ORIGINAL ARTICLE

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Innovation as a cause of highly skilled migration: Evidence from Greece

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Abstract

This study investigates innovation as a cause of highly skilled migration. Drawing on a totally new database that includes all the Greek PhD holders, combined with panel data from the Global Innovation Index covering 57 countries over the 2009–2020 period, we find that innovation constitutes a strong determinant for highly skilled migration. That is, a rise in innovative performance is positively associated with an increase in the number of highly skilled Greek migrants. We further find a two-way causality between innovation and highly skilled migration. Namely an increase in the number of highly skilled Greek migrants positively affects innovative performance. While most of the recent studies have comprehensively addressed the positive effects of skilled migration on innovation, they have not looked at innovation as a determinant of highly skilled migration. We further discuss the potential implications of our findings on countries displaying low innovative performance coupled with brain drain.

INTRODUCTION

Specialised labour constitutes a driving force for today's knowledge economy. Skilled workers make multi-level contributions to knowledge production and dissemination, scientific research, breakthrough innovation and, hence, productivity and growth (Bosetti et al., 2015; Gagliardi, 2015; Kerr et al., 2016). Indeed, educated individuals are increasingly seen as key enablers for technology transfer from universities and research centres to enterprises (Cunningham & O'Reilly, 2018; O'Reilly & Cunningham, 2017; Schweitzer et al., 2015). Furthermore,

the expansion of globalisation and the emergence of knowledge and information as the strategic resources for economic development have increased the global mobility of skilled workers (Ozgen et al., 2011; Pastore & Tomei, 2018) and have resulted in a fierce competition among countries to attract the most talented human capital (Czaika & Parsons, 2017; Docquier & Rapoport, 2009; Kerr et al., 2016). According to Kerr et al. (2016), between 1990 and 2010, the number of skilled migrants in the OECD area increased by almost 130%, reaching 28 million in 2010. In contrast, the increase in low-skilled migrants during the same period was only 40%. According to the OECD (2020), between 2017 and 2018, the number of international students enrolled in tertiary education across the OECD area increased by 5%, reaching the absolute number of 3.9 million students. In 2018, international students accounted for 6% of the OECD tertiary-level student population. On average, in the OECD, international students account for 13% of all enrolments in master's programmes and 22% of PhD enrolments (ibid, p. 31).

Focusing on Greece, brain drain is not a new phenomenon. It goes back to the '70s, it increased in the '90s, while it was exacerbated during the recent financial crisis when Greece suffered one of the most severe brain drains among EU countries. Greece was hit harder by the recession than any other EU country. The resulting rapid shrinkage of the GDP, the sharp increase in the employment rate, especially among the younger generation, and the deterioration of living conditions, combined with the structural weaknesses of the Greek economy led to an unprecedented emigration of skilled individuals (Labrianidis & Sykas, 2021). It has been estimated that the total emigration outflow of skilled Greeks ranged from between 119,000 and 139,000 people at the end of 2010 (Labrianidis, 2011) to between 280,000 and 350,000 people during 2010–2015 (Labrianidis & Pratsinakis, 2016).

A chronic structural weakness that increased brain drain is related to the mismatch in the labour market that leads to unemployment, underemployment and employment in jobs for which skilled workers are overqualified, etc. This is not due, as some tend to suggest (e.g. Pseiridou et al., 2019), to some sort of a "Greek tendency" for over-education, since, according to the Eurostat statistical database, between 2009 and 2019, approximately 28% of the population in Greece received a tertiary education degree – slightly less than the EU-28 average (29.2%). Rather, one can attribute this discrepancy between labour supply and labour demand to the fact that the Greek economy is producing low-value products and services, resulting in low demand for a highly skilled labour force (Labrianidis, 2014). Indeed, while the average percentage of the Information and Communication Technologies (ICT) personnel in total employment, between 2009 and 2019 was 3.9% for the EU-28, the same rate for Greece was only 2.4%. Thus, in order to curb brain drain, a potential avenue for Greece is to move up along the value chain with firms focusing on knowledge-intensive and tech-driven production of both products and services which, in turn, would ignite the need to absorb the supply of skilled workers.

Recently, a growing number of studies have focused on the impact of skilled migration on innovation. Most of them affirm the positive impact of skilled migrants on innovation at the national, regional and firm level (Bosetti et al., 2015; Chellaraj et al., 2008; Fassio et al., 2019; Hunt & Gauthier-Loiselle, 2010). However, the innovation–skilled migration relationship may be a two-way relationship. That is, skilled migrants may not only boost a country's/region's innovation, but may also be attracted by a country's/region's high innovative performance. While most of the studies have stressed the positive effects of highly skilled migrant labour on innovation (Bratti & Conti, 2018; Fassio et al., 2019; Hunt & Gauthier-Loiselle, 2010), what has been missing from the analysis is innovation as a pull factor for skilled migration. In other words, they do not underline innovation as a determinant of skilled migration and thus this issue remains under-researched by the current bibliography.

The purpose of our study is to fill this literature gap. Drawing on a totally new database that includes all the Greek PhD holders, combined with panel data from Global Innovation Index that cover 57 countries over the 2009–2020 period, we show that there is a positive relationship between an increase in innovative performance and the number of highly skilled Greek immigrants.[1] Alternatively, a rise in innovative performance leads to an increase in the number of highly skilled Greek immigrants.

The study is organised as follows. In the next section, we review the relevant literature. In Section 3, we describe the methodology and dataset. In Section 4, we provide and discuss the results. Section 5 concludes the article.

LITERATURE REVIEW: THE RELATIONSHIP BETWEEN SKILLED MIGRATION AND INNOVATION

A growing body of recent literature investigates the effects of skilled migration on innovation. Although there is not a universal consensus, most of the studies conclude that skilled migrants make a positive contribution to innovation, knowledge and technology dissemination (e.g. inventions), productivity and job creation at the national, regional and firm level (Bosetti et al., 2015; Chiswick, 2005; Fassio et al., 2019; Jensen, 2014; Kerr et al., 2016). The importance and contribution of the highly educated individuals have been well recognised in the "transformation" of research towards technology output and innovation. According to Cunningham and O'Reilly (2018), educated individuals act as key enablers at the micro-level in the technology transfer process from research and academia towards the private sector, while principal investigators through their personal traits can enable or disable the same process (O'Reilly & Cunningham, 2017). Equally, Schweitzer et al. (2015) point to the importance of technologically reflective individuals in the development of innovations. This takes place in national and international formats and includes not only mature and well-established individuals but also domestic and international students.

On the latter, Chellaraj et al. (2008) highlight the positive impact of international students on US patent applications. Similarly, Hunt and Gauthier-Loiselle (2010) find significant positive effects of immigrant college and post-college graduates on the US patenting per capita. Dullep et al. (2012) show that immigrants having a college education may stimulate US innovation in various ways including entrepreneurial activity and job creation. Kerr and Lincoln (2010) show that a more open US migration policy is positively related to an increase both in employment of foreign migrants in science and engineering and in patenting of inventors with Indian and Chinese names. According to Stuen et al. (2012), international students have a positive impact on knowledge creation in terms of publications and citations produced within US science and engineering university faculties. Some of the above studies specifically focus on the highest educational level, that is, PhD and post-doctoral students, and show that their contribution to patents (Chellaraj et al., 2008) and the number and the quality of publications (Black & Stephan, 2008; Stuen et al., 2012) are particularly strong, making them a driving force in university research.

At the European level, recent studies present more moderate results. Bosetti et al. (2015) examined a panel of 20 European countries and found a positive association between immigrants employed in skilled professions and both the number of patent applications and the number of citations to scientific publications. Focusing on European industries, Fassio et al. (2019) report positive effects of highly educated immigrants on patent citations, although these effects vary across different industries. An effective patent activity by foreign researchers holding a PhD degree has also been shown by Goel and Göktepe-Hultén (2021), in the case of a large research institution in Germany. Gagliardi (2015) argues that skilled migrants constitute a driving force for local innovative performance in Great Britain. On the other hand, Bratti and Conti (2018), studying the impact of the immigrant population on the innovativeness of both Italian regions and local firms, find neither positive nor negative effects. Additionally, Ozgen et al. (2011) suggest that only after exceeding a critical level may the agglomeration of socio-culturally diverse foreign populations in European regions have a positive impact on patenting.

Scholars focus on two kinds of mechanisms by which skilled migration may enhance innovation (Fassio et al., 2019; Jensen, 2014): the first one refers to the direct involvement of skilled immigrants in research and innovation (Jensen, 2014), which may enlarge the human capital and the knowledge base of a specific region (Gagliardi, 2015). Skilled migrants also contribute to the population growth of cities that may give rise to agglomeration economies and increase productivity and growth (Kerr, 2010; Ozgen et al., 2011). In many cases, skilled migrants display distinguished entrepreneurial and inventive skills in specific scientific fields (e.g. science and engineering) that may also improve innovation (Chellaraj et al., 2008; Zucker & Darby, 2007). These direct mechanisms are often related to migrants' self-selection on specific skills, entrepreneurial abilities, innovativeness and risk-taking behaviour that have a positive impact on innovation (Borjas, 1987; Bratti & Conti, 2018; Fassio et al., 2019; Kerr, 2010; Ozgen et al., 2011).

The second mechanism relates to the importance of socio-cultural diversity of skilled immigrants at the national, regional and industry level. Skilled migrants come from diverse socio-cultural backgrounds that may interact and enhance the creation of new ideas (Niebhur, 2010; Ozgen et al., 2011), knowledge spillovers (Jensen, 2014), innovative learning, a better process of problem-solving, and therefore productivity (Bosetti et al., 2015) in the host country. This is the case especially when migrants provide skills complementary to natives and other migrant groups (Fassio et al., 2019; Hunt & Gauthier-Loiselle, 2010). Positive externalities in terms of knowledge generation and transfer may stem from skilled migrant networks with compatriots (diaspora effect), other immigrants, industries and regions (Fassio et al., 2019; Gagliardi, 2015; Lundvall, 1992). Externalities coming from these networks gradually form a context that is receptive to innovativeness (Glaeser et al., 2010) and may also advance innovation with mutual benefits for migrants, and regional and national economies. On the other hand, diversity may be accompanied by cultural, language and skill barriers and differences that undermine interaction, communication, co-operation and thereby innovation initiatives (Alesina & La Ferrara, 2005; Bosetti et al., 2015).

Although the abovementioned studies have thoroughly addressed the positive effects of skilled migrants on innovation, they do not adequately highlight innovation as a causal factor for attracting skilled migrants, and this is what our research tries to address. That is, while a country's/region's innovative performance may be positively affected by skilled migrants, skilled migrants may also be attracted to countries/regions with high innovative performance. In other words, while the impact of skilled migration on innovation has been extensively studied, the impact of innovation on attracting skilled migrants remains relatively under-researched. Starting with the premise that "there is no obvious dominant causality between labour migration and regional innovation," as Faggian and McCann (2009) point out, we aim to explore the issue through the innovative capabilities of a set group of countries, capabilities assumed to be a critical factor for enabling immigration to these countries.

To the best of our knowledge, there are few studies that address the importance of innovation as a pull factor of skilled migration. Faggian and McCann (2009) investigate the relationship between the interregional flows of university graduates in England and Wales and the innovation capacity of a region. They find that human capital immigration is significantly associated with the innovation dynamism of a region and at the same time foreign graduates positively affect the region's innovativeness, thus identifying a two-way causality. In her study, Marinelli (2013) distinguishes between those Italian graduates who choose to stay in the region of study, those who return and those who move onwards within Italy. She shows that onward movers display a higher academic performance and are more strongly attracted to innovative regions than the returnees. For the USA, Zucker and Darby (2007) pinpoint that many foreign star scientists concentrate in places that also attract high-tech companies. Mihi-Ramirez et al. (2016), in one of the few studies that highlight innovation as a cause of skilled migration, show that the number of patents and the number of publications in scientific and technical journals are positively correlated with the number of immigrants that OECD countries receive. However, their dataset is restricted to those migrants with a 5 or 6 educational level according to the ISCED taxonomy, and they only focus on technical publications.

Theories of economic migration and the related empirical research have recorded a variety of factors that determine skilled migrants' movement, however, without placing particular emphasis on innovation. Specifically, differences in wages and returns to skills between countries (neoclassical perspective) (Borjas, 1987; Cebolla-Boado & Miyar-Busto, 2020; Grogger & Gordon, 2011) and relative deprivation of income and opportunities (New economics of migration) (Bartolini et al., 2017; Massey et al., 2005; Triandafyllidou & Gropas, 2014) may affect decisions to migrate.

In a push–pull factor analytical context, pull factors for skilled migration include economic reasons such as high level of GDP per capita and economic growth, employment-related reasons, such as easier access to the labour market, better career opportunities and efficient labour market, and welfare system policies. It also includes scientific reasons, such as high university ranking and high quality of the educational system, political reasons, such as the institutional environment, modern public services and low corruption, and cultural reasons, such as linguistic similarity and cultural proximity (Baruch et al., 2007; Cavallini et al., 2018; EC, 2018 Gökbayrak, 2012,

Kurekova, 2013; OECD, 2002). Support for research and demand for R&D human resources appears to be significant migration incentives for researchers and academics, while a well-established innovation climate constitutes a motivation factor for entrepreneurs (OECD, 2002). On the other hand, major push factors are high unemployment and long-term unemployment rates, the lack of labour market prospects and career opportunities, low wages, economic downturn, unstable political environment, the organisational and functional inefficiencies of the educational system and the absence of the full recognition of qualifications (Constant & D'Agosto, 2008; Delicado, 2010;EC, 2018; IOM, 2003; Labrianidis & Sykas, 2017).

Some scholars highlight that the segmentation of labour markets forms demand for migrant labour across countries and channels migrants into different segments of the labour market according to their skills (de Haas, 2018; Piore, 1979). The upper segment, offering high wage levels and professional development prospects, attracts privileged and highly skilled migrants that may boost knowledge-based economic growth and innovation (Florida, 2005). A significant role is also attributed to migrant networks. Diaspora scientific communities incentivise more skilled emigrants to leave their home country, increasing thus the outflows of skilled migrants, in a procedure that may be enhanced by agglomeration effects (Beine et al., 2011; EC, 2018; Kerr et al., 2017).

The contribution of our study is twofold: first, it investigates innovation as a determinant for the destination choice of highly skilled migrants and hence it enriches the literature on this under-researched topic. Second, it draws its conclusions from a unique national dataset that includes all the Greek PhD holders. This allows us to focus on the highest level of migrants' education scale, which is important for two reasons: first, because the relationship between PhD graduates and innovation is inherently high and, second, because only a few studies (Black & Stephan, 2008; Chellaraj et al., 2008; Ozgen et al., 2011) focus on PhD holders. The majority of the studies discussed above define skilled migrants as those having a tertiary education degree or more (e.g. Hunt & Gauthier-Loiselle, 2010) and, hence, they treat skilled migrants as a skill-homogenous group. However, within the broad category of skilled migrants, there are significant skill differences (Labrianidis, 2011).

The main hypothesis under investigation is that an increase in innovative performance is positively correlated with an increase in the number of highly skilled Greek migrants. In other words, a rise in innovative performance triggers a rise in the number of highly skilled Greek migrants. In order to address the potential two-way causality between innovation and the number of highly skilled migrants, we estimate a simultaneous equations model.

DATA AND METHODS

As we have already mentioned, the focus has been on the PhD scholars who have obtained their doctorate from a Greek tertiary institution or one such institution abroad. This was made possible by making use of a completely new database, that is, the National Archive of PhD Theses (NAPhD). The NAPhD is the national registry collecting PhD theses from all Higher Education Institutions in Greece as well as those PhD degrees awarded to Greeks by foreign universities and certified by the Hellenic National Academic Recognition and Information Centre (Hellenic NARIC). It spans a period of more than 30 years (1985–2020). In addition, an open-ended announcement made through social media called for the registration of Greek PhD holders who had received their PhD from non-Greek institutions and have not certified them through Hellenic NARIC.

Between May and July 2020, an electronic survey was conducted by the Greek National Documentation Centre (EKT), which is the organisation responsible, by law, for the collection, development and maintenance of the NAPhD and the Regional Development and Planning Research Unit of the University of Macedonia (RDPRU). The survey was conducted on individuals who obtained their PhD during the 1985–2018 period and had submitted their thesis to the NAPhD registry. The number of the doctorates held in the NAPhD amounted to 39,207. During the submission process, individuals also submit their email addresses. This address was used as the main distribution channel of the survey.

A secondary source of emails was initiated. An online open call to Greek PhD holders who had not (up until then) submitted their thesis to the NAPhD database was issued through the website and social media of the "Knowledge and Partnership Bridges" initiative (introduced and implemented by EKT since 2017 and addressed to Greek professionals who work abroad). This further expanded the population by 700 doctorate holders.

Next, the data underwent the process of validation against inconsistencies or incorrect email addresses. This step provided us with 22,349 consistent emails of individual PhD holders. This is the population to which the questionnaire was sent. The survey contained a range of multi-variate questions ranging from demographics, geographical and employment mobility to social and career satisfaction. In addition, it was appropriately customised to cater to different employment statuses of the PhD holders (employed, unemployed, retired, etc.). By the end of the survey (24/9/2020) a total of 10,295 answers (46.1%) had been successfully completed and submitted.

Metrics on innovation performance were drawn from the Global Innovation Index (GII) (see below). GII is an annual ranking of countries by their capacity for and success in innovation published by a number of high-profile international institutions (Cornell University, INSEAD and WIPO, 2008–2020). In order to ensure compatibility between the above dataset and the GII, we had to pose a time and a country restriction on our sample. Specifically, we limited our sample to the 2009–2020 period, since our innovation performance metrics, that is sub-indexes and pillars of GII, have been fully available since 2009. Hence, in order to ensure time comparability, it was decided to limit the time frame of the data to be within the set period. This restriction led to a sub-sample of 2349 PhD holders, that is, 22.8% of the total, who experienced migration to 67 different countries between 2009 and 2020 (Figure 1). Furthermore, we restricted our sample only to those PhD holders living in 57 of the 67 countries for which there is available data from GII. As a result, a sub-sample of 2175 PhD holders (21.1% of our sample) emerged, which includes those who now live abroad and those who used to live abroad in the past but at some point in time returned to Greece, where they now live. These PhD holders constitute the highly skilled migrants used in our analysis.

Combining these two datasets, we constructed a panel data set for 57 countries covering the 2009–2020 time period (N = 684).

As said, we pooled our measures of innovation from the 2009–2020 GII. That is, we made use of GII's yearly reports and downloaded the scores, values and rankings per country per pillar for the entire period. GII and other similar reports, e.g. the European Innovation Scoreboard, build on the idea of composite indicators that are mathematical combinations of a set of indicators in order to prioritise countries, regions, etc. on specific dimensions. In
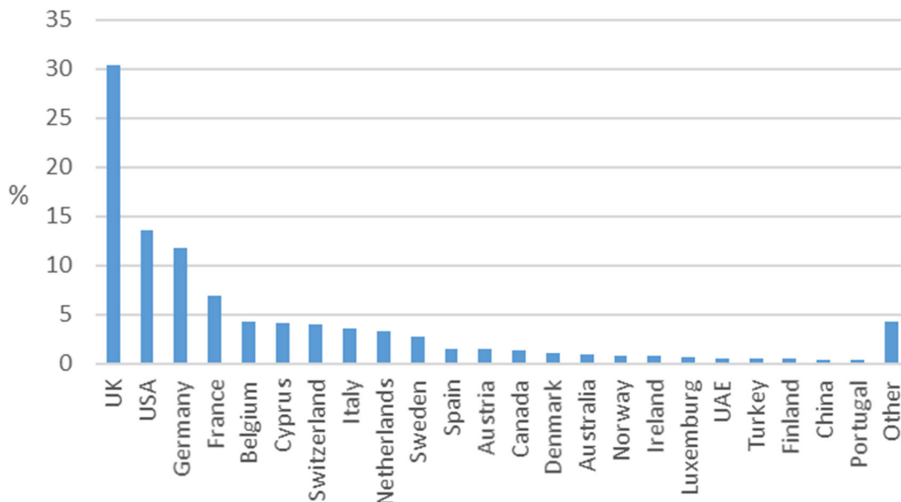

FIGURE 1 Distribution of highly skilled migrants (PhD holders) per country. *Source*: EKT/RDPRU Ph.D. holders survey, calculations by the authors.

addition to consulting and executive reporting, the use of such composite indicators has been used in academic studies (Grupp & Schubert, 2010).

GII is composed of two basic sub-indexes:

The Innovation Input Sub-Index, which includes five pillars:

1. Institutions (Inst) include measures on the political, legal and institutional framework of a country that attracts business and stimulates growth.
2. Human Capital and Research (HCR) addresses the level of education and research activity in each country. It includes indexes about achievements at the primary and secondary education levels (e.g. results in the OECD PISA competition), about tertiary education graduates in scientific fields intensively associated with innovation (engineering, manufacturing and construction) and about the level and quality of R&D activities (e.g. R&D expenditures and ranking of scientific and research institutions).
3. Infrastructure (Inf) includes sub-pillars on ICTs, general infrastructure and ecological sustainability.
4. Market Sophistication (MS) focuses on the entrepreneurial climate of a country and is comprised of various sub-pillars including credit, investment, trade, competition and market scale measures.
5. Business Sophistication (BS) denotes the conduciveness of a host country's firms to innovation. It is comprised of sub-pillars and indicators which, among other things, embody employment in knowledge-intensive services, R&D performance of firms, R&D expenditures financed by business enterprise, innovation linkages measured by business–university partnership in R&D, R&D expenditure financed from abroad, the number of deals in joint ventures and strategic alliances and the total number of Patent Co-operation Treaty (PCT).

The Innovation Output Sub-Index includes two pillars:

1. Knowledge and Technology Outputs (KTO) refers to the creation of knowledge and include various sub-pillars and indicators that, among other things, are related to patent and utility model applications, scientific and technical publications, certificates of conformity with ISO 9001 standard that specifies requirements for a quality management system, spending on computer software, high- and medium-high-tech industrial output, intellectual property receipts, high-tech net exports and exports of ICT services.
2. Creative Outputs (CO) capture the rate of creative activities in a host economy and their international impact. They embrace intangible assets of an economy such as trademark applications and industrial designs. They also incorporate creative goods and services (e.g. cultural and creative services exports, film production and entertainment and media market), as well as online creativity (e.g. mobile app creation, downloads of apps).

As a measure of innovative performance, we use the 2009–2020 score that each of the 57 countries, in which the PhD holders now live or used to live in the past, have obtained in the Knowledge and Technology Outputs (KTO) pillar, which, as mentioned above, constitutes one of the two Innovation Output Sub-Index pillars of GII (for similar treatment, see also Nevezhin et al., 2019). In other words, the 2009–2020 score in the KTO pillar is used as a proxy for the innovative performance of each of the 57 countries in our sample. This is the independent variable of our main interest. We also use as independent variables the above-mentioned input pillars of the 2009–2020 GII.

The dependent variable Highly Skilled Migrants (HSM) is the number of PhD holders in each of the 57 countries during the 2009–2020 time period.

Our study focuses on innovation as a determinant of skilled migration. However, following Faggian and McCann (2009), there is no dominant causality between highly skilled migration and innovation. That is, highly skilled migrants may stimulate a country's innovation and, simultaneously, may be attracted by that country's high innovativeness. In other words, the number of highly skilled immigrants residing in the above countries may

be shaped by the same characteristics that affect performance in innovation. In essence, this points to a two-way causality. In order to capture this two-way causality between highly skilled migration and innovation, we estimate a system of two simultaneous equations (for a similar methodology, see also Mendola, 2008; Faggian & McCann, 2009; Restelli, 2021).

Specifically, we estimate the following system of simultaneous equations:

$$HSM_{it} = \alpha_0 + \alpha_1 KTO_{it} + \alpha_2 Inst_{it} + \alpha_3 HC_{it} + \alpha_4 Inf_{it} + \alpha_5 BS_{it} + \alpha_6 CO_{it} + \varepsilon_{it} \tag{1}$$

$$KTO_{it} = \beta_0 + \beta_1 HSM_{it} + \beta_2 Inst_{it} + \beta_3 HC_{it} + \beta_4 Inf_{it} + \beta_5 BS_{it} + \beta_6 MS_{it} + \eta_{it} \tag{2}$$

where the subscript i ($=1, 2, ..., 57$) refers to country, and t is the time period between 2009 and 2020.

Equation (1) implies that the number of highly skilled Greek migrants is a function of various pull factors related to the host country's economic, innovative, educational and socio-political environment, and more specifically to its innovative performance (KTO), its institutional context (Inst), its level of human capital (HC), its infrastructure (Inf), its firms' openness to innovation (BS) and its creative activities and their global reach (CO). Given the very low rate of entrepreneurs in our sample (see Table 1 below), the MS pillar which captures the entrepreneurial climate of a country has not been included in the first equation.

Equation (2) denotes that the KTO pillar, which is part of the Innovation Output Sub-Index of the GII, is a function of the five pillars which constitute the Innovation Input Sub-Index of the GII plus the number of the highly skilled Greek migrants in each of the 57 countries during the 2009–2020 time period.

In order to estimate the system of simultaneous Equations (1) and (2) and address the two-way causality between innovation and highly skilled migration, we use the three-stage least squares (3SLS) method, developed by Zellner and Theil (1962). 3SLS combines the two-stage least squares (2SLS) and seemingly unrelated regression (SUR) methods. It allows the correlation of the error terms between the simultaneous equations and provides asymptotically efficient estimates. In contrast, 2SLS, which is the most usual technique for estimating simultaneous equations, produces inefficient estimations if the error terms (ε and η) are correlated, while it is also vulnerable to weak instrumental variables. 3SLS is a three-stage estimation procedure of simultaneous equations. The first stage involves the estimation of the residuals of the two structural equations using the 2SLS method. In the second stage, the variance–covariance matrix of cross equation error terms is estimated on the basis of the previously estimated residuals. The estimates of 3SLS are more efficient compared to those of 2SLS, given that it takes into consideration the structure of the error terms. The third stage consists of joint estimation of the two simultaneous equations.

In the following section, we provide findings from the 2009–2020 NAPhD database and we discuss the estimation results.

TABLE 1 Demographic and social characteristics of highly skilled migrants

Gender (%)	Age groups (%)	Professional status
Male: 63.2	Up to 29: 0.6	Professionals: 39.8
Female: 36.8	30–39: 52.9	Academics: 35.6
	40–49: 40.6	Researchers: 16.4
	50–59: 5.5	Managers: 7.4
	60+: 0.3	Other: 0.8
	Over 70: 0.1	

Source: EKT/RDPRU Ph.D. holders survey, calculations by the authors.

RESULTS

Most of the highly skilled Greek migrants are males, 30–39 years old and are professionals, academics and re-searchers (Table 1). The profession of over 50% of the highly skilled migrants, that is, academics and researchers, concerns knowledge and technology production. Being at the forefront of scientific research, it seems probable that they seek educational and professional environments where they can employ their high qualifications and skills.

Figure 2, which presents the reasons for migrating to a specific host country as provided by PhD holders, fur-ther highlights this argument. According to the existing literature (Triandafyllidou & Gropas, 2014), highly skilled Greek migrants are mainly attracted by economic reasons (e.g. better wages) and by professional-related reasons (e.g. professional development, better working conditions and finding jobs in the scientific field). Socio-cultural reasons (e.g. open and meritocratic society, experiencing new cultures) also play a significant role in their decision to migrate. Overall, highly skilled migrants look for a dynamic working, scientific and socio-cultural environment in the host country that matches their high educational and skills level and their high aspirations.

This environment is the one that can be provided by highly innovative countries. It is evident that 64.2% of our sample have lived in 1 of the 10 more innovative countries according to the average 2009–2020 GII (Switzerland, Sweden, United Kingdom, USA, Netherlands, Singapore, Finland, Denmark, Germany and Ireland).

3SLS estimates are reported in Table 2.

The estimates confirm our hypothesis that an increase in innovative performance is positively associated with an increase in the number of highly skilled Greek migrants. In fact, the strongest and most statistically significant pillar that affects the number of highly skilled Greek migrants is the KTO that is the variable of our main interest, which, among other things, is related to knowledge production, patent applications and scientific publications. In terms of elasticities, a 10% increase in KTO is positively associated with a 5.5% increase in the number of highly skilled Greek migrants (alternatively, a unit increase in KTO leads to an increase in highly skilled Greek migrants almost by three). It is worth mentioning that 75.9% of highly skilled Greek migrants reside in those 20 countries that in the 2009–2020 period presented the larger average annual growth rate in the KTO pillar. Despite the high statistical significance of the KTO pillar indicated above, innovation as a migration pull factor has remained un-derappreciated by HSM. This is the case both in our study (see Figure 2) as well as in relevant literature (Bartolini et al., 2017; Labrianidis, 2011; Labrianidis & Pratsinakis, 2016; Pratsinakis, 2021; Triandafyllidou & Gropas, 2014). A possible explanation is that HSM may not be attracted by a country's innovation performance per se, but by
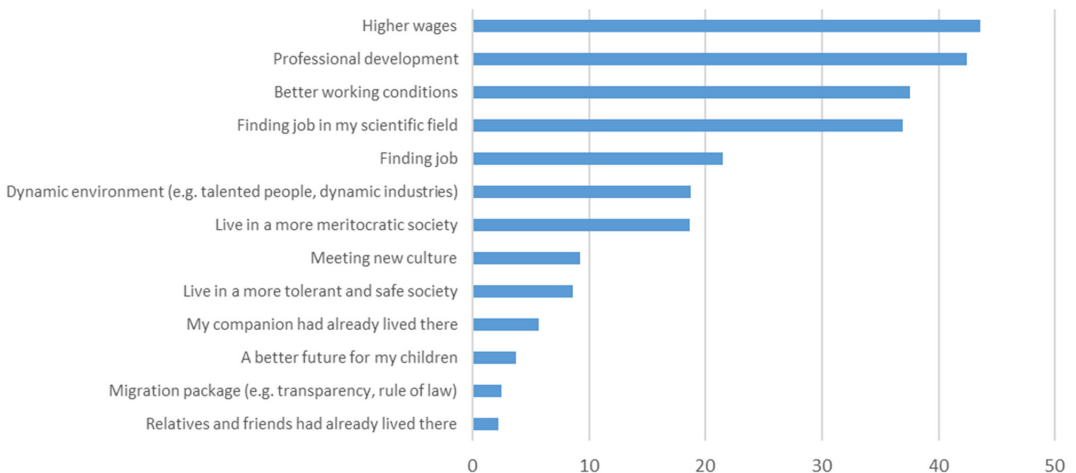

FIGURE 2 Reasons to migrate to the specific host country. *Source*: EKT/RDPRU Ph.D. holders survey, calculations by the authors.

TABLE 2 3SLS estimates: The impact of innovation on highly skilled migration

Independent variables	Coefficients	*p*-values
Dependent variable: HSM		
Constant	0.281	0.950
KTO	2.972	0.000***
Inst	−0.454	0.044**
HC	0.255	0.409
Inf	−0.080	0.760
BS	2.001	0.000***
CO	0.705	0.009***
R-squared: 12.4		
Dependent variable: KTO		
Constant	−1.538	0.014***
HSM	0.056	0.000***
Inst	−0.116	0.000***
HC	0.146	0.000***
Inf	0.089	0.017**
BS	0.660	0.000***
MS	0.117	0.000***
R-squared: 84.2		

Notes: **p<0.05, ***p<0.01.

a series of characteristics such as advanced technological infrastructures, high labour demand in knowledge-intensive industries and high level and quality of R&D activities. It has to be pointed out, though, that these characteristics are highly related to the overall innovation capacity of a given country.

A relatively complex result comes from the negative sign of the Inst pillar coefficient. This pillar includes measures on the political, legal and institutional framework of a country. A 10% increase in this pillar leads to a 1.7% decrease in the number of highly skilled migrants. This may contradict a well-documented push factor of skilled emigration from Greece (Labrianidis, 2011; Labrianidis & Pratsinakis, 2016), that is, the lack of meritocracy, often accompanied by bureaucracy, corruption phenomena and patron–client relations in Greek public administration. Given this fact, one would expect a positive relationship between institutional quality and the number of highly skilled migrants. However, our results indicate that the contrary is true. A possible reason behind this finding is that Inst pillar measures the business- and entrepreneurial-related institutional environment (e.g. ease of starting a business, ease of resolving insolvency). It does not, however, focus on those metrics that highlight the wider legal and institutional conditions as those stated by the HSM that affect their decision to emigrate (e.g. nepotism, corruption and bureaucracy).

The BS pillar, which denotes the conduciveness of a host country's firms to innovation, positively contributes to the number of highly skilled Greek migrants. As stated, this pillar is comprised of various sub-pillars and indicators such as R&D expenditures on the firm level, patenting and innovation linkages that have proved to be strong determinants of innovation (Fassio et al., 2019; Kerr et al., 2017), and in turn, lead to increases in the number of highly skilled migrants. In fact, increasing BS by 10% is associated with a 4.4% increase in the number of highly skilled migrants.

The CO pillar captures the rate of creative activities in a host economy and their international impact. It consists of indexes that mirror the openness of society to creativity, which is strongly related to its innovative activity. A 10% increase in the CO pillar positively contributes to the increase in highly skilled migrants by 1,4%.

In contrast, HC and Inf pillars do not have a statistically significant impact on the number of highly skilled migrants.

Focusing on the second equation, our estimates confirm that there is a two-way causality between highly skilled Greek migrants and the KTO pillar. That is, highly skilled Greek migrants have a positive and statistically significant impact on the KTO pillar. Specifically, a 10% increase in the number of highly skilled Greek migrants leads to a 0,45% increase in the KTO pillar. It is noteworthy that, although we focus on only a specific ethnic cohort of highly skilled migrants, their advanced human capital seems to have a positive effect on the innovative performance of the host countries where they live.

Except for Inst pillar, the remaining explanatory variables have a positive and statistically significant impact on KTO pillar.

A possible weakness of our study is the use of composite indicators as independent variables since they do not allow us to distinguish which individual variables have the greater impact on highly skilled migration (Becker et al., 2017). On the other hand, these indexes are yearly updated, are well respected and cover a broad range of innovative activities, thereby making the ranking among different countries more accurate, and, hence, they are broadly used in the literature (Greco et al., 2019). In that sense, the indexes provide a wide and sound data set for addressing the link between innovation and highly skilled migration.

Overall, our estimates show that an upgrade in innovative performance results in an increase in the number of highly skilled Greek migrants, confirming thus our research hypothesis. Simultaneously, an increase in the number of highly skilled Greek migrants positively contributes to the innovative activity of the host countries in which they reside. Our sample of PhD holders represents a highly skilled and educated class since they constitute some of the most dynamic sectors of Greek society – academics, researchers, managers and professionals. Since they have a precise and complete emigration plan (Labrianidis & Sykas, 2017) and, apart from economic benefits, they pursue an advanced scientific, research and working environment abroad, they move to countries that are able to provide this environment. Within this environment, highly skilled migrants may apply their skills and therefore make a positive contribution to innovation. Subsequently, highly skilled migrants may be attracted by countries where they can fulfil their potentials, thus stimulating even more that countries' innovative performance (two-way causality).

CONCLUSION

Starting with the premise that highly skilled individuals are key enablers for knowledge and technology transfer – key 'ingredients' for instigating and sustaining innovation, in this study, we investigate innovation as a determinant of highly skilled migration. Using a totally new database including all the Greek PhD holders and panel data from GII that cover 57 countries over the 2009–2020 period, we find that innovation constitutes a strong determinant for highly skilled migration. That is, a rise in innovative performance is positively associated with an increase in the number of highly skilled Greek migrants. We further find that there is a two-way causality between innovation and highly skilled migration. That is, an increase in the number of highly skilled Greek migrants positively affects innovative performance.

These findings fill a gap in the recent literature which mainly focuses on the positive impact of skilled migration on a country's/region's innovative performance. In this study, we stress that the opposite also holds true. Plausibly, the fact that innovation acts as a pull factor of highly skilled migration, combined with the fact that the vast majority of highly skilled migrants are concentrated in the most innovative countries, may have positive effects on host countries displaying high increases in innovative performance. These countries, by investing in innovation, gradually form a series of characteristics including advanced technological infrastructures, high rate of employment in knowledge-intensive industries, high level and quality of R&D activities, strong innovation linkages and high university and scientific publication ranking. All the above creates an environment that is receptive

to innovativeness and, thereby, further attracts highly skilled migrants. Within this environment, highly skilled migrants have the opportunity to practice their skills, transfer their rich knowledge and fulfil their potentials stimulating thus the host countries' innovative performance. This two-way causality may be enhanced by the recent transformations in the migration policy of, mainly, highly developed host countries, which aim to attract the best and the brightest migrants (OECD, 2020).

A possible weakness of our study is the use of composite indicators as independent variables. Composite indicators, for all their merits, do not allow us to distinguish which individual variables have the greater impact on highly skilled migration. Hence, a future research direction is to zoom into and address which specific innovation factor(s) shape both the migration decision of highly skilled migrants and their duration of stay. This could provide policymakers with evidence on which initiatives could be undertaken in terms of innovation and migration policy in order to attract/retain the highly skilled migrants.

The mutual interdependence between innovation and highly skilled migration may be detrimental for home countries presenting meagre innovation activity coupled with brain drain. The loss of valuable human resources, knowledge, new ideas, scientific discoveries and innovation may further harm their innovation capacity. A path for cancelling this ominous trajectory calls for these countries to re-orientate their growth pattern towards knowledge and develop a set of policy initiatives that aim to counter this trajectory on a short-, medium- and long-term horizon. Investing in education, placing emphasis on knowledge-intensive industries, incentivising innovation activities through technology valorisation and nurturing industry–academia collaborations are major fault lines of migration policy.

In the case of Greece, the upcoming Greek Partnership Agreement (2021–2027) and the Greek Recovery and Resilience Facility can provide the necessary financial and institutional leverage. These initiatives should be geared towards incentivising knowledge-intensive productivity and growth as a means of retaining and regaining the domestic skilled human capital. Part and parcel of a coherent migration policy is undertaking all those financial and regulatory steps that would give out signals that the domestic production system offers significant opportunities in terms of salary and career opportunities for the highly educated.

A change in the country's economic development pattern towards knowledge-intensive production stands as a plausible medium- and long-term solution for enabling brain gain. Equally realistic, we can reasonably suggest that most of those who now live and work outside Greece are not going to return home in the immediate future. Thus, policies that aspire to make the most of expatriates, while they remain abroad ("virtual return"), by way of, e.g. creating "bridges" with Greek industries, universities and professionals could moderate the negative consequences of their departure. Such "bridges" include science and innovation collaboration, provision of mentoring and networking opportunities and a range of other knowledge transfer practices to the domestic science and business base. Indeed, virtual return options may also contribute to the creation and maintenance of social ties with Greece. A possibility, that, under more favourable conditions, might even transform into a physical return.

DATA AVAILABILITY STATEMENT
Research data are not shared.

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ENDNOTE
[1] We define highly skilled migrants as those individuals who have experienced migration, hold a Ph.D. degree and perform highly skilled occupations. In essence, they constitute a sub-group within the broader set of highly skilled migrants as defined by the IOM (2019). According to IOM (2019, p.92), a highly skilled migrant worker "has earned, by higher level education or occupational experience, the level of skill or qualifications typically needed to practice a highly

skilled occupation." Highly skilled occupations (Managers, Professionals, Technicians and Associate Professionals) refer to occupations classified at skill levels 3 and 4 of the ISCO-08 Skill Level (ILO, 2012), while skill levels 3 and 4 usually correspond to levels of education at level 5 (short-cycle tertiary education), 6 (bachelor's or equivalent level), 7 (master's or equivalent level) or 8 (doctoral or equivalent level) of the ISCED-2011 levels of education (IOM, 2019; UNESCO, 2012). Hence, in terms of the above classifications, the highly skilled migrants of our study mostly perform occupations classified at skill levels 3 and 4 (ISCO-08) (see Table 1), and their educational level belongs to level 8 (ISCED-2011). The main reason we focus on this special educational cohort (i.e. PhD holders) is that their educational level and their professional activity are highly associated with the receiving country innovation performance, a fact that has been well documented by recent literature (Black & Stephan, 2008; Chellaraj et al., 2008; Stuen et al., 2012). Hence, they are the proper population for our research purpose.

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