and economies involved. If the migrant flow is well managed (supported by appropriate and effective policies and cooperation at the international level), it promotes inclusive and sustainable development in both sending and receiving countries. Therefore, policymakers from all nations should develop policies that harness the benefits and mitigate the downsides that can arise from the migration movements (IOM, 2006).

Considerable attention has been drawn to the migration of highly-educated individuals, which represent an important aspect of global integration. Educated migrants spur innovation and economic growth through technological progress, contribute to labour-market flexibility and support knowledge diffusion not only from sending to receiving countries, but also vice versa. Therefore, the nexus between migration and innovation has become a weighty subject in several related disciplines and fields (Lissoni, 2017).

Nowadays, all developed economies are characterized by “brain exchanges” between countries, and those countries that are not able to have a proper exchange of skilled workers may face a hinder to economic development (Findlay and Lowell, 2016).

This research investigates the impact of highly-educated immigrants on innovation at the country-level, in the case of three developed European countries, namely Austria, Finland and Sweden. The reason for which we study the case of these three countries is because they are all developed countries with predominantly educated immigrants.

The paper also emphasizes to what extent the financial support in R&D (in different sectors) and investment in human capital (from diverse fields) contribute to the enhancement of innovation.

The period took into consideration is from 2011 to 2017. This timeframe highlights the seven years after the economic and financial crisis of 2007-2010. The reason why we have considered 2011 the first year is because we aimed to examine how the process of innovation and migration has evolved after the economic and financial crisis of 2007-2010. Also, the year 2017 was the last year for which most of the indicators used could be found.

For the empirical analysis of the study case, we used panel data and developed a multiple linear regression model estimated through the ordinary least squares method (OLS).

2. Literature Review

2.1 Global migration trends

During the last decades, international migration has steadily increased (figure no. 1). Currently, the number of international migrants worldwide reached approximately 272 million (representing 3.5% of the global population), growing faster than the world population and maintaining an upward trend (UN DESA, 2019).

Figure no. 1: International migrants, 1990-2019 (millions)

Source: IOM, 2019

While in 1990, the share of the international migrants was 2.9% of the total population (approximately 153 million), nowadays this share has increased by up to 3.5% (approximately 272 million). At present, one in every 28 people in the world lives abroad, compared to 1990 when one in every 35 people was considered a migrant. Although globally, the proportion of international migrants has risen (3.5% of the total population), the vast majority of people remain within their country of birth (96.5% of the total population) (IOM, 2019).

A great number of international migrants relocate between countries situated within the same region. Martin and Zürcher (2008) emphasize that when people elect to move to another place, they commonly seek similar and closer regions to their former home, rather than choosing a farther location. Fewer individuals are willing to establish in remote regions, which they have little knowledge.

More than half of all international migrants have established in regions from Europe and Northern America, this trend persevering during the years (figure no. 2).

Figure no. 2: International migrants by region, 2000 and 2019 (millions)

Source: IOM, 2019

In 2019 almost one-third of all international migrants (82.3 million) resided in Europe and approximately 59 million have lived in countries from Northern America. At opposite extremes is Oceania, which hosted the lowest number of international migrants (9 million). International migrants accounted for 12% of the total population in the more developed regions, while in less developed regions they constituted 1.9% of the total population (IOM, 2019).

In 2019 two-thirds of all international migrants were domiciled in only 20 countries. Top 5 destinations of international migrants were USA (50.7 million), Germany (13.1 million), Saudi Arabia (13.1 million), the Russian Federation (11.6 million) and the UK (9.5 million). At the opposite pole, one-third of all international migrants originated in only 10 countries. Among the top 5 origin countries of international migrants were India (17.5 million), Mexico (11.8 million), China (10.7 million), Russian Federation (10.5 million) and Syrian Arab (8.2 million). Worldwide, the number of male migrants (52.1% of total migrants) was higher than the number of female migrants (47.9% of total migrants) (UN DESA, 2019).

2. 2 Drivers of migration (pull and push factors)

Individuals may have plenty of reasons that determine them to leave one place and settle in another (temporary or permanently). These decisions may have economic, social, political, cultural, or environmental causes.

The forces that determine people to migrate are known as drivers of migration (push and pull factors) and operate at a macro-, meso- and micro-level (figure no. 3).

Macro-level factors are those factors that people have no control over. Political, demographic, socio-economic and environmental issues are the most common reasons that contribute to forced migration (either internal or international).

Meso-level factors include organizations, social networks, communication technology, diaspora links and peer groups, which persuade people to forsake their homes and move to countries with better living conditions.

Micro-level factors refer to individual characteristics, values and expectancies, such as education level, religious belief, marital status, or attitudes towards migration (Castelli, 2018).

Figure no. 3: Drivers of migration a macro-level, meso-level and micro-level

Source: Foresight: Migration and Global Environmental Change (2011), modified

The push and pull drivers of migration intermingle with each other and operate differently beyond contexts, determining individuals to make distinctive migration resolutions (Van Hear et al., 2017).

Push factors are those factors from the origin country, which force people to abandon their former homes and move in other corners of the world, seeking a better subsistence for themselves and their families. Usually, these are negative factors, such as unsustainable conditions of living, unemployment/ underemployment, lack of job opportunities, lack of education opportunities, poverty, scarcity of land resources, small harvest, famine, natural disasters (droughts, flooding), conflict, war, human rights abuses, racism, discrimination of persons or social groups, extreme religious activity, etc.

In comparison to push factors, pull factors come from the destination country and make people want to live in that particular environment. These are positive factors, such as better

standards of living, economic and technological development, education opportunities, better wages, better health care systems, social and political security, etc. (IOM, EASO, 2016).

2.3 Effects of migrants on destination countries (brain gain)

There are countless pieces of evidence that migrants (especially highly-qualified) represent a “brain gain” for host countries. Highly-skilled migrants (defined as tertiary-educated) contribute significantly to innovation in destination countries, and at last, improve productivity and stimulate economic growth. A reason for this statement is the fact that the cultural diversity of skilled migrants increases the team’s performance and encourages unique and creative thinking (Gelb and Krishnan, 2018).

Ozgen et al. (2012) purport that tertiary-educated migrants from diverse cultural backgrounds spur knowledge formation, improve entrepreneurship, record a larger number of patent applications, and at last contribute to economic growth.

Similarly, Ferrucci and Lissoni (2019) emphasize that team diversity is fundamental for the increase of the team’s creativity and performance and generates patents of a higher quality. Besides, mixed local-foreign inventors teams with different nationalities always outperform both local teams and same-nation foreign teams.

In his empirical research, Niebuhr (2010) reveals the positive impact of cultural diversity on the performance of R&D sectors in German regions. Therefore, the diversity of knowledge and capabilities of workers enhances regional innovation, generating new ideas, processes, and products. Although the diversity of the labour force produces a series of costs (for example costs with communication barriers), these downsides are outweighed by the benefits induced in regional R&D sectors.

Hunt and Gauthier-Loiselle (2010) found that scientists and engineers migrants or migrants with college or post-college education increase significantly patents per capita in the US. Moreover, highly qualified immigrants have positive spill-overs on native workers, providing complementary skills and knowledge.

Of a similar style, Chellaraj et al. (2008) emphasize the positive nexus between foreign graduate students and the number of patents awarded to university and non-university institutions in the US. Additionally, skilled foreign workers may support the rise of aggregate real incomes in the long run and may provide complementary abilities to fellow researchers.

Conducting a study for 16 European industries Fassio et al. (2019) discovered that skilled immigrants have a greater influence on innovativeness in industries with low levels of over-education, high levels of FDIs and openness to trade. Also, at the firm level, the ethnic diversity of educated immigrants plays an important role in the innovation process, providing complementary skills to natives and contributing to knowledge spill-overs.

For a panel of 20 European receiving countries, Bosetti et al. (2015) reveal that highly-skilled migrants contribute to both “private” and “public” knowledge creation (measured by patents number and citations number to published articles).

Innovation, productivity, and entrepreneurship are aspects of regional competitiveness that are profoundly impacted by migration and population ageing (Poot, 2007). While population ageing mitigates regional competitiveness, highly-qualified immigrants foster innovation and regional growth. Since migrants are younger, on average, they tend to be less risk-averse and adjust easily to economic changes, in contrast to their native peers. Also, skilled foreigners with different backgrounds are more inventive and start more new businesses. Yet, the diversity of individuals can create a less cohesive society, which may diminish trustworthiness and competitiveness. Another crucial factor in spurring competitiveness and economic performances and growth, besides skilled migration, is represented by R&D investments (Goschin, 2014).

2. 4 Effects of migrants on origin countries

Migrants have significant direct and indirect effects not only on host countries but also on origin countries. Some of the consequences are beneficial and some harmful, depending on different country-specific factors. Among these factors is the magnitude of migration level and composition of migration, the country’s level of development, population size, language, and geographic location (Docquier, 2014).

2. 4. 1 Positive effects (optimal/ beneficial brain drain)

Migrants provide plenty of positive feedback effects on origin country through technology and knowledge diffusion, remittances transfers and return of expatriates. Migrants may spur origin's economic growth through investments in business (they set up their enterprises or invest in start-ups with local partners, providing financial support) or through the money they send home (Gelb and Krishnan, 2018).

In a recent study, Miguelez and Noumedem Temgoua (2019) argue that migrant inventors, especially those employed in science, technology, engineering and mathematics fields (STEM migration) represent important channels of knowledge production and diffusion. Therefore, policymakers should focus more on finding strategies which support and consolidate relations between STEM migrants and non-migrant fellows, through suitable knowledge networks, in both sending and receiving country.

The knowledge gained abroad by migrants can be conveyed in origin country through diaspora networks and further be exploited under sound Intellectual Property Rights institutions (IPR), in order to encourage domestic innovation (Naghavi and Strozzi, 2015).

When it comes to money transfers, remittances have positive and meaningful consequences for reducing poverty, strengthening the financial systems and accelerating economic growth. These financial flows can be used for final consumption, savings, or investments (Martin and Zürcher, 2008).

The physical return of expatriates may be as important as technology and money transfers. Return migrants, especially those who have gained qualifications, skills and work experiences abroad can accelerate productivity and minimize the “brain drain” effect, which can harm the origin country (Findlay and Lowell, 2016).

There are cases when the negative effects of “brain drain” can be converted into positive effects for origin countries. Even though the emigration of qualified individuals may diminish a country's human capital stock, it may trigger positive network externalities (Docquier and Rapoport, 2012).

Moreover, at an optimal level of highly skilled emigration (known as “beneficial brain drain”), neither too much, nor too little, origin countries may benefit. If in origin country (developing country) exists opportunities of emigration to higher-wage countries (developed countries), then individuals will be more determined to attend higher education, as they anticipate that in the future they may pursue better-remunerated jobs abroad. Therefore, enrolment in school (domestic educational levels) increases, the share of skilled workers rises and as a result, economic growth is spurred (Beine, et al, 2001). It is well known that the quality of education, measured through the cognitive skills of the population, has a significant impact on individual earnings, income distribution, and economic growth in the long term (Hanushek and Woessmann, 2020).

In their research, Stark et al. (1997) indicate that workers are paid according to their productivity at the workplace. Therefore, low-skilled migrants undergo a decrease in wage payment in contrast to skilled workers. Such wage adjustments may determine individuals from developing countries (who prospect to migrate in the future) to invest more in acquiring human capital, with positive effects on global welfare.

Mountford (1997) emphasizes that when human capital accumulation decisions are endogenous and when emigration of the most educated inhabitants is not a certainty, the “brain drain” converts into a “beneficial brain drain” (BBD), which has positive effects on the average level of productivity. If in origin country the opportunities of emigration to more developed countries are restricted, individuals will be less stimulated to pursue education, and thus domestic enrolment will decrease. On the opposite pole, if in a sending country the volume of highly skilled emigrants is too high, economic growth will be slowed. Therefore, an “optimal level of emigration” is required.

There are also other cases when emigration is not harmful to origin countries. When native-born workers from sending countries cannot be fully employed in their homelands, or are employed in inappropriate jobs for their qualification (underemployment), it appears the “brain

waste” effect. This effect reduces the incentives of people to acquire education and undermines the possibility of “brain gain” to arise (Garcia Pires, 2015). Therefore, in those cases, emigration does not represent an economic threat, but a reduction of unemployment in some sectors in sending countries. Unfortunately, the “brain waste” effect may occur in receiving countries too. It is the case when the qualification acquired by migrants in origin country is not recognized in the host country, thus preventing them to exploit their potential.

Quinn and Rubb (2005) argue that the decision of migration is highly influenced by the matching or mismatching between education attainment level and job characteristics. Therefore, people who work in jobs that require less knowledge than their education level, are more expected to migrate to other regions or countries, so they can achieve a better match.

2. 4. 2 Negative effects (brain drain)

Often, for sending countries, the emigration of highly-educated workers may represent a loss of the most skilled individuals (known as “brain drain” effect), with negative effects on productivity (Djiofack et al., 2013). Concerning developing countries with quite a modest number of tertiary-educated people, a massive outflow of human capital may have negative repercussions on economic growth, education, income distribution, and welfare.

Similarly, Wong and Yip (1999) emphasize that although “brain drain” may improve the wage rate of the remaining skilled workers it reduces the wage rate of the remaining unskilled workers and hence increases inequality. A reduction in the growth rate of human capital causes a drop in the national income and harms the welfare of future generations.

Noja and Son (2016) gauge the impact of migration flows on labour market performances in Europe, from an economic point of view. The results are different from one country to another, positive in some and negative in others. Although emigration diminishes the unemployment rate, in the long term, the countries of origin are experiencing a slowdown in GDP growth.

3. Empirical Case Study

3.1 Objectives

This research aims to investigate the impact of highly-educated immigrants on the number of patents (a good proxy for measuring innovation activities), at the country-level, in the case of three developed European countries, namely Austria, Finland and Sweden. The reason for which we study the case of these three countries is because they are all developed countries with predominantly educated immigrants.

The paper also emphasizes to what extent the financial support in R&D (in different sectors) and investment in human capital (from diverse fields) contribute to the enhancement of innovation.

The period taken into consideration is from 2011 to 2017. This timeframe highlights the seven years after the economic and financial crisis of 2007-2010. The reason why we have considered 2011 the first year is because we aimed to examine how the process of innovation and migration has evolved after the economic and financial crisis of 2007-2010. Also, the year 2017 was the last year for which most of the indicators used could be found.

3.2 Data and specification

For the empirical analysis of the study case, we used panel data and developed a multiple linear regression model estimated through the ordinary least squares method (OLS), at the country-level, for the years 2011-2017.

The data source is represented by Eurostat - European Commission and data processing is computed by using STATA 14 econometric package. The endogenous variable and exogenous variables taken into consideration are specific to the process of innovation and migration, and the data panel forms a strongly balanced panel.

The baseline empirical specification has all the variables expressed in natural logarithm and has the following general form:

$$\ln Patents_{it} = \alpha_0 + \alpha_1 * \ln Educated Immigrants_{it} + \alpha_2 * \ln X_{it} + \varepsilon_{it} \quad (1)$$

where i represents the country (Austria, Finland and Sweden), t represents each year (from 2011 to 2017), α_0 is the constant and ε_{it} is the error term.

As the number of patent applications is considered to be one of the most popular proxies for innovation (Furman et al., 2002), in our empirical model, the dependent variable is the number of patent applications ($\ln Patents_{it}$) at the European Patent Office (EPO) expressed in thousands.

Highly-educated immigrants ($\ln Educated Immigrants_{it}$) represent the variable of interest which comprises:

- Tertiary-educated employed immigrants (age from 25 to 64 years), as a percentage;
- Foreign doctoral students, as a percentage of all doctoral students.

We consider an immigrant or a foreigner any person who has different citizenship from that of the country in which he/she lives and works.

$\ln X_{it}$ is a vector of relevant controls and comprises indicators such as:

- Employment in knowledge-intensive activities, as a percentage of total employment;

- Human resources with tertiary education and employed in science and technology (HRST) (age from 25 to 64 years), as a percentage of the total population;
- Population involved in lifelong learning (age from 25 to 64 years), as a percentage of the total population;
- R&D expenditure by sectors of performance (all sectors, business sector and higher education sector), as a percentage of GDP;
- Gross Domestic Product (GDP) at current market price, in purchasing power standards per inhabitant.

Table no. 1 displays the summary statistics for each variable used in the empirical specification (original sample, non-logarithmic data), for the three European countries, between 2011 and 2017. The descriptive statistics report the number of observations, average value, standard deviation, minimum and maximum value for each variable.

Table no. 1 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Patents_no	21	2160.853	677.3994	1296.99	3379.68
Immi_ed_empl	21	70.39524	6.071859	57.7	77.4
Foreign_doct	21	25.88333	6.931313	11.95	35.13
Empl_KIA	21	16.07619	1.484892	14	18.5
HRST	21	46.72857	6.158826	33.7	54.9
Pop_learning	21	22.7619	6.27921	13.5	30.4
GERD_%gdp	21	3.107143	.2390845	2.67	3.62
BERD_%gdp	21	2.147619	.1939047	1.78	2.55
HERD_%gdp	21	.7604762	.0807141	.68	.9
GDP_pps	21	34249.52	2433.546	30490	38060

Source: personal processing in STATA 14

The sample consists of 21 observations because we took into consideration three countries (Austria, Finland and Sweden) and seven years (2011-2017).

In terms of maximum values, Austria had the highest percentage of immigrants employed with tertiary education (77.4 %) and the highest GDP in purchasing power standards per inhabitant (38060) in 2017. Finland had the highest percentage of expenditures on research and development (GERD) (3.62 % of GDP) in 2011. Sweden had the highest number of patent applications (3379.68) in 2014 and the highest percentage of foreign doctoral students (35.13 % of all doctoral students) and individuals employed in knowledge-intensive activities (18.5 % of total employment) in 2017. On the other hand, in terms of minimum values, Austria had the lowest percentage of people employed in knowledge-intensive activities (14 % of total employment) and expenditures on research and development (GERD) (2.67 % of GDP) in 2011. Finland had the lowest number of patent applications (1296.99) in 2017, the lowest percentage of immigrants employed with tertiary education (57.7 %) in 2011, the lowest

percentage of foreign doctoral students (11.95 % of all doctoral students) in 2011 and the lowest GDP in purchasing power standards per inhabitant (30490) in 2013.

3.3 Scatterplots

Figures with numbers 4, 5, 6 and 7 present the scatterplots of the causal relationship between an exogenous variable (tertiary-educated employed immigrants/ foreign doctoral students/ employment in knowledge-intensive activities/ R&D expenditure in the higher education sector) and the endogenous variable (the number of patent applications).

Figure no. 4. Scatterplot for the relationship between tertiary-educated employed immigrants and the number of patent applications, 2011-2017

Figure no. 5. Scatterplot for the relationship between foreign doctoral students and the number of patent applications, 2011-2017

Figure no. 6. Scatterplot for the relationship between employment in knowledge-intensive activities and the number of patent applications, 2011-2017

Figure no. 7. Scatterplot for the relationship between R&D expenditure in the higher education sector and the number of patent applications, 2011-2017

Source: personal processing in STATA 14

Figures no. 4 and 5 emphasize that, generally, both variables of interest have a positive and direct influence on the number of patent applications. Therefore, an increase in the number of

highly-educated immigrants (employed or Ph.D. students) is associated with an increase in the development of new patent applications. However, this positive correlation is not present every year (in the case of Finland is more obvious), as the process of innovation depends on many other factors.

In line with the existing literature, the results of the scatterplot in figure no. 6 show that people employed in knowledge-intensive activities have a positive and significant role in patent creation. This is the best highlighted in the case of Austria. In the case of Finland and Sweden, we can observe a positive correlation between the two variables considered between only 2011 and 2014.

Figure no. 7 presents a positive, direct and strong relationship between investments in R&D in the higher education sector and the dependent variable. This tight correlation is the best accentuated in the case of Sweden, where an increase in R&D expenditures results in a direct increase in the number of patents, in all seven years.

4. Findings and Results

In table 2 we measure the impact of highly-educated immigrants, along with different combinations of other relevant variables, on the number of patents (a good proxy for measuring innovation activities), by developing a multiple linear regression model estimated through the ordinary least squares method (OLS), at the country-level.

Table no. 2 The impact of highly-educated immigrants on patent applications (OLS), 2011-2017

	(1) Patents_no	(2) Patents_no	(3) Patents_no	(4) Patents_no	(5) Patents_no	(6) Patents_no	(7) Patents_no
Immi_ed_empl	2.295*** (7.04)	2.728*** (5.36)	3.516*** (4.84)				
Foreign_doct				0.704*** (6.97)	0.507*** (5.79)	0.334** (3.41)	0.263* (2.60)
Empl_KIA	1.890*** (5.47)			0.848* (2.38)			
HRST		1.050** (3.18)				-0.322 (-1.59)	
Pop_learning			0.549*** (4.37)				0.249* (2.43)
GERD_%gdp	1.229** (2.94)		1.653** (3.54)				
BERD_%gdp		1.216* (2.65)		1.275*** (3.97)	0.782** (3.00)		
HERD_%gdp					1.500*** (5.19)	2.418*** (6.63)	2.673*** (7.06)
GDP_pps			0.548 (0.63)			0.424* (2.22)	
Constant	-8.753*** (-5.22)	-8.913** (-3.06)	-5.153 (-0.76)	2.049* (2.43)	5.828*** (12.41)	4.354 (0.72)	8.301*** (12.66)
R-squared	0.8585	0.6993	0.8261	0.8660	0.9310	0.9127	0.9216
Root MSE	0.12696	0.1851	0.14508	0.12358	0.0887	0.10283	0.0945
N	21	21	21	21	21	21	21

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

Source: personal processing in STATA 14

For the computation of Ordinary Least Squares (OLS) regression models, we used the natural logarithmic form of each variable. The endogenous variable is the number of patent

applications (representing a good proxy for innovation) and the exogenous variables are external factors of innovation, such as highly-educated immigrants and internal factors of innovation, such as financial support in R&D (in different sectors) and human capital (from diverse fields). The two explanatory variables of interest (representing independent variables) are immigrants employed with tertiary-education and foreign doctoral students.

For each model, it is reported the value of R-squared, Root MSE (Root mean squared error) and N (the number of observations). R-square highlights the amount of variance of the number of patents explained by the independent variable. Root MSE represents the standard deviation of the regression (the closer to zero, the better the fit). All models have 21 observations because we considered three countries (Austria, Finland and Sweden) and seven years (2011-2017).

In model 1, all three independent variables have a positive and significant impact on the number of patents. Immigrants employed with tertiary-education are significantly at 1 per cent level and a 1% increase in their number leads to a 2.3% increase in the number of patent applications. Employment in knowledge-intensive activities is also significantly at 1 per cent level, while R&D expenditure in all sectors (GERD) is significantly at 5 per cent level. The value of R-squared of 0.8585 emphasizes that the model explains 85% of the variance in the number of patents. The value of Root MSE (0.12696) is pretty close to zero value, indicating a good fit of the model.

In combination with HRST (human resources with tertiary education and employed in science and technology) and R&D expenditure in the business sector, immigrants employed with tertiary-education have a vaster effect on patents, a 1% increase their number resulting in a 2.7% increase in the number of patent applications (model 2). Therefore, the positive consequences of investments in R&D and human resources on innovation are strengthened.

In model 3, employed educated immigrants, together with the population involved in lifelong learning are significantly at 1 per cent level and investment in R&D sectors is significantly at 5 per cent level. An increase of 1% in the number of the population involved in lifelong learning generates an increase in the number of patents by about 0.5%.

In model 4, the exogenous variables foreign doctoral students, along with R&D expenditure in the business sector are significantly at 1 per cent level, while employment in knowledge-intensive activities is significantly at 10 per cent level.

In model 5, it is revealed the importance of R&D expenditures in the higher education sector, being significantly at 1 per cent level. A 1% increase in the share of these expenditures leads to a 1.5% increase in the number of patents. In this model, root MSE has the best value from all seven models (0.0887), because its value is the closest to zero value. A value of R-squared of 0.9310 emphasizes that the model explains 93% of the variance in the number of patent applications.

Both GDP per capita (model 6) and people involved in lifelong learning (model 7) are meaningful for patent development, being significantly at 10 per cent level. A 1% increase in

GDP per inhabitant results in a 0.4% increase in the number of patent applications and a 1% increase in the number of people involved in lifelong learning leads to a 0.2% increase in the number of patent applications.

To conclude, the main finding of this paper is that the influence of highly-educated immigrants (employed or Ph.D. students) on innovation activity is positive and statistically significant (at 1, 5 or 10 per cent level, depending on the model considered). Also, tertiary-educated immigrant employees seem to have a much greater influence on patents than foreign doctoral students. The other relevant independent variables considered also generate positive outcomes on innovation, their impact and magnitude being different from one model to another. As we can observe, investments in R&D in the higher education sector contribute considerably to the patents enhancement, being significantly at 1 per cent level. Therefore, not only should countries try to attract educated immigrants, but also invest more in R&D and human resources. The more investments are allocated to R&D and the more attention is paid to the development of human capital, the higher the opportunity for innovation.

5. Conclusions

Migration, whether internal or international, represents a crucial issue at regional, national and global levels, generating both opportunities and challenges for individuals and economies involved. If the migrant flow is well managed (supported by appropriate and effective policies and cooperation at the international level), it promotes inclusive and sustainable development in both sending and receiving countries.

Considerable attention has been drawn to the migration of highly-educated individuals, which spur innovation and economic growth through technological progress, contribute to labour-market flexibility and support diffusion not only from sending to receiving countries but also vice versa.

This research investigates the nexus between highly-educated immigrants (immigrant employees with tertiary education and foreign doctoral students) and the number of patent applications (a good proxy for innovative activity) in the case of three developed European countries, namely Austria, Finland and Sweden. The paper also emphasizes to what extent the financial support in R&D (in different sectors) and investment in human capital (from diverse fields) contribute to the enhancement of innovation. The period considered is from 2011 to 2017. For the empirical analysis of the study case, we used panel data and developed a multiple linear regression model estimated through the ordinary least squares method (OLS), at the country-level.

In line with the vast existing literature, the main finding of this paper is that highly-educated immigrants (employed or Ph.D. students), representing external factors of innovation, have a positive and significant impact on the number of patent applications in all three receiving countries. However, tertiary-educated immigrant employees seem to have a much greater influence on patents than foreign doctoral students.

The other relevant finding is that financial support in R&D (in different sectors) and investments in human capital (from diverse fields), representing internal factors of innovation, also contribute vastly to the enhancement of innovation. Therefore, not only should countries try to attract educated immigrants in order to boost innovation and economic growth, but also invest more in R&D and human resources.

The limit of this research is the short timeframe considered, only seven years. The reason why we have considered 2011 the first year is because we aimed to examine how the process of innovation and migration has evolved after the economic and financial crisis of 2007-2010. Also, the year 2017 was the last year for which most of the indicators used could be found. Therefore, the period for this study is between 2011 and 2017.

References

- Beine, M., Docquier, F., Rapoport, H. (2001). 'Brain drain and economic growth: theory and evidence'. *Journal of Development Economics*, 64(1), pp. 275–289.
- Bosetti, V., Cattaneo, C., Verdolini, E. (2015). 'Migration of skilled workers and innovation: A European Perspective'. *Journal of International Economics*, 96(2), pp. 311–322.
- Castelli, F. (2018). 'Drivers of migration: why do people move?' *Journal of Travel Medicine*, 25(1).
- Chellaraj, G., Maskus, K. E., Mattoo, A. (2008). 'The Contribution of International Graduate Students to US Innovation'. *Review of International Economics*, 16(3), pp. 444–462.
- Djiofack, C. Z., Djimeu, E. W., Boussichas, M. (2013). 'Impact of Qualified Worker Emigration on Poverty: A Macro-Micro-Simulation Approach for an African Economy'. *Journal of African Economies*, 23(1), pp. 1–52.
- Docquier, F. and Rapoport, H. (2012). 'Globalization, Brain Drain, and Development'. *Journal of Economic Literature*, 50(3), pp. 681–730.
- Docquier, F. (2014). 'The brain drain from developing countries: The brain drain produces many more losers than winners in developing countries'. *IZA World of Labor*.
- European Commission. Eurostat Database [Online]. Available at: <https://ec.europa.eu/eurostat/data/database>.
- Fassio, C., Montobbio, F., Venturini, A. (2019). 'Skilled migration and innovation in European industries'. *Research Policy*, 48(3), pp. 706–718.
- Ferrucci, E. and Lissoni, F. (2019). 'Foreign inventors in Europe and the United States: Diversity and Patent Quality'. *Research Policy*, 48(9).
- Findlay, A. and Lowell, B.L. (2016). 'Migration of Highly Skilled Persons From Developing Countries: Impact and Policy Responses'. *International Migration Papers. Synthesis Report*. ILO, Geneva.
- Foresight: Migration and Global Environmental Change. (2011). Final Project Report. *The Government Office for Science*, London.

- Furman, J. L., Porter, M. E., Stern, S. (2002). 'The determinants of national innovative' capacity. *Research Policy*, 31(6), pp. 899–933.
- Garcia Pires, A.J. (2015). 'Brain drain and brain waste'. *Journal of Economic Development*, 40(1), pp. 1-34.
- Gelb, S. and Krishnan, A. (2018). 'Technology, migration and the 2030 Agenda for Sustainable Development'. *ODI Briefing Note*, London: Overseas Development Institute.
- Goschin, Z. (2014). 'R&D as an Engine of Regional Economic Growth in Romania'. *Romanian Journal of Regional Science*, 8(1), pp. 24-37.
- Hanushek, E. A. and Woessmann, L. (2020). 'Education, knowledge capital, and economic growth'. *The Economics of Education*, pp. 171–182.
- Hatton, T.J. and Williamson, J.G. (2006). 'Global migration and the world economy: Two centuries of policy and performance'. *Cambridge: Cambridge University Press*.
- Hunt, J. and Gauthier-Loiselle, M. (2010). 'How Much Does Immigration Boost Innovation?' *American Economic Journal: Macroeconomics*, 2(2), pp. 31–56.
- IOM. (2006). 'Migration and Development: Opportunities and Challenges for Policymakers'. *IOM Migration Research Series*. No.22.
- IOM. (2016). 'The Push and Pull Factors of Asylum-Related Migration: A Literature Review'. International Organization for Migration. *European Asylum Support Office (EASO)*.
- IOM. (2019). 'World Migration Report 2020'. *International Organization for Migration: Geneva, Switzerland*.
- Lissoni, F. (2017). 'International migration and innovation diffusion: an eclectic survey'. *Regional Studies*, 52(5), pp. 702–714.
- Martin, P. and Zürcher, G. (2008). 'Managing migration: The global challenge'. *Population Bulletin*, 63(1).
- Migueluez, E. and Noumedem Temgoua, C. (2019). 'Inventor migration and knowledge flows: A two-way communication channel?' *Research Policy*, 103914.
- Mountford, A. (1997). 'Can a brain drain be good for growth in the source economy?' *Journal of Development Economics*, 53(2), pp. 287–303.
- Naghavi, A. and Strozzi, C. (2015). 'Intellectual property rights, diasporas, and domestic innovation'. *Journal of International Economics*, 96(1), pp. 150–161.
- Niebuhr, A. (2010). 'Migration and innovation: Does cultural diversity matter for regional R&D activity?' *Papers in Regional Science*, 89(3), pp. 563–585.
- Noja, G. G. and Son, L. (2016). 'Challenges of International Migration in a Globalized World: Implications for Europe'. *International Journal of Innovation and Economic Development*, 2(3), pp. 7-17.
- Ozgen, C., Nijkamp, P., Poot, J. (2012). 'Immigration and innovation in European regions'. *Tinbergen Institute Discussion Paper*, No. 11-112/3.

- Poot, J. (2007). 'Demographic Change and Regional Competitiveness: The Effects of Immigration and Ageing'. *Population Studies Centre (PSC) Discussion Papers*, No. 64.
- Quinn, M.A. and Rubb, S.D. (2005). 'The importance of education-occupation matching in migration decisions'. *Demography*, 42(1), pp. 153-167.
- Stark, O., Helmenstein, C., Prskawetz, A. (1997). 'A brain gain with a brain drain'. *Economics Letters*, 55(2), pp. 227–234.
- UN. (2019). 'International Migration Report 2019'. *Department of Economic and Social Affairs (DESA). Population Division*. United Nations: New York.
- Van Hear, N., Bakewell, O., Long, K. (2017). 'Push-pull plus: reconsidering the drivers of migration'. *Journal of Ethnic and Migration Studies*, 44(6), pp. 927–944.
- Wong, K. and Yip, C.K. (1999). 'Education, economic growth, and brain drain'. *Journal of Economic Dynamics and Control*, 23(5-6), pp. 699-726.