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The Determinants of Immigrants' Skill Composition

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Abstract: Movements of labor across the world is an ongoing debate in the literature in terms of its drivers and results in sending and receiving areas. Skill composition of immigrant labor has been discussed by several papers, although they generally focused on visa policies or firm level productivity. However, this paper focuses on the relationship between immigrants' educational attainment and government budgeting on research and development (R&D). Panel data analysis is applied for European countries, along with instrumental variable approach as a robustness check. Findings reveal that higher budget allocation for R&D is associated with higher skill level of immigrants within overall immigrant population. This finding is driven by young immigrants whose ages are between 25 and 34 and female immigrants in these countries, suggesting that this relationship varies among sub-groups of immigrants, which would have significant policy implications. Hence, the novel and original approach of the paper resides in the deciding factors of immigrants' skill composition.

Keywords: high-skilled labor immigrants; R&D expenditure; panel data; labor demand mechanism; labor market; human resources; economic growth; competitiveness; innovation; education; sustainable development; well-being; Sustainable Development Goals (SDGs)

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1. Introduction

The shortage of high-skilled labor received significant attention in the past decade. The worldwide competition for talented people has become more prevalent under the pressure of globalization. As a result, the skill gap between labor supply and demand has continuously increased in recent years. The World Economic Forum (2020) emphasized that the skill gaps in the local labor market and the inability to attract specialized talent are the top two barriers for companies when adopting new technologies (World Economic Forum 2020). These figures could explain why governments are interested in setting less stringent migration rules to attract foreign labor to fill some skill gaps in the countries (World Economic Forum 2020).

Moreover, understanding the labor market transitions, with a particular accent on the dissimilarities that exist between different socio-economic groups of workers, has the immeasurable power to shed new light on the scope, pattern, and trends that characterize the labor market reallocation, as well as the vital effects induced by the COVID-19 pandemic and COVID-19 crisis (Organization for Economic Co-Operation and Development (OECD) 2020, 2021). Furthermore, according to a recent descriptive analysis published by the Organization for Economic Co-Operation and Development (OECD) that targets the workers' transitions across European countries and the United States, it was displayed that the labor market transitions are, on the one hand, different from one country to another and, on the other hand, vary "within countries from one socio-economic group to another" (Organization for Economic Co-Operation and Development (OECD) 2021).

If we take the United Kingdom (UK) as an example, the points-based system was introduced in January 2021 to provide a more flexible and straightforward way to attract skilled labor into the UK. For instance, if the high-skilled worker with STEM (science, technology, engineering, and mathematics) background and endorsed by a relevant body, they can use the Global Talent route to enter the UK without a job offer. Meanwhile, in the new immigration points-based system, the UK government will not implement a route for low-skilled workers (Gov.UK 2021). Likewise in the European countries, the European Parliament introduced a migration system, called the "EU Blue Card Scheme", in 2009, to attract high-skilled non-EU workers. However, this scheme has not worked properly since it launched; only 3664 Blue Cards were issued in the EU in 2012, and the number grew up to 36,806 in 2019, especially 78% of them issued by Germany (Eurostat 2021a). Therefore, the European Parliament proposed to reform the current migration policy to make a more flexible criterion for non-EU high-skilled workers.

In the current research, scholars focused on labor supply to estimate the impact of high-skilled immigration on economic growth and innovation and how it enlarges the size of the domestic labor market (Wigger 2021; Ruhs and Vargas-Silva 2020; Campo et al. 2018; Organization for Economic Co-Operation and Development (OECD) 2014). This is the case, as the stock of high-skilled immigration increased in the receiving countries. Because of their ability, the high-skilled labor will contribute to economic growth, explore new technology, and support flexibility of the domestic labor market.

However, the reasons for attracting high-skilled immigration are still unsolved. There is a research gap on the labor demand side to explain the mobility of immigrants. Some research papers estimated that the reform of immigrant policy in the host country would attract high-skilled labor and contribute to the science and engineering sectors, therefore, increasing the productivity in the host country (Grossmann 2021; Xu 2016; Paserman 2013). These research papers have explained the advantage of immigration policy reform, which influences the movement of high-skilled labor. However, the host country's labor demand mechanism that attracts high-skilled labor still has not been clearly explained.

According to the latest data in the Eurostat, 27.9% of foreign-born labor (15–64 years) was with tertiary education in 2020, and it was only 19.6% in 2006. The foreign-born labor population with less than primary, primary, and lower secondary education was 36.2%, and 35.9% of them was with upper secondary and post-secondary non-tertiary education in 2020, which dropped from 42.4% and 38.0%, respectively, in 2006 (Eurostat 2021b).

Besides all these, the United Nations' Sustainable Development Goals (SDGs), which are part of the "2030 Agenda for Sustainable Development" adopted in 2015, place a vital emphasis on the role of education and lifelong learning for the benefit of all individuals all around the world, the specialist focus being on finding viable solutions in order to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (United Nations 2015). In this matter, education is seen as one of the most important factors capable of ensuring, over time, people's capacity to find better work opportunities, empowering individuals by offering them dignity, happiness, prosperity, success, security, well-being, and an increased level of self-esteem (United Nations 2022). Nevertheless, the COVID-19 pandemic has, regrettably, managed to deepen the international learning crisis and worsen the inequalities among individuals at an accelerated rate, which was revealed in the most recent statistics presented by the United Nations Educational, Scientific and Cultural Organization (UNESCO), according to which: "Enrolment in primary education in developing countries has reached 91%, but 57 million children still remain out of school", while "more than half of children who are not enrolled in school live in sub-Saharan Africa"; also, "an estimated 50% of out-of-school children of primary school age live in conflict-affected areas", and besides all these aspects, "103 million youth worldwide are still illiterate, and more than 60% of them are women" (United Nations 2022; United Nations Educational, Scientific and Cultural Organization (UNESCO) 2022).

Therefore, our research will focus on the labor demand side to assess the relationship between R&D expenditure and immigrants' educational attainment. We would like to

measure the mechanisms of migration movement along with the labor demand side. We attempt to estimate if there is an expansion in the host country's labor demand and whether it will attract high-skilled foreign-born labor into the labor market. We use the Eurostat and World Bank datasets and estimate this relationship for 27 European countries from 2008 to 2020.

The rest of this paper is structured as follows: the literature review of the current research on the high-skilled labor movement will be presented in Section 2. Section 3 will discuss mechanisms of immigration mobility through labor demand in three aspects—R&D expenditure, social cluster, and wage (or living standard)—thus establishing the model. In Section 4, we will discuss the materials and methods (namely, the research methodology and dataset with the data description) used in this paper. Finally, we will discuss the main findings and conclusions in Section 5, respectively.

2. Literature Review

According to reputed specialists worldwide, legal migration represents a phenomenon capable of offering great benefits to several parties, namely to migrants, to the countries of origin, and to the countries of residence, based on the fact that the people who take the decision to migrate seek better circumstances capable of improving their lifestyle, while the host countries look for skilled and talented workers expected to fulfill, in the best manner possible, the needs of the labor market (European Commission (EC) 2022, p. 1). Under these given circumstances, the European Commission recently published documents address the case of migration as probably one of the mostly praised assets that the member states possess in their quest of "attracting talent and different types of skills that can contribute to the dynamism of EU economies", based on the strong belief that "migration and mobility are and will continue to be inherent features of humanity, globally and in the EU" (European Commission (EC) 2022, p. 1). What is more, the up-to-date analyses belonging to the European Commission on the European labor market evolution as a result of the influences of legal migration phenomenon are highly encouraging; first of all, based on the most recent statistics, "the European labor market is overall returning to pre-pandemic levels" due to the opportunities offered by legal migration, despite the crisis situation that was encountered in all major areas (demographic, social, economic, financial, and political) and that was generated in the recent years by the COVID-19 pandemic; second of all, based the most recent information on the status of the SDGs implementation at the EU level, "the EU's transition towards a green and digital economy" can successfully return to the pre-pandemic levels with the aid of the benefits of the legal migration, since "the transition to a climate-neutral economy" requires "additional labor and new skills" (European Commission (EC) 2022, p. 1).

Nathan (2014) argues that the current research on high-skilled immigrants focuses more on the "wider effect" of the production and consumption of economy, rather than sticking on the labor market and fiscal changes (Nathan 2014). The "wider effect" refers to all factors outside the labor market but that influences the high-skilled immigration (Nathan 2014). For instance, firm-level productivity and innovation activities, openness of a country, welfare of labor, and competition in the industry (Nathan 2014).

While focusing on the benefits and importance of innovation, researchers mentioned the fact that one of the highly expected and praised side-effects that national governments seek when encouraging legal migration, even though innovation obtained with the help of this particular phenomenon, is very difficult to quantify, in some circumstances even impossible (Cambridge Econometrics, COWI, Directorate-General for Environment (European Commission), ECORYS Nederland BV 2013, p. 151). A valuable example provided by the case of Germany showed that the labor market these days is highly dependent on the capacity of individuals to cooperate in order to "boost innovation", while high-skilled, talented immigrants might be the solution capable to ensure sustainable development and the right geographical coverage necessary to ensure prosperity at all levels for this

European country (Cambridge Econometrics, COWI, Directorate-General for Environment (European Commission), ECORYS Nederland BV 2013, p. 161).

While referring to the critical effects of immigration on the levels of the labor markets competitiveness, Malchow-Møller, Munch, and Skaksen specify that there are numerous novel effects of immigration on salaries, as follows: on the one hand, in competitive labor markets, even though the immigration phenomenon affects the level of wages, as well as the aggregate labor supply, employers will choose to hire, in most cases, either high-skilled immigrant workers or native workers instead of low-skilled immigrant workers; on the other hand, in not fully competitive labor markets, the immigration phenomenon influences in a consistent manner the level of salaries, especially in those situations in which, due to financial reasons and the nature of work activities, entities are keen on hiring low-skilled immigrant workers instead of high-skilled immigrant workers or native workers (Malchow-Møller et al. 2012).

In the same vein as the aforementioned aspects, the Europe Agenda for 2020 focusing on "a European strategy for smart, sustainable and inclusive growth", positioned smart growth, sustainable growth, and inclusive growth among the desired targets of a healthy society, based on knowledge and innovation, seeking the best interests of individuals, accentuating the need to foster people's happiness and well-being, as well as environmental friendly activities and actions (European Commission (EC) 2020). Moreover, a "high-employment economy" is believed to be the result of the "wider effect" analyzed above, in the context in which the development of the labor market would become capable to support "social and territorial cohesion" and a strong and competitive economy (Cambridge Econometrics, COWI, Directorate-General for Environment (European Commission), ECORYS Nederland BV 2013, p. 33; European Commission (EC) 2020).

2.1. Firm-Level

Literature provides empirical investigations on how high-skilled immigrant labor influences firm level decisions and output.

While centering on the case of high-skilled immigration, Waugh highlighted in the work on the firm's dynamics and immigration the fact that those changes that occur in the entities' level manage to offer new perspectives both in the short-run and long-run in terms of the economic performance, the financial results, the labor demand distribution, and the wages of the high-skilled immigrants (Waugh 2017). In addition, it was emphasized that the expansion of and the elimination of the H-1B visa program are highly influential when referring to the decision and to the process of creating new firms (Waugh 2017).

As one of them, Laursen et al. (2019) claimed that the high-skilled immigrants have diversities of knowledge networks and experience, which could promote innovation performance in the firms (Laursen et al. 2019). The authors have estimated 16,241 Dutch firms from 2000 to 2010 by using Cobb–Douglas production function and found that there is a positive significant relationship between high-skilled immigrant worker and firms' innovation performance (Laursen et al. 2019).

Another impact of high-skilled immigrants might be observed in the relocation decision of firms. Accordingly, Olney and Pozzoli's (2021) research, which investigated 35,000 firms in 97 Danish municipalities from 1995 to 2011, found that influx of immigrants reduces the need for firms to relocate jobs in the foreign country (Olney and Pozzoli 2021). Therefore, they suggested that immigration and offshoring can substitute each other (Olney and Pozzoli 2021).

Moreover, Morales (2021) used the Cobb–Douglas production model from 2001 to 2014 to estimate the effect of two main visa programs, H-1B and L-1, in the United States (Morales 2021). He found that multinational enterprises in the United States play an essential role in how immigration affects the location of production and welfare (Morales 2021). It was pointed out that when the government was setting an immigration policy, they had to consider the relationship between MNEs' activities and immigration to attract

foreign investment (Morales 2021). The restricted immigration policy may prohibit the inflows of investment.

2.2. H-1B Visa

Visa policies have considerable effects on firms. In their studies, Ghosh et al. (2014) combined the high-skilled immigrant labor on the labor condition application records and the firm-level data of the Compustat Industrial Annual data set to examine how firm productivity is influenced by H-1B visa holders (Ghosh et al. 2014). They observed the H1-B visa holders in 4000 firms between 2001 and 2006 (Ghosh et al. 2014). Findings revealed that the firms could obtain higher productivity and profit if the government relaxed the H-1B visa cap (Ghosh et al. 2014). In other words, the more H-1B workers in the firms, the higher returns to the firms, especially in the R&D intensive ones.

Similarly, Doran et al. (2016) compared the firms that had winning or losing lotteries of H-1B visas in the fiscal year in 2006 and 2007 (Doran et al. 2016). They found that if the firms won the H-1B lotteries, they could only increase the overall employment and have a higher profit, although the more H-1B workers hired in the R&D intensive firms cannot increase the number of patent holders (Doran et al. 2016). Moreover, the H-1B worker may crowd out the employment opportunities to the non-H-1B holders and lead to lower average earnings of employees (Doran et al. 2016).

Kerr et al. (2015a) have summarized six characteristics of firms to emphasize that firms often play an essential role in the US immigration process for skilled workers (Kerr et al. 2015a). These characteristics include employment structure, wage rate, innovation outcomes, global connections firm lobbying, and skilled immigration and entrepreneurship (Kerr et al. 2015a). Moreover, they suggested the further research focus on the micro and macroeconomic perspectives and how these two areas could affect skilled immigration (Kerr et al. 2015a). Furthermore, Kerr et al. (2015b) explored the longitudinal employer household dynamics database and created an unbalanced panel data for 319 firms from 1995 to 2008 (Kerr et al. 2015b). Using OLS and IV estimation methods, they revealed that young and skilled immigrants significantly influence the firms' employment structures (Kerr et al. 2015b).

A fundamental work brings to the attention the controversies surrounding the arguments brought by specialists while addressing the high-skilled immigration encouragement or restriction (Glennon 2020). In this particular matter, Glennon points out, on the one hand, that by supporting the high-skilled immigration firms could have tremendous benefits in terms of increased competitiveness and unprecedented innovation levels (Glennon 2020). Nevertheless, Glennon expresses, on the other hand, great concerns when it comes to the disadvantages brought by the high-skilled immigration in terms of discouraging native workers employment, as well as unjustifiably driving down the salaries (Glennon 2020). What is more, Glennon closely studies the implications of restrictive high-skilled immigration policies on the offshoring of high-skilled jobs by US multinational companies centering the attention on a novel matched firm-level dataset of H-1B visas and multinational company activity (Glennon 2020). Furthermore, the results are believed to be vital in today's context, since the immigration policy implications were unprecedented due to the fact that, in essence, by imposing restrictions on H-1B immigration firms decided to focus on offshoring jobs abroad (Glennon 2020).

In line with the aforementioned studies, in the conference paper on the effects of high-skilled immigration policy on firms, published in December 2021, Doran, Gelber, and Isen brought to light the fact that the largest high-skill immigration program in the US, represented by the H-1B temporary work visa, is considered these days a topic for continuous debate and tremendous controversies (Doran et al. 2021). The work of these specialists starts by pointing out that some of the US firms consider, on the one hand, that they are highly dependent on H-1B workers in order to become more creative and innovative, thus being able to grow faster on the marketplace. In continuation, these researchers mention, at the same time, that other US firms, on the other hand, believe

that H-1B workers have insignificant or even no effect at all on the firms' development levels and innovation potential, since in their opinion H-1B workers may only lead to crowding employment and they do not have any unique skills by comparison with the already employed US workers (Doran et al. 2021). Nevertheless, Doran, Gelber, and Isen stressed the following decisive facts: first of all, by hiring H-1B workers the companies increased their profits and decreased their payments per employee, mainly based on the fact that firms are usually paying less than the average wage to the H-1B workers; second of all, by hiring high-skilled H-1B workers the companies crowd out other workers that possess similar levels of attributes and skills, which leads to serious doubts and important questions while referring to the benefits and opportunities offered by the US immigration policies (Doran et al. 2021). Moreover, Doran, Gelber, and Isen argued that even though the general results point out that the firms' level of innovation increased and the firms' managed to grow faster after hiring the H-1B workers, the reasoning behind these high levels of growth and innovation could be simply because these entities are different in other ways while compared with the entities that do not rely their activities on hiring the H-1B workers (Doran et al. 2021).

Apart from the US case, there are some other case countries that are examined in the related literature. In this respect, Paserman (2013) has estimated the mass immigration wave between 1990 and 1999, from the former Soviet Union to Israel (Paserman 2013). He found there is no significant causation between the high concentration of immigration and firms' productivity (Paserman 2013). However, the result shows a positive relationship in the high technology industry using first-order differences estimation method (Paserman 2013). In this way, the result suggested that the technology intensive firms may attract more immigrants (Paserman 2013).

Bettin et al. (2012) estimate the ratio of domestic workers to immigrant workers in a sample of 3264 Italian manufacturing firms between 2001 and 2003 (Bettin et al. 2012). Findings showed that in the high-skill intensive industry, the immigrants and domestic workers are complementary, though this relationship changes to the substitute if domestic workers' wage rate is increased, especially in the low-skill incentive sectors (Bettin et al. 2012).

2.3. High-Skill Movement

Firm productivity through high-skilled labor is one aspect of this mobility, as supported by Campo et al. (2018), which found positive relationship between high-skilled workers and productivity using the number of immigrants in the labor market from an annual population survey secure access between 2004 and 2016 (Campo et al. 2018). They suggest that the high-skilled immigrant workers may promote the training for the native workers (Campo et al. 2018).

In addition to productivity of firms, the movement of high-skilled labor across the world has various impacts. Kerr et al. (2016) have discussed the key factors that may influence global talent mobility in the OECD countries in 1990, 2000, and 2010 (Kerr et al. 2016). They found the reasons behind the high-skilled labor flows to the OECD countries, such as the raising of human capital, skill agglomeration, lower costs of communication and transportation, and increases in tertiary education (Kerr et al. 2016). Furthermore, Kerr et al. (2017) emphasized existence of a significant trend of high-skilled immigrants' agglomeration in the OECD countries (Kerr et al. 2017). This paper introduced the available data to measure the migration patterns and the reasons behind them, such as the demand factors and policy factors that could shape the global high-skilled migration flows (Kerr et al. 2017).

An eye-opening report published in June 2018 by the European Union (EU) under the form of a "Study on the movement of skilled labor", centered on exposing the latest data on "the trends, drivers and policy responses in relation to brain flow in Europe between 2004 and 2016", stressing the following key facts: the high-skilled EU movers are "relatively young"—most of the individuals "being of prime working age", existing "an even balance between men and women"; usually, they choose to work for more than 10 years in the

residence countries; and the social, economic, and political conditions are vital for the EU movers in choosing the new place of residence (European Union (EU) 2018, p. 1). In general lines, the findings show that the high-skilled, highly educated "EU movers account for a small part of the European labor market when measured in terms of their actual share of the employed population", since just a small percentage of individuals (namely, under 1.4%) represent the high-skilled, highly educated EU movers (European Union (EU) 2018, p. 1). Nevertheless, the 2016 available data look promising, since it shows that the share of high-skilled immigrants has managed to increase significantly between 2004 and 2016: it has been reported that the proportion of high-skilled EU movers, out of the employed EU population, reached a total of 3.6 million individuals, which is almost triple the figures from 2004 (European Union (EU) 2018, p. 1). However, the high-skilled immigrants have chosen specific destinations, not being equally spread across the EU regions and member states, since based on the 2016 data, the share of the medium and the high-skilled movers from other EU countries as a proportion of all the individuals employed in the EU "was highest in Cyprus (around 10%), Ireland (around 9%), Austria (around 7.5%), the UK (just over 6%) and Belgium (6%)" (European Union (EU) 2018, p. 1).

3. Materials and Methods

3.1. Data Description

The data used in the analysis of this study were retrieved mainly from Eurostat, containing plenty of information on country specific indicators for the period 2009–2020. Besides, some of explanatory variables used in the model come from OECD and UNCTAD. The dataset includes 27 European countries (namely, Austria, Belgium, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom) and after a procedure of dropping observations with missing data for variables of interest (R&D expenditures and foreign-born population with tertiary education), we end up a panel with a sample of 388 observations. Number of observations and countries vary across specification based on data availability for particular variables and years. If there is no data for particular independent variables in particular countries, these countries will be dropped. Because of the missing observations in the sample, our panel is unbalanced. Data availability for some countries and years limits the size of our sample.

In the analysis, we intend to identify the relationship between national level research and development activities and the existence of high-skill immigrants in these countries over the period of 2008–2020. Our independent variable is share of government's budget allocations for R&D expenditures in total general government expenditure. R&D expenditures are used to increase the level of knowledge and utilization of this knowledge in several aspects of life. Thereby, it captures a set of crucial efforts to influence human life in a good way. In this study, we want to see immigrants' contribution to these efforts if they exist. R&D expenditures in 2020 were presented in the map below for countries with data:

Figure 1 presents the share of R&D expenditures across countries in our sample for year 2020. Dark blue color means higher expenditure in comparison with lighter ones. Accordingly, countries, such as Germany, Norway, Denmark, and Croatia, seem to have the greatest R&D expenditure as share of their total government expenditures. On the lower part of the scale, countries, such as Romania, Malta, Hungary, and Bulgaria, take place as countries with less than 0.6% R&D expenditure/Government total expenditure.

The key independent variable of interest in this study is the size of high-skilled immigrants across countries. We first need to clarify who is immigrant and what is high skill. We consider foreign country-born individuals as immigrants, as a standard approach in the literature instead of nationality. Regarding the skill endowments of immigrants, we use having tertiary education (levels 5–8) as measure of skill. Accordingly, distribution of immigrants with tertiary education across countries in 2020 in the sample is shown below.

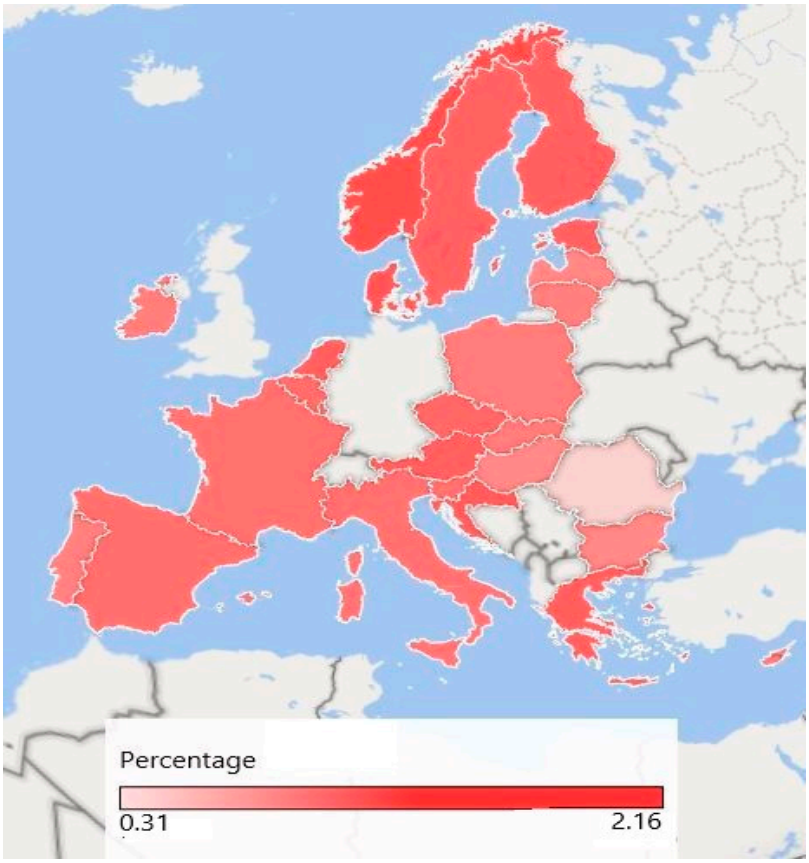

Figure 1. Government budget allocation for R&D expenditures across countries, 2020. Source: Eurostat (Share of GBARD in total general government expenditure).

According to Figure 2, the percentage of immigrant population with tertiary education (*pop_edu_f*) in 2020 was at the highest level (57.1%) in Poland and followed by Ireland (52.7%), Luxemburg (50.6%), and so on. On the right side of the figure, we see lower percentages of high-skill immigrants among immigrant population in these countries. Italy as a country with lowest high-skill population had about 12% of immigrant population with tertiary education. Along with the share of total immigrant population with tertiary education, we also look at specific groups of immigrants, such as young immigrants (pop_edu_f2534), females (pop_edu_ffemale), and males (pop_edu_fmale), to investigate if the results would differ depending on the gender and age of high-skilled immigrants.

We include a set of control variables in the analyses for better explanation of the dependent variable. Among those, our model specification includes important macroeconomic labor market indicators which provide useful information on the national economies. First, *New_Employed_imm,* which is share of foreign-born people in current job for 12 months or less, in total employment. Second, human resources in science and technology (HR_st) are included as a labor market indicator for high-skill labor. One can consider these variables as demand side variables that are expected to be positively related to the share of high-skilled immigrants within overall immigrant population, which would also be an incentive to acquire skill. Third, *Labor_cost* is an index measuring labor cost structure in terms of wages and salaries for financial and insurance activities; real estate activities; professional, scientific, and technical activities; administrative and support service activities. Therefore, we expect that if labor cost for high-skilled jobs increases, demand for high-skilled workers is likely to decrease, which would in turn lower the share of high-skilled immigrants in overall immigrant population as it means lower demand for this type of workers due to higher costs.

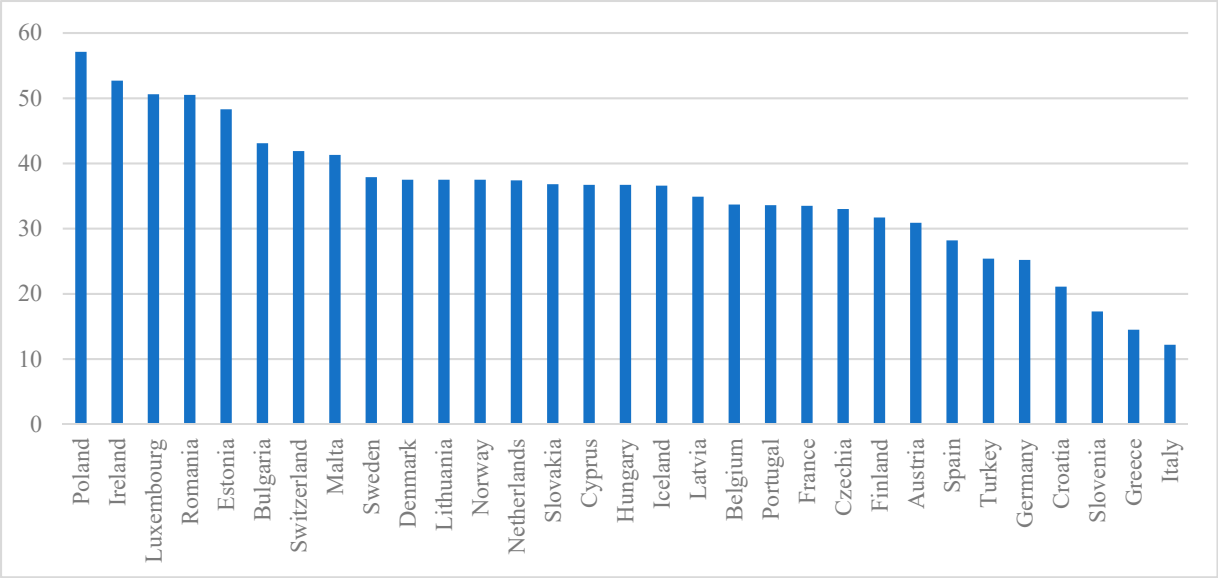

Figure 2. Immigrant population with tertiary education as percentage, 2020. Source: Eurostat (Population by educational attainment level). Note: Individuals with tertiary education and aged from 15 to 64 are covered in the figure. There is no data for UK in 2020.

Moreover, we also include some welfare indicators that may influence skill preferences of immigrants. As income sources, we involve gross domestic product (*GDP_pc*) and *remittances* (log_remittances). As other welfare indicators, we take *Gini* coefficient that would give an idea on equality in society, poverty risk of immigrants (Poverty_imm), and self-perceived health of immigrants (health_imm).

HICP as a measure of the level of consumer prices' inflation and effective exchange rates of countries (exc_r) that can affect immigrants' preferences are also included in our specifications. Summary statistics of the variables used in this study are given in Table A2 in Appendix A section.

It might be useful to check if high correlation is observed between independent variables that means a violation of the condition of independence of independent variables. Pairwise correlation coefficients are as presented in Table A2 in Appendix A section. Even though these coefficients do not refer to a robust relationship, it still provides useful check to alert high correlations among variables (if any) that would cause multicollinearity problem. Correlations range from -1 to $+1$ and correlation coefficient of -1 or $+1$ means a perfect correlation. Since independent variables must be independent, having high correlated variables might give rise to unreliable estimation results. As presented in Table A2, independent variables used in this study do not seem to have high correlations among each other. Hence, this analysis is not likely to suffer multicollinearity problem.

We strongly believe that the greatest and the most valuable intangible asset that entities and countries worldwide possess is human resources, since human resources competencies, skills, talent, and level of education and knowledge make the difference when it comes to ensuring the nations' prosperity and wealth, based on the input of the human capital and the intellectual capital benefits and opportunities provided at all levels. In this matter, high-skilled immigrants become an integrating part of the entities where they work and they come to support through their work the knowledge and the technology assets, thus enhancing the development of the business value chain and nations productivity.

3.2. Research Methodology

In our research, we want to examine the high-skilled labor movement from the labor demand side. Therefore, we have developed a process with three mechanisms that the host country can use to attract highly skilled labor (See Figure 3). Suppose, Country A

indicates an advanced country but with a significant shortage of high-skilled labor in the domestic market. In Country B, there is a group of high-skilled labor who are seeking job opportunities in the global market. Therefore, from the labor demand side, there are three possible mechanisms.

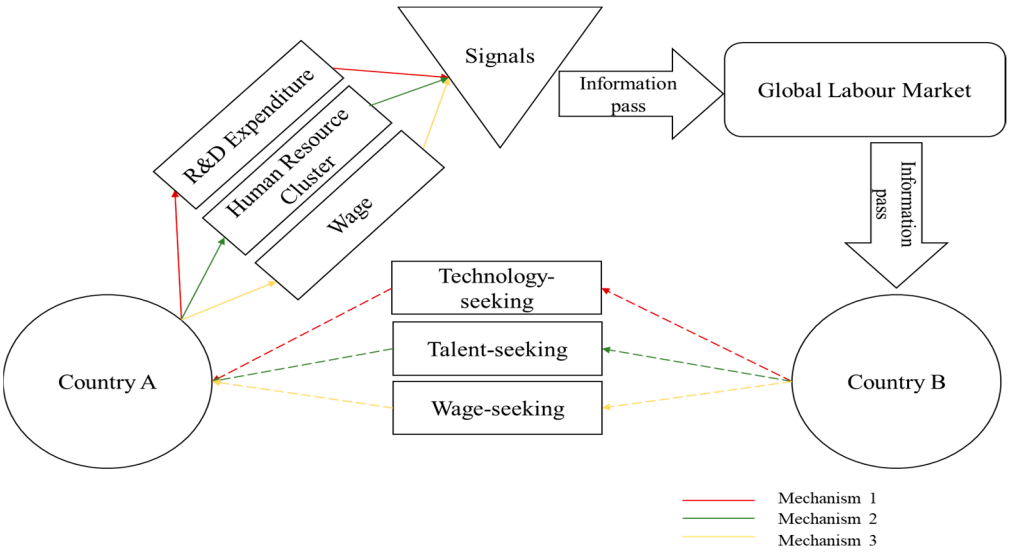

Figure 3. Three mechanisms for attracting high-skilled labor. Source: own illustration based on the reference section.

3.2.1. Mechanism 1: R&D Expenditure

The government in Country A increases R&D expenditure that needs extra high-skilled labor to explore the new technology. Therefore, Country A creates new vacancies and sends this signal to the global labor market. On the other hand, the high-skilled labor in Country B received this signal, and they are the technology seeker and willing to contribute to develop the new technology, then they will move into Country A.

3.2.2. Mechanism 2: Human Resource Cluster

Some talented people exist in Country A with similar knowledge, culture, language, and research background (e.g., Chicago School). They may want to expand the network to enlarge the human resource cluster in Country A. Therefore, once the signal passes to the global labor market, it will be received by a similar group of talented people in Country B. Once they find it challenging to show their talents in Country B, they will move to Country A.

3.2.3. Mechanism 3: Wage Level

As Country A is an advanced country, the living standard is much higher than Country B. In particular, the workers who work in the high-technology sectors are always paid a high wage rate. Therefore, if the high-skilled laborer in Country B knows they will be paid a higher wage rate in Country A, they prefer to move out and get a better living standard.

The research question of this paper is whether research and development expenditure is a good predictor of high-skill endowments of immigrants at the national level. We explore this possibility by the following panel specification:

$$HS_{cy}^{imm} = \alpha + \beta R\&D_{cy}^{exp} + \gamma O_{cy} + \phi_y + U_{cy} \quad (1)$$

where $R\&D^{exp}$ presents research and development expenditures and subscript c is for country and y is for time. Our main dependent variable is the size of high-skilled immigrants (i.e., immigrants with tertiary education) within immigrant population in country c in year y. Therefore, β measures how much impact R&D expenditures of host countries have on

immigrants' high-skill endowment. O presents other explanatory variables that are likely to influence our dependent variable and are listed in the next section. Finally, ϕ_y is year fixed effect that controls for possible business cycle effects.

We applied the Hausman test to determine whether random or fixed effect model would be more efficient for our model. Hausman test favors fixed effect over random effect estimates, and hence we use fixed effect model in our specification.

4. Results

In this section, we present empirical findings from our main specification, as well as sub-group specifications. Starting from the first four specifications as seen in Table 1, we investigate whether government's budget allocation on R&D expenditures have any impact on the share of high-skilled immigrants within total immigrant population. R&D expenditures were taken as 1-year and 2-year lags because of the fact that their effect is likely to be felt gradually not immediately. Apart from the variable of R&D, we also include human resources in science and technology (HR_st), labor cost for skilled jobs (Labor_cost), as well as some variables, such as poverty risk (Poverty_imm), health (Health_imm) of immigrants, and GDP per capita (GDP_pc), as welfare indicators. Later in the 3rd and 4th specifications, there are a few other controls that are expected to influence immigrants' skill composition. Finally, in the 5th specification, we include 1-year and 2-year gap on R&D expenditures with rest of our controls.

Table 1. Results of the panel specifications, dependent variable is the share of high-skilled immigrants (HS_imm).

Variables	1	2	3	4	5
$R\&D_{(t-1)}$	1.632		2.048 *		1.530
	(1.058)		(1.065)		(1.340)
$R\&D_{(t-2)}$		1.441		1.669 *	0.802
		(0.999)		(1.000)	(1.255)
New_Employed_imm			−0.104	−0.106	−0.106
			(0.066)	(0.066)	(0.066)
Labor_Cost	−0.078 *	−0.077 *	−0.069	−0.068	−0.071 *
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Remittances			0.635	0.666	0.666
			(0.679)	(0.682)	(0.682)
Gini	0.074	0.079	0.078	0.081	0.080
	(0.101)	(0.101)	(0.103)	(0.104)	(0.103)
Poverty_imm	0.054	0.050	0.049	0.045	0.048
	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)
Health_imm	0.092 ***	0.087 ***	0.091 ***	0.085 ***	0.089 ***
	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)
Exchange_Rate			−0.035	−0.033	−0.034
			(0.040)	(0.040)	(0.040)
Inflation			0.119	0.100	0.115
			(0.080)	(0.079)	(0.080)
HR_st	0.962 ***	0.971 ***	1.025 ***	1.039 ***	1.032 ***
	(0.110)	(0.110)	(0.115)	(0.115)	(0.115)
GDP_pc	−0.089	−0.076	−0.056	−0.044	−0.051
	(0.058)	(0.058)	(0.061)	(0.061)	(0.061)
Constant	−25.621 ***	−25.567 ***	−48.439 **	−47.075 **	−49.220 **
	(6.300)	(6.317)	(19.363)	(19.350)	(19.428)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Number of cid	28	28	28	28	28
Observations	269	269	269	269	269
R-squared	0.702	0.701	0.711	0.710	0.712

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: own illustration.

Accordingly, Table 1 presents findings of our main specification, where all immigrants with tertiary education from 15 to 64 years are included. As presented, β coefficient for the first column where 1-year lag of R&D expenditure is considered as 1.632 with 1.058

standard error. The effect of R&D expenditures on the size of high-skilled immigrants is positive though it is not statistically significant. In the second column of Table 1 we check whether 2-year lag with current control variables would matter. Findings reveal similar outcome for this specification as well. However, additional controls in the 3rd and 4th columns change the magnitude and significance of β coefficient. The effect of R&D became larger and statistically significant at 10 per cent significance level. Specification 5, notwithstanding, does not any give significant effect of R&D allocation.

This means share of government budget allocation for R&D in total government expenditures is likely to be positively associated with the size of high-skill immigrants within total immigrants as expected. Besides, immigrants' self-perception of health and human resources in science and technology were found to be positively related to our dependent variable.

Table 2 presents our findings for specific immigrant groups that are young immigrants, females, and males. As seen in the first column of table, the coefficient of the independent variable of interest is higher for young immigrants in magnitude and significance level, which means young immigrants skill endowments are more affected by government R&D expenditures. Differently from the first specification that covers all immigrant population, the variable of Gini was found statistically significant and negatively associated with our dependent variable for young immigrants. The Gini coefficient measures the relationship of cumulative shares of the population arranged according to the level of equivalized disposable income, to the cumulative share of the equivalized total disposable income received by them (Eurostat 2021c), and where zero represents perfect equality, while 100 represents perfect inequality. Hence, we can say that when inequality increases in a society, the size of high-skilled immigrants gets smaller for young immigrants.

Table 2. Results of the panel specifications, dependent variable is the share of high-skilled immigrants, specific groups.

Variables	HS_imm, from 25 to 34 Years	HS_imm, Female	HS_imm, Male
$R\&D_{(t-1)}$	5.956 ***	2.854 **	1.743
	(2.278)	(1.335)	(1.095)
New_Employed_imm	−0.058	0.058	−0.175 **
	(0.153)	(0.083)	(0.071)
Labor_Cost	−0.320 ***	−0.053	−0.089 **
	(0.094)	(0.053)	(0.043)
Remittances	1.088	1.529 *	−1.366 *
	(1.512)	(0.881)	(0.722)
Gini	−0.608 **	−0.161	0.032
	(0.275)	(0.136)	(0.121)
Poverty_imm	0.059	0.088 *	0.016
	(0.098)	(0.048)	(0.042)
Health_imm	0.006	0.120 ***	0.018
	(0.076)	(0.040)	(0.034)
Exchange_Rate	0.173 *	−0.114 **	0.060
	(0.088)	(0.050)	(0.041)
Inflation	0.111	0.289 ***	0.194 **
	(0.178)	(0.102)	(0.085)
HR_st	0.891 ***	1.011 ***	1.024 ***
	(0.251)	(0.144)	(0.118)
GDP_pc	−0.202	0.033	−0.081
	(0.130)	(0.076)	(0.062)
Constant	−42.913	−72.614 ***	−14.526
	(42.108)	(24.617)	(20.138)
Year Fixed Effect	Yes	Yes	Yes
Number of cid	27	28	28
Observations	250	266	263
R-squared	0.520	0.674	0.646

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: own illustration.

β coefficient for female immigrant group is also larger than the first specification, which means there is a gender difference as government budget allocation for R&D has a larger impact on female immigrants. We should note remittances and poverty risk variables were found positively related, though they are only marginally significant for female immigrants. Furthermore, self-perceived good health also has a statistically significant positive impact on the share of high-skilled female immigrants.

The coefficient for male immigrants is not statistically significant. We see that labor market indicators of the newly employed and labor costs are negative and statistically significant. This gender difference might be due to the fact that the male population is more active than the female population in the labor market. The coefficient of remittances is negative for males. So, the more personally received remittances, the lower share of high-skilled male immigrants. This might be because of the fact that external income is used for education purposes for female immigrants, while it is not for male immigrants.

In social science studies, it is not easy to estimate a casual effect, since the estimation is done under a certain set of assumptions. The violation of at least one assumption may cause a biased effect that means unreliable results. One way of avoiding potential bias is using an instrumental variable (IV) technique, which is commonly used in social science literature (see for example Card 2001). Therefore, considering potential endogeneity issue that would cause biased estimates, this study offers an instrumental variable approach as a robustness check of the current results of the effect of R&D expenditures on the share of high-skill migrants in European countries. IV is expected to be correlated with the variable of interest (i.e., R&D expenditures) but not with error term and not with the share of high-skilled migrants. In this respect, lagged R&D expenditures is chosen as an instrument. The findings of the IV approach is given in Table 3.

Table 3. First and second stages of IV estimate.

	R&D Expenditures	
IV	1.669 *	
	(1.000)	
R&D expenditures		2.946 *
		(1.764)
Rest of the variables and year fixed effect	Yes	Yes
F-test	27.07	
N	269	269
R^2	0.7103	0.7101

Standard errors in parentheses * $p < 0.1$. Source: own illustration.

Assessing the relevance of the instruments in terms of its correlation with endogenous variable is represented by the first stage F-statistic. As a rule of thumb, if the F-statistic on the joint significance of the instruments is less than 10, then the instrument is suggested to be weak. According to Table 3, the first stage F-statistic is above the rule-of-thumb of 10 in the specification, suggesting that the instrument is strong. The IV result is consistent with OLS estimates, confirming that there is a positive relationship between R&D expenditures of government and the share of high-skill migrants.

5. Discussion, Conclusions, and Recommendations

If governments put a higher share of budget on R&D activities, then high-skilled immigrants across the world could flow into these countries. So, immigrants with high-skill endowments are likely to head for countries with high levels of R&D activities. Not only are high-skill immigrants from abroad going to be attracted, but also immigrants who already reside in these countries are likely to have a good incentive to increase their skill endowments. From academic literature, we know that high-skill endowments of immigrant workers increase firm productivity. However, very little known about governments' efforts on R&D could help increase the size of high-skilled immigrants in a given country.

This study explores the role of governments in European countries, although research and development expenditures in the private sector should also influence distribution of skill level of residents. The main finding of this paper is that government's higher budget allocation for R&D brings about higher skill endowment within immigrant population that could possibly increase productivity in countries. However, this finding is driven by young immigrants whose age is between 25 and 34 and female immigrants in these countries. Therefore, one can say that governments' efforts are important for youth and females in terms of their skill endowments. Governments' expenditures in European countries seem a strong signal for young and female immigrants, as suggested by findings. These groups become prominent within the immigrant population for responding signals. In this respect, policymakers should consider this finding in their migration policy. More clearly, if more flexibility for these groups is provided by European governments, this could help improve the skill level of immigrant population that could contribute productivity.

The perceived health of female immigrants is also very important. One policy implication could be gender differences in health care services to be provided by governments to attract more high-skilled immigrant labor and to increase acquired skill of immigrant residents. Moreover, young immigrants (age of 25–34) are found to be more responsive to the signals from the global market. High labor cost and inequality in the society influence this group negatively. Therefore, eliminating these obstacles would help attract young talent, which contributes efficiency.

Based on the aspects highlighted in the sections above, it ought to be pointed out that this study represents a novel and an original approach, which has the great power of providing a fresh and vital perspective on a very hot topic these days. In this particular matter, the authors of this current scientific research centered their work on the deciding factors of immigrants' skill composition, which proved to have tremendous implications on supporting lifelong education programs, economic growth, innovation, intellectual capital, happiness, prosperity, success, security, well-being, and sustainable development. In this context, it ought to be mentioned that the findings of this current study are supported by the previous literature. In this matter, for instance, Waugh's work on the importance, the influences and the role of high-skilled immigrants on the firms' dynamics showed that the market size, the changes in the relative wages, the output, the consumption, and the welfare policy represent key points when addressing the economic aspects regarding the immigration phenomenon (Waugh 2017). Moreover, Doran, Gelber, and Isen's pivotal studies on the largest high-skill immigration program in the US, namely the H-1B temporary work visa express, express the vital importance of the US employment policies, raising both awareness and concern when it comes to the firms' decision to choose hiring high-skilled immigrants instead of US high-skilled workers (Doran et al. 2016; Doran et al. 2021). Another notable example that supports this current study's essential results tackles the decisive impact and the immeasurable role of human resources and human capital on the global performance of the European Union (Popescu et al. 2015; Popescu 2019, 2022; Šebestová and Popescu 2022). What is more, the employees' high skills are crucial to the development and growth of entities, since the knowledge-based economy centers on the power of information, knowledge, innovation, research, and the consistent investments into human resources that come to support long-term company performance (Popescu et al. 2015; Popescu 2019, 2022; Šebestová and Popescu 2022). Furthermore, the countries' future and prosperity depends on the manner in which the labor market competitiveness is encouraged (Organization for Economic Co-Operation and Development (OECD) 2019). Hence, there is a continuous struggle to ensure that countries worldwide are capable of attracting talented and skilled individuals, and immigration contributes to providing organizations with foreign talent (Organization for Economic Co-Operation and Development (OECD) 2019).

The future research directions that ought to be highlighted at this point are the following decisive ones: (a) firstly, in our next research papers we believe that we could continue the analysis that we started here by focusing on the key factors that might determine immigrants to continue their education in the countries of destination, as vital

motivation and the necessity to become better trained and qualified in order to occupy better paid positions in the countries of residence; (b) secondly, in our next works, we intend to center on analyzing at a more profound level and on understanding at a more advanced scale the role of health of male and female immigrants, in terms of the gender differences in health care services, due to be provided by governments in order to attract more high-skilled immigrant labor—with a particular accent in the specific health care services for female immigrants, since this is of great interest in the literature these days; (c) thirdly, in our next studies, our great desire is to analyze the connections that might be encountered between the regions and the countries migration policies and the level of migration, in order to discover the reasoning behind high-skilled immigrants choices towards specific destinations—with a particular emphasis on the governments' efforts to attract talent, and the obstacles encountered by individuals to be accepted as part of the legal migration phenomenon in the countries of destination; and (d) finally, considering the research methodology of this research, applying fixed effect might be a limitation of this study. Therefore, other approaches rather than fixed effect can be applied to see whether findings change.

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Appendix A

Table A1. Variables used in the analysis, 2009–2020.

Variables		Source	Count	Mean	SD	Min	Max
HS_imm	Population by educational attainment level, foreign country birth, from 15 to 64 years, %	EUROSTAT	388	30.26	10.26	10.4	62.3
HS_imm_25–34	Population by educational attainment level, foreign country birth, from 25 to 34 years, %	EUROSTAT	356	36.69	13.86	8.1	70.3
HS_imm_females	Population by educational attainment level, foreign country birth, from 15 to 64 years, females, %	EUROSTAT	376	31.5	10.49	10.3	62.5
HS_imm_males	Population by educational attainment level, foreign country birth, from 15 to 64 years, males, %	EUROSTAT	373	28.03	10.2	7.5	54.4
R&D	Share of Government budget allocations for R&D in total general government expenditure, %	EUROSTAT	388	1.26	0.49	0.31	2.96

Table A1. *Cont.*

Variables		Source	Count	Mean	SD	Min	Max
New_Employed_imm	Newly employed (share of people in current job for 12 months or less, in total employment), foreign country birth, %	EUROSTAT	388	18.31	5.86	0.6	38.7
Labor_Cost	Labor cost index, wages, and salaries (total) for skilled jobs *, percentage change on previous period	EUROSTAT	278	3.25	4.37	−13.8	39.1
Remittances	Logarithm of personal remittances received (current USD)	World Bank	388	21.3	1.22	18.36	23.99
Gini	Gini coefficient of equivalized disposable income before, scale from 0 to 100 social transfers	EUROSTAT	382	35.11	3.64	24.3	46.8
Poverty_imm	People at risk of poverty or social exclusion, foreign country birth, population aged 18 and over	EUROSTAT	375	31.29	9.39	12.1	62.8
Health_imm	Self-perceived health, perception of very good or good, %	EUROSTAT	377	64.71	18.64	18	90.5
Exchange_Rate	Industrial countries' effective exchange rates	EUROSTAT	376	101.98	5.89	77.73	125.62
Inflation	Harmonized index of consumer prices, annual average index	EUROSTAT	388	98.82	5.77	68.71	113.15
HR_st	Human resources in science and technology, share of the active population in the age group 25–64	EUROSTAT	358	45.78	9.04	23.5	65
GDP_pc	Real GDP per capita, percentage change on previous period	EUROSTAT	388	0.71	3.81	−14.5	24
Cid	Country ID		388	18.83	10.46	2	38
Year	Year		388	2013.99	3.74	2008	2020

* Financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service activities. Source: own illustration.

Table A2. Pairwise correlations.

Variables	$R\&D_{(t-1)}$	New_Employed_imm	Labor_Cost	Remittances	Gini	Poverty_imm	Health_imm	Exchange_Rate	Inflation	HR_st	GDP_pc
$R\&D_{(t-1)}$	1.000										
New_Employed_imm	0.310 * (0.000)	1.000									
Labor_Cost	−0.175 * (0.003)	−0.163 * (0.006)	1.000								
Remittances	0.076 (0.138)	−0.043 (0.402)	0.053 (0.379)	1.000							
Gini	−0.110 * (0.034)	0.106 * (0.039)	0.022 (0.720)	0.098 (0.055)	1.000						
Poverty_imm	−0.149 * (0.004)	0.072 (0.167)	−0.265 * (0.000)	0.069 (0.185)	0.398 * (0.000)	1.000					
Health_imm	0.149 * (0.004)	0.416 * (0.000)	−0.369 * (0.000)	−0.129 * (0.012)	0.010 (0.851)	0.066 (0.203)	1.000				
Exchange_Rate	−0.047 (0.374)	−0.003 (0.954)	0.189 * (0.002)	−0.048 (0.357)	0.148 * (0.004)	0.168 * (0.001)	−0.158 * (0.002)	1.000			
Inflation	−0.034 (0.513)	0.002 (0.976)	0.245 * (0.000)	0.122 * (0.017)	−0.001 (0.977)	0.054 (0.295)	−0.013 (0.809)	0.111 * (0.031)	1.000		
HR_st	0.547 * (0.000)	0.471 * (0.000)	−0.096 (0.109)	−0.051 (0.332)	0.066 (0.219)	−0.202 * (0.000)	0.248 * (0.000)	0.092 (0.087)	0.243 * (0.000)	1.000	
GDP_pc	−0.133 * (0.010)	0.044 (0.386)	0.231 * (0.000)	−0.005 (0.928)	0.068 (0.182)	−0.083 (0.107)	−0.176 * (0.001)	−0.074 (0.153)	0.142 * (0.005)	0.032 (0.544)	1.000

Source: own illustration. * $p < 0.05$.

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